VA SHLY'AY AKIMEL FINAL SALT RIVER ECOSYSTEM RESTORATION STUDY

COMMUNICATION

FROM

THE DEPUTY ASSOCIATE DIRECTOR ENERGY, SCIENCE AND WATER, THE DEPARTMENT OF THE ARMY

TRANSMITTING

A STUDY FOR THE ECOSYSTEM RESTORATION AND RECREATION FOR THE SALT RIVER (VA SHLY'AY AKIMEL), MARICOPA COUNTY, ARIZONA

JANUARY 27, 2009.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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U.S. GOVERNMENT PRINTING OFFICE

46–760 WASHINGTON : 2009

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

JAN 15 2009

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SPEAKER'S ROOM
U.S. HOUSE OF REPS

Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

HOUSE DOCUMENT NUMBER 111-16

Dear Madam Speaker:

A resolution adopted by the Committee on Public Works and Transportation of the House of Representatives, dated May 17, 1994, requested a review of reports for the State of Arizona to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, environmental protection and restoration, and related purposes. As a result of this review, a study has been completed for ecosystem restoration and recreation for the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona. The proposal is described in the report of the Chief of Engineers dated January 3, 2005, which includes other pertinent reports and documents. The views of the Department of the Interior and the Environmental Protection Agency are set forth in the enclosed report. The project for environmental restoration for the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona, was authorized in Section 1001(6) of the Water Resources Development Act of 2007.

The recommended ecosystem restoration and recreation project would restore ecosystem functions and values to about a 14-mile reach of the Salt River, within the Salt River Pima-Maricopa Indian Community and the City of Mesa, Arizona. The recommended plan includes restoration plantings, reshaping of abandoned quarry pits and the river channel to provide a low-flow channel and terraces, construction of new drainage channels, irrigation diversions and pipelines, installation of a groundwater well to nourish vegetation planted on the terraces along the river, and construction of a grade control structure to protect the restoration area. The recreation plan consists of approximately 5.1 miles of multi-use trails, parking lots, rest stops, and interpretive signs. Implementing this plan would restore and improve approximately 1,485 acres of habitat, including 880 acres of Cottonwood/willow community, 380 acres of mesquite bosque, 200 acres of wetlands, and 25 acres of Sonoran desert scrub shrub. Additionally, about 2,600 acres of existing cover type would be improved through invasive

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species control. This plan would support endangered and special species recovery, improve water quality, and restore greater ecological balance in the project area.

Based on October 2008 prices, the total first cost of the project is estimated at $179,400,000 with the ecosystem restoration portion estimated at $177,700,000 and the separable recreation features estimated at $1,700,000. In accordance with WRDA 1986, as amended, the cost sharing for ecosystem restoration would be 65 percent Federal and 35 percent non-Federal, and the separable recreation features would be cost shared 50 percent Federal and 50 percent non-Federal. Thus, the Federal share for ecosystem restoration would be about $115,500,000 and the non-Federal share would be about $62,200,000. The Federal and non-Federal shares for the separable recreation features, which have a benefit cost ratio of 1.5, would be about $850,000 each. The total first cost of the project would be shared at about $116,350,000 Federal and about $63,050,000 non-Federal. The costs for all operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project, plus associated supplemental water costs, are estimated at $2,200,000 annually. The non-Federal sponsors are the Salt River Pima-Maricopa Indian Community and the City of Mesa, Arizona.

The Corps of Engineers recommends that the project should be exempt from the requirement to obtain State water quality certification as provided for by Section 404(r) of the Clean Water Act (CWA). Section 404(r) provides that the discharge of dredged or fill material as part of the construction of a specifically authorized Federal project is not subject to the requirement to obtain State water quality certification "if information on the effects of such discharge . . . is included in an environmental impact statement for such project . . . [which] has been submitted to Congress before actual discharge of dredged or fill material in connection with the construction of such project and prior to either authorization of such project or an appropriation of funds for such construction." The provisions of Section 404(r) may be met, by submitting to Congress an environmental impact statement with the required information prior to appropriation of funds for construction of this project. Operations and maintenance activities will comply with applicable environmental laws and regulations. The State of Arizona does not object to the use of Section 404(r) of the CWA.

Army review of the recommendations contained in the report of the Chief of Engineers determined that the Corps did not demonstrate that the proposed plan represents an efficient way to target Federal and non-Federal resources for aquatic ecosystem restoration. To put this proposed project on par with similar Administration supported desert southwest aquatic ecosystem restoration activities, upland habitat restoration would need to be removed from the project or provided by others as part of a locally preferred plan.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress. However, construction funding would not be considered by the Administration for the project recommended in the report of the Chief of Engineers because the project is not consistent with the policy and programs of the President. A copy of its letter is enclosed. I am providing a copy of this transmittal and the OMB letter dated January 13, 2009 to the House Subcommittees on Energy and Water Development, and Water Resources and Environment.

Very truly yours,

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosures

6 Enclosures

1. Record of Decision, Jan 21, 2009
2. OMB Letter Jan 13, 2009
3. EPA Letter Dec 08, 2004
4. DOI Letter Dec 08, 2004
5. Report of the Chief of Engineers, Jan 03, 2005
6. Va Shly'ay Akimel, Final Salt River Ecosystem Restoration Study, Arizona - Final Feasibility Study and Final Environmental Impact Statement, September 2004 (Vols. 1-4)

RECORD OF DECISION
SALT RIVER (VA SHLY'AY AKIMEL) ECOSYSTEM RESTORATION
MARICOPA COUNTY, ARIZONA

The Final Feasibility Report and Final Environmental Impact Statement (FR/EIS) for Salt River (Va Shly'ay Akimel) Ecosystem Restoration in Maricopa County, Arizona, dated September 2004, addresses ecosystem restoration and recreation opportunities for the Va Shly'Ay Akimel reach of the Salt River in Maricopa County, Arizona. Based on this review and views of interested agencies and the concerned public, I find the ecosystem restoration project authorized by Congress in Section 1001(6) of the Water Resources Development Act of 2007 (Public Law 110-114) to be environmentally and economically justified, technically sound, in accordance with environmental statutes, and in the public interest.

The Va Shly'ay Akimel project provides environmental restoration to approximately 14 miles of the Salt River from Granite Reef Dam to the Pima Freeway (State Route 101) and includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. The purpose of this project is to restore ecosystem functions and values thereby expanding wildlife diversity and quantity along the Salt River from Granite Reef Dam downstream to the Pima Freeway (SR101). The authorized plan will restore and improve approximately 1,485 acres of habitat, including 880 acres of cottonwood/willow community, 380 acres of mesquite bosque, 200 acres of wetlands, and 25 acres of Sonoran desert scrub shrub. Specific ecosystem restoration features include:

- Reshaping of abandoned quarry pits and the river channel to provide a low-flow channel and terraces.
- Creation and restoration of native plant communities by extensive plantings and by eradication of salt cedar and other invasive species.
- Construction of new drainage channels, irrigation diversion structures and pipelines, and/or spillways.
- Installation of a groundwater well to nourish vegetation planted on the terraces.
- Construction of a grade control structure spanning the width of the channel, approximately 1,000 feet.
- Construction of a 5.1 mile 12-foot-wide multi-use decomposed granite trail, parking lots with trailheads, interpretive signs, and rest stops that typically will include a shade structure, picnic table, trash receptacles, and bike stand.

In addition to the no action and proposed alternatives, 16 alternatives were screened down to a final array of 5 alternative plans selected for detailed analyses. These alternatives are fully discussed in the FR/EIS. The U.S. Army Corps of Engineers, together with the non-Federal sponsors, the SRPMIC and the City of Mesa, have determined Alternative O to be the preferred alternative. Alternative O is also the National Ecosystem Restoration (NER) plan. All practicable means to avoid or minimize adverse environmental effects have been incorporated into the selected plan. The project will have relatively few adverse impacts on geomorphology, environmental resources, land use, aesthetics, public safety, and recreation. There will be

temporary, significant increases in turbidity, sediment deposition, air emissions, fugitive dust, and noise. These impacts will be mitigated or reduced to non-significant levels by implementing the following measures: erosion control and spill prevention, PM10-reduction, and noise-reduction. SRPMIC would like to include a Cultural Center in conjunction with this project. If this is added to the project, a supplemental EIS will be prepared.

The authorized ecosystem restoration plan complies with applicable environmental requirements. Recommendations made by the U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department have been incorporated into the plan. Consultation under the Endangered Species Act for the Yuma clapper rail, southwestern willow flycatcher, cactus ferruginous pygmy-owl, California brown pelican, and bald eagle has been completed. The USFWS concurred that the proposed project may affect, but is not likely to adversely affect these threatened or endangered species. Water quality impacts have been evaluated in accordance with the 404(b)(1) guidelines and are not adverse. Full compliance with the Clean Water Act will be accomplished prior to execution of a project partnership agreement and initiation of construction. Coordination with the Arizona State Historic Preservation Office pursuant to the National Historic Preservation Act (NHPA) has been accomplished. In accordance with the NHPA, additional evaluations will be conducted to determine eligibility of cultural sites for the National Register of Historic Places (NRHP). If any resources are determined to be NRHP eligible, and avoidance is not feasible, mitigation measures would be detailed in a Memorandum of Agreement between the Corps, Arizona State Historic Preservation Officer, Salt River Pima-Maricopa Indian Community, and the City of Mesa in accordance with Section 106 of the Act. Compliance with the Clean Air Act will be met through mitigation measures that reduce emissions and limit potential nuisance effects from dust to less-than-significant levels. Impacts associated with social equity or environmental justice are not anticipated.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's Principles and Guidelines. All applicable laws, executive orders, regulations, guidelines, and local government plans were considered in the evaluation of the alternatives. Based on review of these evaluations, I find that the monetary and non-monetary benefits gained by this ecosystem restoration portion of the Salt River far outweigh any adverse effects. This Record of Decision completes the National Environmental Policy Act process.

21 JAN 09
Date

Steven L. Stockton, P.E.
Director of Civil Works

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

The Honorable John Paul Woodley, Jr.
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, D.C. 20310-0108

Dear Mr. Woodley:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of your recommendation concerning the feasibility report of the Army Corps of Engineers (Corps) for the ecosystem restoration and recreation project for the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona.

We agree with your recommendation that this project is not consistent with the policy and programs of the President, because the Corps of Engineers' report does not demonstrate that the proposed plan represents an efficient way to target Federal and non-Federal resources for aquatic ecosystem restoration.

The Office of Management and Budget does not object to you submitting the report to Congress.

Sincerely,

Richard A. Mertens
Deputy Associate Director
Energy, Science and Water

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

December 8, 2004

Ken Zwickl
Headquarters
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Rd.
Alexandria, VA 22315-3860

Subject: Final Environmental Impact Statement for the Va Shly'ay Akimel Salt River Ecosystem Restoration Study, Maricopa County, Arizona (CEQ # 040523)

Dear Mr. Zwickl:

The Environmental Protection Agency (EPA) has reviewed the above referenced document pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508), and Section 309 of the Clean Air Act. Our detailed comments are enclosed.

EPA reviewed the Draft Environmental Impact Statement (DEIS), and provided comments to the U.S. Army Corps of Engineers on June 24, 2004. We rated the DEIS as Environmental Concerns - Insufficient Information (EC-2) and indicated our concerns about potential impacts from the construction and operation of the project's recreational facilities, impacts to water quality from the use of stormwater for irrigation, the effects of increased recreation on local traffic, and the potential cumulative impacts of the project.

EPA continues to have concerns that the impacts of the recreational components, including the 64,300 square foot Cultural Center complex located within the footprint of the ecosystem restoration project, have not been fully addressed in the EIS. The National Environmental Policy Act regulations (40 CFR Part 1508.25) define the scope of analysis for a project to include connected actions that are closely related interdependent parts of a larger action and require their discussion in the same EIS. This would not be limited to just cost-sharable elements or features that involve Corps participation. We understand that the locally-sponsored "betterment" was not required for the feasibility study, however it should be addressed in the NEPA process as a connected action. We recommend that the Record of Decision (ROD) address the environmental impacts of the Cultural Center, or identify the future NEPA process where it will be fully evaluated.

We appreciate an added reference to existing stormwater pollution permits in the FEIS. We recommend that the ROD include a commitment for the development of a water quality program to address any elevated levels of pollutants identified during stormwater monitoring, including an assessment of impacts related to treatment facilities or structures.

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We appreciate the opportunity to review this FEIS and commend the Corps for this valuable restoration effort. When the Record of Decision is signed, please send one copy to the address above (mail code CMD-2). If you have any questions, please contact me or Karen Vitulano, the lead reviewer for this project. Karen can be reached at 415-947-4178 or vitulano.karen@epa.gov.

Sincerely,

Lisa B. Hanf, Manager
Federal Activities Office

U.S. Environmental Protection Agency Rating System for Draft Environmental Impact Statements Definitions and Follow-Up Action*

Environmental Impact of the Action

LO – Lack of Objections

The U.S. Environmental Protection Agency (EPA) review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC – Environmental Concerns

EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce these impacts.

EO – Environmental Objections

EPA review has identified significant environmental impacts that should be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no-action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU – Environmentally Unsatisfactory

EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the Council on Environmental Quality (CEQ).

Adequacy of the Impact Statement

Category 1 – Adequate

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis of data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2 – Insufficient Information

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses or discussion should be included in the final EIS.

Category 3 – Inadequate

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the National Environmental Policy Act and or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

* From EPA Manual 1640 Policy and Procedures for the Review of Federal Actions Impacting the Environment. February, 1987.

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

TAKE PRIDE IN AMERICA

ER 04/874

DEC - 8 2004

Ms. Linda D. Garvin, Chief
South Pacific Division, Regional Integration Team
Headquarters, U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Ms. Garvin:

The U.S. Department of the Interior has reviewed the Chief of Engineers' Proposed Report, Final Feasibility Report and Environmental Impact Statement on the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona.

The Fish and Wildlife Service (Service) Arizona Ecological Services Field Office participated in the planning process for this study through an interagency transfer funding agreement with the Corps of Engineers. The Service has participated in alternative formulation and incremental benefits analysis, finalized a Fish and Wildlife Coordination Act Report, and completed section 7 consultation under the Endangered Species Act. As a result, the Final Feasibility Report and EIS accurately reflect our planning assistance and recommendations.

Accordingly, the Department has no comments to offer and does not object to the proposed project.

Sincerely,

Willie R. Taylor
Director, Office of Environmental
Policy and Compliance

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

03 JAN 2005

CEMP-SPD (1105-2-10a)

SUBJECT: Salt River (Va Shly'ay Akimel), Maricopa County, Arizona

THE SECRETARY OF THE ARMY

1. I submit, for transmission to Congress, my report on the study of ecosystem restoration and recreation opportunities on the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona. It is accompanied by the report of the district and division engineers. These reports are in partial response to Section 6 of the Flood Control Act of 1938 and a resolution adopted by the Committee on Public Works and Transportation of the House of Representatives on 17 May 1994. The statute and the resolution requested a review of reports for the State of Arizona to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, environmental protection and restoration, and related purposes. This is the authority under which pre-construction engineering and design activities will continue.

2. The reporting officers recommend authorization of a plan to restore ecosystem functions and values to about a 14-mile reach of the Salt River, within the Salt River Pima-Maricopa Indian Community and the City of Mesa, beginning immediately downstream of the Granite Reef Dam and continuing down to the Pima Freeway and the Red Mountain Freeway interchange. The recommended plan includes the following measures to support the restoration plantings:

- Reshaping of abandoned quarry pits and the river channel to provide a low-flow channel and terraces.
- Construction of new drainage channels, irrigation diversions and pipelines, and/or spillways.
- Installation of a groundwater well to nourish vegetation planted on the terraces along the river.
- Construction of a grade control structure across the channel at the abandoned Gilbert Road quarry.
- A passive recreation plan consisting of approximately 5.1 miles of multi-use decomposed-granite trails, parking lots with trailheads, rest stops spaced approximately at one per mile, and interpretive signs.

CEMP-SPD
SUBJECT: Salt River (Va Shly'ay Akimel), Maricopa County, Arizona

3. Additionally, the reporting officers recommend that the U. S. Army Corps of Engineers participate in cost-shared monitoring and minor modifications, as may be required to ensure success of the project, as identified and described within the monitoring and adaptive management plan of the report. The reporting officers further recommend that the plans, recommended herein, be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Clean Water Act. The 404(r) exemption will cover the construction phase and the operation and maintenance phase of the project, as described in the feasibility report and environmental impact statement.

4. Based on October 2003 price levels, the estimated total first cost of the recommended plan is $138,970,000. In accordance with cost sharing provisions of the Water Resources Development Act of 1986, as amended, the Federal share of total project cost would be approximately $90,130,000 and the non-Federal share would be approximately $48,840,000. The estimated total first cost for the ecosystem restoration portion of the recommended plan is $137,600,000, and cost shared 65 percent Federal and 35 percent non-Federal, has an estimated Federal cost of $89,400,000 and an estimated non-Federal cost of $48,200,000. The estimated total first cost of the plan includes approximately $4,300,000 for 5 years of monitoring and adaptive management necessary to ensure success of the project. Additionally, the total first cost includes the cost of the recreation portion of the project, estimated at $1,370,000. Recreation features are cost shared 50 percent Federal and 50 percent non-Federal, and have an estimated Federal cost of $685,000 and an estimated non-Federal cost of $685,000. The total estimated annual operation and maintenance costs for the project, which are the responsibility of the non-Federal sponsors, are estimated to be $390,000, with an associated non-Federal sponsors water cost of $1,280,000 annually. The Salt River Pima-Maricopa Indian Community and the City of Mesa are the non-Federal sponsors for the project.

5. The recommended plan for the Salt River (Va Shly'ay Akimel) ecosystem restoration project would restore and improve approximately 1,485 acres of habitat, including 880 acres of Cottonwood/willow community, 380 acres of mesquite bosque, 200 acres of wetlands, and 25 acres of Sonoran desert scrub shrub. Restoration of this resource in this urban setting is significant because riparian areas in the Southwest represent only one percent of the landscape, yet the survival of more than 75 percent of wildlife in the West is dependant on riparian areas. In Arizona, over 90 percent of riparian areas have been lost due to impacts from European settlement and urbanization. To ensure recommendation of an efficient plan, the alternative ecosystem restoration plans were evaluated using functional assessment, cost effectiveness, and incremental analysis techniques. The cost of the recommended ecosystem restoration features are justified by the increase of 1,006 average annual functional capacity units and by achieving ecosystem function increases in the most cost effective manner. The recommended plan would reconnect wildlife corridors, restore wildlife habitat for species significant to Maricopa County as well as the arid Southwest, provide potential habitat for threatened and endangered species, and

restore threatened plant communities of cottonwood/willow riparian forest, seasonal wetlands, and mesquite bosque. The recommended plan is the national ecosystem restoration plan and is the plan that is locally preferred. Based on October 2003 price levels and a discount rate of 5.625, the recreation plan provides average annual benefits of about $510,000 which when compared to average annual costs of about $339,000 results in a benefit to cost ratio of 1.5. Additionally, high- and low-flow water harvesting channels on the Finger Rock Wash tributary in the recommended plan would provide incidental flood damage reduction benefits of about $260,000 annually.

6. I concur with the findings, conclusions, and recommendation of the reporting officers. Accordingly, I recommend that the Salt River (Va Shly'ay Akimel), Maricopa County, Arizona, project be constructed in accordance with the reporting officers' recommended plan. My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including the Water Resources Development Act (WRDA) of 1986, as amended by WRDA 1996. Federal implementation of the authorized project would be subject to the non-Federal sponsors agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide 35 percent of the separable project costs allocated to environmental restoration and 50 percent of the separable project costs allocated to recreation, as further specified below:

(1) Enter into an agreement, which provides, prior to execution of a project cooperation agreement for the project, 25 percent of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

(4) Provide or pay to the Government the cost of providing all retaining dikes, waste weirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the separable project costs allocated to environmental restoration and 50 percent of the separable project costs allocated to recreation.

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

c. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

j. Prevent future encroachments on project lands, easements, and rights-of-way, which might interfere with the proper functioning of the project.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

l. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)).

m. Provide the non-Federal share of that portion of the costs of archeological data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with cost sharing provisions of the agreement;

n. Not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

o. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

p. For so long as the project remains authorized, provide the quantity of water for such periods that the Government determines is necessary to construct, operate, repair, replace, rehabilitate, and otherwise maintain the project.

CEMP-SPD
SUBJECT: Salt River (Va Shly'ay Akimel), Maricopa County, Arizona

7. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsors, the State, interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

CARL A. STROCK
Lieutenant General, US Army
Chief of Engineers

NOTICE

SALT RIVER (VA SHLY'AY), AZ

Since Congress has authorized the project, the Army Corps of Engineers does not request that the report be printed. If there are any questions about this, please call Mr. Zwickl at Corps Headquarters. You can reach Mr. Zwickl at (202) 761-4085.

Volume 1 of 4: Final Feasibility Report

Volume 2 of 4: Final Feasibility Report Technical Appendices

Volume 3 of 4: Final Environmental Impact Statement/Appendices

Volume 4 of 4: Final Environmental Impact Statement

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Prepared by:

U.S. Army Corps of Engineers
South Pacific Division
Los Angeles District

In partnership with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

Va Shly'ay Akimel Salt River
Ecosystem Restoration Feasibility Study
Maricopa County, Arizona

Volume 1 of 4: Final Feasibility Report

Prepared by:

U.S. Army Corps of Engineers
South Pacific Division
Los Angeles District

In partnership with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

CITY OF MESA
Great People, Quality Service!

With technical assistance from:

TETRA TECH, INC.
17770 Cartwright Road, Suite 500
Irvine, CA 92614

September 2004

Errata Sheet – Response 2a

CHAPTER IX
RECOMMENDATIONS

I recommend that the plan herein for environmental restoration and recreation be authorized for implementation as a Federal project. The total first cost of the project is currently estimated at $138,968,000 under October 2004 prices ($137,630,400 for ecosystem restoration and $1,337,600 for recreation). The Federal share is currently estimated at $90,128,560 ($89,459,760 for ecosystem restoration and $668,800 for recreation).

I recommend that the plans recommended herein be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Act. The 404(r) will cover the construction phase and the operation and maintenance phase of the project, as described in the feasibility report and EIS.

My recommendation is subject to cost-sharing, financing, and other applicable requirements of Federal and State laws and policies, including Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, and in accordance with the following requirements, which the non-Federal sponsor must agree to prior to project implementation.

a. Provide 35 percent of the separable project costs allocated to ecosystem restoration and 50 percent of the separable project costs allocated to recreation, as further specified below:

    1. Enter into an agreement which provides, prior to execution of a project cooperation agreement for the project, 25 percent of design costs;

    2. Provide, during construction, any additional funds needed to cover the nonfederal share of design costs;

    3. Provide all lands, easeme nts, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

that are situated above floodplains influences may be incorporated into the project and used for ecosystem restoration. The lands are all undeveloped with the principle economic or industrial use being sand and gravel extraction. Typically these operations occupy leased land of the SRPMIC. Should any such areas be incorporated into the project it will the responsibility of the SRPMIC to extinguish or otherwise terminate the mineral extraction rights or leases.

Since the land is generally in a floodplain or if out of the actual floodplain inside the river corridor, there has been no development and the land lies mostly vacant and unimproved. There will be no residential or businesses to relocate.

10. Acquisition Authorities and PCA Responsibilities

The Community (SRPMIC) is a sovereign self governing entity with the capability to hold title to lands and property within the bounds of its territorial reservation established by Federal treaty.

As to the City of Mesa that may be acquiring some of the lands along the left bank of the Salt River, the City of Mesa is a duly organized municipal corporation in the State of Arizona and is vested with sufficient power to acquire and hold title, and to condemn lands as needed for public purposes.

At this point in project formulation, it has been determined that the project will entail two components and two sponsors: the SRPMIC and the City of Mesa will sponsor their respective components of the project. Each sponsor will enter into its own PCA to implement its respective components as located within areas within their respective jurisdictional boundaries.

At this time in project formulation, we are aware of no unusual requirements or non-standard terms or articles for these prospective PCA's. The PCA for each sponsor will contain the standard responsibilities as set forth on the governing standard PCA for environmental restoration applicable at the time of project implementation and as negotiated with the Non Federal Sponsors.

11. Project Maps: Project maps have been included in the main body of this feasibility report .

12. Land Value Estimate:

A gross appraisal, in four separate appraisal reports for 4 reaches or segments, has now been obtained and provided to Real Estate Division on April 12, 2004. The report carries a submittal date by the appraiser of March 26 and a date of valuation of February 27, 2004. The gross appraisal has been reviewed and approved by the Corps of Engineers. It provides a basis of this planning estimate for the estimated value of LERRD's to be contributed toward the project. The gross appraisal estimate provides no guarantee or representation as to the actual value of lands at the time the are made available for an implemented project. The actual crediting will be governed by separate appraisals after a PCA is signed and when the final crediting determinations as provided in the PCA, are all accomplished and approved.

There is another source of uncertainty in the LERRD estimate as to the potential impact of any HTRW in the project area. A fuller discussion of the HTRW considerations is at paragraph 21 here and in the separate Geotechnical Appendix of this Feasibility Report.

For the SRPMIC component of the project there are 4003 acres to be contributed toward the project at fee simple value with a total gross appraisal estimate of $ 21, 750,000

This is an estimate of potential project costs only and is not a representation of actual credit that may be approved for this project component.

For the City of Mesa component there are 100 acres to be contributed toward the project at fee simple value with a total gross appraisal estimate of $2, 260,000

This is an estimate of potential project costs only and is not a representation of actual credit that may be approved for this project component.

Any such estimates are preliminary in nature pending such review and approval and are subject to revision. Crediting appraisals will be used to approve any actual LERRD credits to be applied to an approved project.

13. Crediting for LERRD's:

Crediting will follow standard procedures as set out in a model Project Cooperation Agreement. Credit for Community lands and interests will be determined by an appraisal of such interests as if available and appraised for the "fair market value" and highest and best use, etc, by standard appraisal practices assuming such lands can be sold on the "open market". This issue has a precedent in the planning and development of the Tres Rios Environmental Restoration project, also in Maricopa County but involving the separate Gila River Indian Community. On that project this issue was resolved in the determination that tribal lands should be valued at "fair market value", as this term is applied in standard appraisal practices and in a Model PCA.

14. Facility Relocations:

Because the project lies in a vacated area , a wash and riverbed, no utilities or roads are likely to be affected or relocated. The principle aims of the project are to invest in environmental restoration benefits and so a guiding principle of the plan formulation and project design would be that the existing major utility installations and infrastructure would be are allowed to remain in place and that design work around these facilities.

Subsequent research of utilities or public facilities will be done in subsequent phases of the project and if approved for implementation, during project "PED" or Pre-Construction Engineering and Design.

Note: The following policy statement and disclaimer concerning any potential facility relocations prevails over any other statement, description or presentation in this report. Any conclusion or categorization contained in this report that an item is a utility or facility relocation to be performed by the Non Federal Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation and maintenance of the project after further analysis. A Final Attorney's Opinion of Compensability would be provided if necessary to address any such relocations added to the project as a result of this analysis.

15. Mineral Activity:

EXECUTIVE SUMMARY

This report summarizes technical and feasibility study planning efforts undertaken to date to establish existing, future without-project, and future with-project conditions within the Va Shly'ay Akimel Salt River study area in Maricopa County, Arizona, to examine the measures and alternatives developed, and to present a recommended plan. This Feasibility Report serves to document plan formulation efforts in the development of potential alternatives for ecosystem restoration. These efforts will culminate in a complete feasibility report that identifies and recommends an implementable solution to improve the overall ecological health of the river and reestablish a more stable, less degraded, and sustainable condition.

The primary problem and focus of much of the efforts discussed in the report relates to the severe degradation and loss of riparian habitat along the Salt River. Historically, the study area supported significant biological resources including extensive riparian and marsh habitats. Urban development, diversion of water to support agriculture, and domestic livestock grazing have eliminated or altered most of the natural vegetation communities that occupied the study area leaving only scattered remnants of the original vegetation communities. Modifications of the river system, such as damming and flow diversion, currently do not allow flows through the study area except during flood events. In addition, sand and gravel mining operations have induced additional changes to the river channel and hydrology. As diversions of water increased, the perennial flows in the river ceased, causing the groundwater table to drop. These changes in hydrological conditions caused the natural riparian ecosystem to decline resulting in only small, isolated fragments of this former habitat remain. Furthermore, the changes in hydrology have also allowed saltcedar, an invasive non-native plant species with minimal habitat value, to become established in the region. Today, the study area consists of a highly disturbed riverbed with minimal extant native vegetation. It is expected that growth and development will increase the demand for local water supply, taxing groundwater and surface water resources, which could limit the availability of water for existing vegetative use or for ecosystem restoration in future years.

This Feasibility Report includes identification of problems, opportunities, constraints, and planning objectives. A wide range of technical issues were analyzed with the goal of developing an accurate description of historic, existing, and future without-project conditions within the study area. This baseline assessment serves to identify, confirm,

and refine problems, opportunities, and planning objectives and to guide the formulation of solutions. The major technical areas of focus for the study include hydrology and hydraulics, vegetation and wildlife habitat, cultural resources, projections on growth and development, and water availability and extent, particularly in reference to its effect on the riparian zone. Chapter 4 of this report details all of the areas of evaluation that comprise the without-project conditions. Detailed documentation of technical studies is included in the study's Technical Appendices, under separate cover.

This report also develops and discusses potential solutions as a guide to potential Federal and non-Federal involvement in a restoration project and as a resource to assist in the decision-making of local government and others. This report provides a description and discussion of the likely array of alternative plans, including their benefits, costs, and environmental effects, and outputs. Chapter 5 of this report presents the results of the plan formulation process used in the development of alternatives. Assessments of the impacts of each alternative are also presented in Chapter 5. Chapter 6 identifies and describes the coordinated implementable solution (Selected Plan) that best meets the planning objectives of a comprehensive ecosystem restoration through the study area. This study effort is a joint partnership of the Salt River Pima-Maricopa County Indian Community, the City of Mesa, and the Corps of Engineers, Los Angeles District.

A wide variety of management measures were identified for use in developing full-scale alternatives. Various combinations of these measures formed the first array of five preliminary alternative plans. After the initial screening of the preliminary alternative plans, a second array of 16 more refined alternative plans were developed. Each alternative plan was then independently evaluated and compared to the No Action Alternative. Resulting from this evaluation were three action plans and the No Action Alternative carried forward into the final array for further analysis and comparison (used as the basis for selecting the recommended plan).

Based on the cost-effectiveness and incremental cost evaluation, together with the analysis of impacts in the system of accounts and associated evaluation criteria, Alternative O2 is the plan that reasonably maximizes net ecosystem restoration benefits by having the maximum amount of restoration benefits compared to costs. Therefore, Alternative O2 is identified as the NER Plan and is presented as the recommended plan to be considered for implementation.

The total first cost of the project is currently estimated at $138,968,000 under October 2004 prices ($137,630,400 for ecosystem restoration and $1,337,600 for recreation). Based on the requirements of WRDA 1986, cost-sharing for ecosystem restoration features including of all lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) would be 65 percent Federal and 35 percent non-Federal. Thus, the Federal share is currently estimated at $90,128,560 ($89,459,760 for ecosystem restoration and $668,800 for recreation). Cost sharing for the recreation plan (Recreation Alternative B) would be 50 percent Federal and 50 percent non-Federal, or 0 percent Federal and 100 percent non-Federal, depending upon the features. USACE guidance (ER 1105-2-100, Appendix E) specifies that the level of financial participation by the Corps in recreation development may not increase the Federal cost of the project by more than 10 percent. The cost for all operations and maintenance would be the responsibility of the non-Federal sponsor. Annual operations and maintenance for the ecosystem restoration project and recreation is currently estimated at $131,000 and $256,500, respectively. In addition, all water rights and costs associated with providing water to the project shall be borne by the non-Federal sponsors. The value of this water has been estimated at $1,283,000 annually.

The recommended plan provides restoration benefits of 1,006 average annual functional capacity units (AAFCU), which results in an average annual cost per AAFCU of $10,100.

The Salt River Pima Maricopa Indian Community and the City of Mesa have expressed willingness in continuing to be non-Federal sponsors for project implementation. Both have indicated support for the project and willingness to assume cost-shared financial obligations for its implementation.

The analysis presented in this report shows that the recommended plan is feasible and would provide environmental restoration benefits that serve the public interest. Therefore, it is recommended that the recommended plan described herein for ecosystem restoration be authorized for implementation as a Federal project, with such modifications as in the discretion of the Chief of Engineers that may be advisable, and subject to cost sharing and financial arrangements satisfactory to the President and Congress.

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TABLE OF CONTENTS

Executive Summary ES-1
List of Tables vii
List of Figures x
List of Technical Appendices xii
List of Acronyms xiv
CHAPTER I I-1
STUDY AUTHORITY I-1
CHAPTER II II-1
STUDY INFORMATION II-1
2.1 Study Purpose and Study Scope II-1
2.2 Need for the Project/Proposed Action II-2
2.3 Study Area II-3
2.4 History of the Investigation II-3
2.5 Planning Process and Report Organization II-6
CHAPTER III III-1
PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS III-1
3.1 Prior Studies and Reports III-1
3.1.1 Water Resources Studies or Reports III-1
3.1.2 Recreation and Urban Development Studies or Reports III-5
3.1.3 Environmental Assessment Studies or Reports III-6
3.2 Existing Water Projects III-7
3.2.1 Salt River Project System III-7
3.2.2 Tres Rios Demonstration Project III-7
3.2.3 Salt River Channelization III-9
3.2.4 Tempe Town Lake III-9
CHAPTER IV IV-1
EXISTING CONDITIONS IV-1
4.1 Historic Conditions IV-1
4.2 Existing/Baseline Conditions IV-4
4.2.1 Geology, Topography, and Geomorphology IV-5
4.2.1.1 Soils IV-6
4.2.1.2 Gradient IV-7
4.2.1.3 Faults and Seismicity IV-7
4.2.1.4 Subsidence IV-8
4.2.1.5 Sources of Construction Materials IV-8

TABLE OF CONTENTS

(continued)

4.2.2 Hydrology and Hydraulics IV-8
4.2.2.1 Surface Water Hydrology IV-8
4.2.2.2 Surface Water Quality IV-16
4.2.2.3 Groundwater Hydrology IV-18
4.2.2.4 Groundwater Quality IV-25
4.2.3 Water Budget and Sources Analyses IV-25
4.2.3.1 Inflows/Water Sources IV-25
4.2.3.2 Outflows IV-53
4.2.3.3 Water Sources Assessment Summary IV-56
4.2.4 Vegetative Habitat IV-61
4.2.4.1 Cover Types IV-62
4.2.4.2 Habitat Evaluation IV-68
4.2.5 Hazardous, Toxic, or Radioactive Waste IV-78
4.2.6 Cultural Resources IV-86
4.2.7 Socioeconomics IV-88
4.2.7.1 Flood Damages IV-88
4.2.7.2 Population Trends IV-95
4.2.8 Land Use IV-96
4.2.9 Real Estate IV-97
4.2.10 Recreation IV-98
4.3 Future Without-Project Conditions IV-99
4.3.1 Hydrology and Hydraulics IV-100
4.3.1.1 Erosion Analysis IV-101
4.3.2 Environmental Resources IV-103
4.3.2.1 Biological Resources IV-103
4.3.2.2 Habitat Value IV-106
4.3.3 Land Use IV-108
4.3.4 Recreation IV-109
4.3.5 Economics IV-109
4.3.5.1 Structure and Content Damages IV-109
4.3.5.2 Emergency and Cleanup Costs IV-110
4.3.5.3 Agricultural Damages IV-112
4.3.5.4 Flood Damage Analysis Summary IV-114

CHAPTER V V-1
PLAN FORMULATION AND EVALUATION V-1
5.1 Planning Process V-1

TABLE OF CONTENTS

(continued)

5.2 Problems and Opportunities V-2
5.2.1 Public Concerns V-2
5.2.2 Problems V-3
5.2.3 Opportunities V-4
5.3 Planning Objectives and Constraints V-5
5.3.1 Federal Planning Objectives V-5
5.3.2 Specific Planning Objectives V-5
5.3.3 Planning Constraints V-6
5.4 Alternative Development and Evaluation Process V-7
5.5 Preliminary Management Measures and Alternatives V-9
5.5.1 Preliminary Management Measures V-9
5.5.2 Preliminary Alternatives V-12
5.5.2.1 Alternative 1: No Action V-12
5.5.2.2 Alternative 2: Restoration Based on Existing Water Budget V-13
5.5.2.3 Alternative 3: Restoration through Non-Structural Methods (Grade Improvement and Additional Water) V-13
5.5.2.4 Alternative 4: Restoration through Structural and Non-Structural Alternatives V-14
5.5.2.5 Alternative 5: Comprehensive Restoration V-15
5.6 Screening of Alternative Plans – Second Array V-17
5.6.1 Features Common to the Alternative Plans – Second Array V-18
5.6.1.1 Water Sources V-21
5.6.1.2 Water Distribution System V-21
5.6.1.3 Irrigation Techniques V-24
5.6.1.4 Reshaping V-25
5.6.1.5 Vegetation V-26
5.6.1.6 River Channelization V-28
5.6.1.7 Grade Control Structures V-29
5.6.1.8 Buried Guide Dikes V-30
5.6.1.9 Bank Stabilization V-32
5.6.1.10 Levee V-34
5.6.1.11 Cultural Center V-35
5.6.2 Second Array of Alternatives V-35
5.6.2.1 Alternative A V-38

TABLE OF CONTENTS

(continued)

5.6.2.2 Alternative B V-42
5.6.2.3 Alternative C V-47
5.6.2.4 Alternative D V-52
5.6.2.5 Alternative E V-57
5.6.2.6 Alternative F V-63
5.6.2.7 Alternative G V-69
5.6.2.8 Alternative H V-75
5.6.2.9 Alternative I V-82
5.6.2.10 Alternative J V-88
5.6.2.11 Alternative K V-94
5.6.2.12 Alternative L V-99
5.6.2.13 Alternative M V-104
5.6.2.14 Alternative N V-110
5.6.2.15 Alternative O V-115
5.6.2.16 Alternative P: No Action Alternative V-120
5.7 Comparison and Evaluation of the Second Array of Alternatives V-122
5.7.1 Water Budget V-122
5.7.1.1 Vegetation Water Demand V-122
5.7.1.2 Water Sources V-123
5.7.1.3 Irrigation System Inefficiency V-124
5.7.2 Cultural Resources V-125
5.7.3 Hazardous, Toxic, or Radioactive Waste V-127
5.7.4 Biological Resources V-133
5.7.4.1 Vegetative Cover Types V-133
5.7.4.2 Biological Risk and Uncertainty V-133
5.7.5 Environmental Benefits V-136
5.7.5.1 Period of Analysis V-138
5.7.6 Costs V-139
5.7.6.1 Real Estate V-140
5.7.6.2 Operation and Maintenance Considerations V-142
5.7.6.3 Associated Costs V-142
5.7.6.4 Project Costs V-142
5.7.7 Cost-Effectiveness and Incremental Cost Analysis V-146
5.7.8 Recreation V-150
5.7.8.1 Proposed Recreation Alternatives V-151
5.7.8.2 Benefit Analysis V-154

TABLE OF CONTENTS

(continued)

5.8 Alternative Plans – Final Array V-158
5.8.1 System of Accounts V-158
5.8.1.1 National Economic Development (NED) V-158
5.8.1.2 Environmental Quality (EQ) V-158
5.8.1.3 Regional Economic Development (RED) V-159
5.8.1.4 Other Social Effects (OSE) V-159
5.8.2 Associated Evaluation Criteria V-172
5.8.2.1 Completeness V-172
5.8.2.2 Effectiveness V-172
5.8.2.3 Efficiency V-173
5.8.2.4 Acceptability V-173
5.9 Alternatives Considered for Recommendation in the Feasibility Report V-176
5.9.1 National Economic Development Plan V-176
5.9.2 National Ecosystem Restoration Plan V-176
5.9.3 Locally Preferred Plan V-176
5.9.4 Selection of the Recommended Plan V-177

CHAPTER VI VI-1
DESCRIPTION OF THE RECOMMENDED PLAN VI-1
6.1 The Recommended Plan VI-1
6.2 Plan Features VI-1
6.3 Project Outputs VI-6
6.4 Cost Estimate VI-6
6.5 Maintenance Considerations VI-8
6.5.1 Drainage Maintenance VI-8
6.5.2 Maintenance and Replacement of Water Distribution System and Irrigation Infrastructure VI-8
6.5.3 Vector Control VI-8
6.5.4 Sediment Removal VI-9
6.5.5 Maintenance Activities in Specific Areas VI-9
6.6 Recreation Plan VI-10
6.7 Associated Non-Federal Considerations VI-11
6.8 Monitoring and Adaptive Management Plan VI-11

CHAPTER VII VII-1
PLAN IMPLEMENTATION VII-1

TABLE OF CONTENTS

(continued)

7.1 Study Recommendation VII-1
7.2 Division of Plan Responsibilities VII-1
7.2.1 Federal Responsibilities VII-1
7.2.2 Non-Federal Responsibilities VII-2
7.3 Cost Apportionment VII-5
7.4 Current and Future Work Eligible for Credits VII-7
7.5 Institutional Requirements VII-7
7.6 Environmental Requirements VII-7
7.6.1 National Environmental Policy Act VII-7
7.6.2 Endangered Species Act VII-8
7.6.3 Fish and Wildlife Coordination Act VII-8
7.6.4 Clean Water Act, Section 404(b)(1) VII-9
7.6.5 National Historic Preservation Act VII-9
7.7 Sponsorship Agreements VII-9
7.8 Procedures for Implementation VII-10

CHAPTER VIII VIII-1
SUMMARY OF COORDINATION AND PUBLIC VIEWS VIII-1
8.1 Non-Federal Views and Preferences VIII-1
8.2 Views of Non-Federal Sponsor VIII-1
8.3 Summary of Study Management, Coordination, Public Views, and Comments VIII-2

CHAPTER IX IX-1
RECOMMENDATIONS IX-1

CHAPTER X X-1
REFERENCES X-1

TABLE OF CONTENTS

(continued)

LIST OF TABLES

Table 1. Major Dams and Reservoirs in the Gila River Basin IV-9
Table 2. Frequency-Duration Values for the Salt River IV-13
Table 3. Summary of Interior Drains IV-15
Table 4. Types of Water Contaminants in the Lower Salt River IV-17
Table 5. General Depths (feet) to Groundwater near the Lower Salt River IV-20
Table 6. Annual Recharge Rates IV-24
Table 7. Recharge Rates Used in Model IV-24
Table 8. Potential Sources of Water IV-26
Table 9. Storm Drain Average Annual Runoff Volumes (ac-ft) IV-41
Table 10. SRPMIC Irrigation Water Use IV-45
Table 11. Consumptive Use for Salt River Habitat IV-54
Table 12. Riparian and Constructed Wetland Vegetation Requirements IV-55
Table 13. Seasonal Evaporation from Open Water IV-56
Table 14. Water Sources Assessment Summary IV-57
Table 15. Wetland Functions Evaluated IV-71
Table 16. FCI Function Models, Variables, and Performance Target IV-73
Table 17. Variables Used in Assessment IV-74
Table 18. Baseline Acreages for Partial Wetland Assessment Areas IV-76
Table 19. Baseline Acreages for Other Cover Types IV-76
Table 20. Baseline Conditions Analysis Results IV-77
Table 21. Site Names for Figure 25 ..... IV-82
Table 22. Number of Structures IV-92
Table 23. Value of Structures and Contents by Structure Type – 500 Year Floodplain IV-93
Table 24. Damages by Reach and Event (Base Year 2011) IV-94
Table 25. Expected Annual Damages by Reach and Structure Type (Base Year 2011) IV-95
Table 26. Without-Project AAFCUs IV-107
Table 27. Without-Project Expected Annual Damages – Future Conditions (2060) IV-109
Table 28. Without-Project Equivalent Annual Damages IV-110

TABLE OF CONTENTS

(continued)

Table 29. Without-Project Expected Annual Cleanup Costs by Reach IV-110
Table 30. Without-Project Expected Annual Temporary Housing Costs by Reach IV-112
Table 31. Estimate of Crop Production Losses by Flood Event – Reach 6 ..... IV-113
Table 32. Estimate of Floodplain Crop Acreages – Reach 6 ..... IV-113
Table 33. Without-Project Equivalent Annual Damages IV-114
Table 34. Second Array of Alternatives V-18
Table 35. Reach Description V-19
Table 36. Comparison of Second Array of Alternatives V-36
Table 37. Vegetated Area and Evapotranspiration Rate – Alternative A V-40
Table 38. Vegetated Area and Evapotranspiration Rate – Alternative B V-45
Table 39. Vegetated Area and Evapotranspiration Rate – Alternative C V-50
Table 40. Vegetated Area and Evapotranspiration Rate – Alternative D V-55
Table 41. Vegetated Area and Evapotranspiration Rate – Alternative E V-61
Table 42. Vegetated Area and Evapotranspiration Rate – Alternative F V-67
Table 43. Vegetated Area and Evapotranspiration Rate – Alternative G V-73
Table 44. Vegetated Area and Evapotranspiration Rate – Alternative H V-80
Table 45. Vegetated Area and Evapotranspiration Rate – Alternative I V-86
Table 46. Vegetated Area and Evapotranspiration Rate – Alternative J V-92
Table 47. Vegetated Area and Evapotranspiration Rate – Alternative K V-97
Table 48. Vegetated Area and Evapotranspiration Rate – Alternative L V-102
Table 49. Vegetated Area and Evapotranspiration Rate – Alternative M V-108
Table 50. Vegetated Area and Evapotranspiration Rate – Alternative N V-113
Table 51. Vegetated Area and Evapotranspiration Rate – Alternative O V-118
Table 52. Annual Vegetation Water Demand (ac-ft/yr) V-123
Table 53. Water Source Requirement (ac-ft/yr) V-124
Table 54. Water Demand with Irrigation Inefficiencies (ac-ft/yr) V-125
Table 55. Sites of Potential Environmental Concerns V-131
Table 56. With-Project Cover Types and Acreages V-134
Table 57. With-Project Average Annual Function Capacity Units – Second Array of Alternatives V-137
Table 58. With-Project Average Annual Function Capacity Units – Adjusted Results V-139

TABLE OF CONTENTS

(continued)

Table 59. Real Estate Costs V-141
Table 60. Annual Operation and Maintenance Costs V-143
Table 61. Annual Associated Costs – Water V-143
Table 62. Cost Summary – Second Array of Alternatives with Drip Irrigation V-144
Table 63. Cost Summary – Second Array of Alternatives with Braided Irrigation .. V-145
Table 64. Average Annual Cost per Average Annual FCU V-146
Table 65. Cost-Effective Alternatives V-148
Table 66. Incremental Cost Analysis – Best Buy Alternatives V-148
Table 67. Unit Day Value Assessment V-156
Table 68. Expected Annual Benefits for Recreation Alternatives V-156
Table 69. Costs by Alternative and Benefit-Cost Analysis V-157
Table 70. National Economic Development (NED) Account V-160
Table 71. Environmental Quality Account V-161
Table 72. Regional Economic Development Account V-168
Table 73. Other Social Effects Account V-170
Table 74. Associated Evaluation Criteria V-174
Table 75. Detailed Cost Estimate – Recommended Plan VI-7
Table 76. Cost Apportionment – Recommended Plan VII-6

TABLE OF CONTENTS

(continued)

LIST OF FIGURES

Figure 1. House Resolution 2425 ..... I-2
Figure 2. Project Study Area II-4
Figure 3. Location of Other Corps Projects II-5
Figure 4. Existing Water Projects III-8
Figure 5. 100-Year Floodplain within the Study Area IV-12
Figure 6. Depth to Groundwater Map IV-21
Figure 7. Salt River Upstream of Granite Reef IV-28
Figure 8. Seepage Downstream of Granite Reef IV-29
Figure 9. Water Budget Map IV-30
Figure 10. Wetlands Downstream of Granite Reef IV-31
Figure 11. Salt River near Greenfield Road IV-31
Figure 12. Salt River at Alma School Road IV-36
Figure 13. Price Drain IV-39
Figure 14. Evergreen Drain Turnout IV-47
Figure 15. Hennessey Drain Turnout IV-47
Figure 16. Sand and Gravel Operation at Dobson Plant IV-50
Figure 17. SRP's Arizona Canal IV-51
Figure 18. SRP's Southern Canal IV-52
Figure 19. Biological Communities IV-63
Figure 20. Saltcedar Growth IV-64
Figure 21. Scrub-Shrublands Dominated by Saltbush and Rabbitbush IV-66
Figure 22. Wetland/Emergent below Granite Reef Dam IV-67
Figure 23. Baseline FCIs for Va Shly'ay Akimel IV-77
Figure 24. Baseline FCUs for Va Shly'ay Akimel IV-78
Figure 25. Activities in and near the Study Area with Potential Environmental Concerns IV-81
Figure 26. Base Year (2011) Floodplain Delineations IV-90
Figure 27. Reach Delineations IV-91
Figure 28. Historic Channel Bank Locations (Superimposed on 2002 Imagery) IV-102
Figure 29 Without-Project AAFCU Trend Chart IV-108
Figure 30. Base Year (2011) vs. Future (2060) Conditions 500-Year Floodplain IV-111

TABLE OF CONTENTS

(continued)

Figure 31. Va Shly'ay Akimel Location Map – Reaches and Project Sub-areas V-20
Figure 32. Water Source Location Map V-22
Figure 33. Location of Water Surface Sources, New Wells, and Distribution Pipes V-23
Figure 34. Surface Braided Irrigation Network (SBIN) Diagram V-25
Figure 35. Longitudinal Profile of Salt River Main Channel with Grade Control Structure V-30
Figure 36. Guide Dikes Locations V-31
Figure 37. Channel Stabilization Locations V-33
Figure 38. Alternative A V-41
Figure 39. Alternative B V-46
Figure 40. Alternative C V-51
Figure 41. Alternative D V-56
Figure 42. Alternative E V-62
Figure 43. Alternative F V-68
Figure 44. Alternative G V-74
Figure 45. Alternative H V-81
Figure 46. Alternative I V-87
Figure 47. Alternative J V-93
Figure 48. Alternative K V-98
Figure 49. Alternative L V-103
Figure 50. Alternative M V-109
Figure 51. Alternative N V-114
Figure 52. Alternative O V-119
Figure 53. Alternative P V-121
Figure 54. Incremental Cost Analysis – Best Buy Alternatives Chart V-149
Figure 55. The Recommended Plan (Alternative O2) VI-2
Figure 56. Letter of Support from the Local Sponsor VIII-3

TABLE OF CONTENTS

(continued)

LIST OF TECHNICAL APPENDICES

(Under separate covers)

Volume 2 of 4

Appendix A Hydraulics and Hydrology
Appendix B Water Budget Analysis
Appendix C Interior Drainage
Appendix D Groundwater Model
Appendix E Geotechnical
Appendix F Design
Appendix G Cost

Volume 3 of 4

Appendix H Biological Assessment
Appendix I HGM Assessment (WASS Gerke & Associates)
Appendix J Economics
Appendix K Real Estate
Appendix L Recreation

Volume 4 of 4

Appendix M Environmental Impact Statement (Jones & Stokes)

LIST OF ACRONYMS

AAC	average annual cost
AAFCU	average annual functional capacity unit
ac-ft	acre-feet
ADEQ	Arizona Department of Environmental Quality
ADMP	Area Drainage Master Plan
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game & Fish Department
AMA	Active Management Area
ANPP	Arizona Nuclear Power Project
APS	Arizona Public Service Company
ASA	Assistant Secretary for the Army
ASU	Arizona State University
BIC	Buckeye Irrigation Company
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
CAFOs	concentrated animal feeding operations
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
DPI	Direct Production Investment
EA	Environmental Assessment
EDC	engineering during construction
EIS	Environmental Impact Statement
EL	Environmental Laboratory
EPA	US Environmental Protection Agency
EQ	Environmental Quality
ERDC	Engineering Research and Development Center
ESRV	East Salt River Valley
FCDMC	Flood Control District of Maricopa County
FCIs	Functional Capacity Indices
FCTC	Flood Control Technical Committee

FCUs	Functional Capacity Units
FEMA	Federal Emergency Management Agency
gpm	gallons per minute
GRIC	Gila River Indian Community
GRUSP	Granite Reef Underground Storage Project
GWSI	Ground Water Site Inventory
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic Modeling
HSI	Habitat Suitability Index
HTRW	Hazardous Toxic Radioactive Waste
HU	Habitat Unit
HV	Habitat Value
IDC	interest during construction
LAU	Lower Alluvial Unit
LERRDs	lands, easements, rights-of-way, relocations, and disposal areas
LPP	Locally Preferred Plan
MAG	Maricopa County Association of Governments
MAU	Middle Alluvial Unit
mgd	million gallons per day
MM	Modified Mercalli Intensity Scale
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NFIP	National Flood Insurance Program
NPDES	National Pollution Discharge Elimination System
NPV	net present value
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRPA	National Recreation and Parks Association
NWWRP	Northwest Water Reclamation Plant
OHV	off-highway vehicles
OMRR&R	operations, maintenance, repair, replacement, and rehabilitation

OSE	Other Social Effects
PED	preconstruction engineering design
PIR	Phoenix International Raceway
PYs	Project Years
RCP	reinforced concrete pipe
RED	Regional Economic Development
RID	Roosevelt Irrigation District
RWCD	Roosevelt Water Conservation District
S&A	supervision and administration
SBIN	Surface Braided Irrigation Network
SCORP	Arizona Statewide Comprehensive Outdoor Recreation Plan
SHPO	State Historic Preservation Officer
SPD	South Pacific Division
SROG	Multi-City Subregional Operating Group
SRP	Salt River Project
SRPMIC	Salt River Pima Maricopa Indian Community
SRS&R	Salt River Sand & Rock
SWPPP	storm water pollution prevention plan
TDS	total dissolved solids
TRRMP	Tres Rios River Management Plan
TYs	Target Years
UAU	Upper Alluvial Unit
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
VSA	Va Shly'ay Akimel
VOCs	Volatile Organic Compounds
WQRAF	Arizona Water Quality Revolving Assurance Fund
WSRV	West Salt River Valley
WWTP	Wastewater Treatment Plant

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CHAPTER I
STUDY AUTHORITY

This report was prepared as an interim response to the following authorities provided by Congress:

a. House Resolution 2425 (HR 2425), dated May 17, 1994, (Figure 1) which states:

" ... the Secretary of the Army is requested to review reports of the Chief of Engineers on the State of Arizona ... in the interest of flood damage reduction, environmental protection and restoration, and related purposes."

b. The second authority is given in Public Law 761, Seventy-fifth Congress, dated June 28, 1938, known as Section 6 of the Flood Control Act of 1938 of Public Law 761, which reads in part as follows:

"The Secretary of War is hereby authorized and directed to cause preliminary examination and surveys ... at the following localities: ... Gila River and tributaries, Arizona."

The Energy and Water Development Appropriations Act of 2001 (Public Law 106-377, dated October 17, 2000) provided $150,000 for the Corps of Engineers to evaluate opportunities for environmental restoration and related matters on the Salt River in Arizona.

Figure 1. House Resolution 2425

U.S. House of Representatives

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION

SUITE 2165 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-4472

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

RESOLUTION

State of Arizona
Docket 2425

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the State of Arizona, published as House Document 331, Eighty-first Congress, First Session; Senate Document 116, Eighty-seventh Congress, Second Session; Senate Document 127, Eighty-Seventh Congress, Second Session; House Document 625, Seventy-Eighth Congress, Second Session, House Document 648, Seventy-Eighth Congress, Second Session; Senate Document 63, Eighty-eighth Congress, Second Session; and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of flood damage reduction, environmental protection and restoration, and related purposes.

Adopted: May 17, 1994

ATTEST:

NORMAN Y. MINETA, Chair

CHAPTER II
STUDY INFORMATION

2.1 Study Purpose and Study Scope

The Va Shly'ay Akimel Salt River Restoration Study is being conducted by the U.S. Army Corps of Engineers (USACE), Los Angeles District, the Salt River Pima-Maricopa Indian Community (SRPMIC), and the City of Mesa, Arizona. The purpose of this study is to identify whether there is a Federal interest in implementing an ecosystem restoration project along the Salt River from Granite Reef Dam downstream to the Pima Freeway (SR101). This study identifies feasible ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The SRPMIC and the City of Mesa, as non-Federal sponsors, support the proposed project purpose to provide ecosystem restoration, passive recreation, and other related outputs.

This report describes the existing conditions in the project area, the future without-project condition, and the future with-project condition. Conditions that exist at the time of the study are collectively called the existing condition. The without-project condition is the same as the "no action" alternative, and describes what is expected to happen in the absence of Federal action. The future with-project condition describes what is expected to happen if each alternative plan is implemented. The significant natural, economic, and social resources described in the existing and future without-project condition are compared to the future with-project condition in order to identify differences among alternatives.

Alternative plans are being developed to provide for restoring a diversity of riparian habitat to a more natural state. This report is intended to ultimately be a complete decision document that presents the results of the feasibility phase of the General Investigation effort. Specifically, this feasibility report will:

- Provide a complete presentation of study results and findings, so that readers can reach independent conclusions regarding the reasonableness of recommendations;
- Assure compliance with applicable statutes, executive orders, and policies, in accordance with budgetary priorities; and

- Provide a sound and documented basis for decision-makers at all levels to judge the need and justification for the recommended solution(s).

2.2 Need for the Project/Proposed Action

The SRPMIC, the City of Mesa, and the Corps of Engineers together are conducting the feasibility study to identify and define environmental degradation, flooding, and related land and water resource problems and to develop solutions to restore the environment.

The primary problem is the severe degradation and loss of riparian habitat along the Salt River since the early 20th century. The Salt River once flowed perennially and supported substantial growth of cottonwoods, willows, and mesquites. The river channel carried abundant water that supported early irrigation projects. Increasing appropriation of surface and ground water to support expansion of agriculture and growing urban populations resulted in the transformation of the Salt River to a dry river that flows only ephemerally in response to storm runoff.

As a result of this change, stands of native riparian habitat are rare in the study area. Loss of riparian habitat is extremely significant in the arid southwest. Historically comprising a mere three percent of the landscape, over 95 percent has already been lost in Arizona. This type of river-connected riparian and fringe habitat is of an extremely high value due to its rarity. Arid southwest riparian ecosystems are designated as a critically endangered habitat type. It has been estimated that 75 to 90 percent of all wildlife in the arid southwest is riparian dependent during some part of its life cycle. As a direct consequence of the extent of the lost or degraded riparian habitat, the area has experienced a major reduction in species diversity and in the population of remaining species. In addition, destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions. Such plants consume more water than do native vegetation because of their ability to occupy a greater areal extent on the landscape, placing additional strains on limited water supply.

Presently, there are still adjacent parcels of undeveloped land in the Salt River area, and potential sources of water for restoration still exist. As long as these conditions remain unchanged, there is an opportunity to accomplish significant restoration in the study area. Restoration options have the potential to increase riparian habitat acreage and quality thereby expanding wildlife diversity and quantity, controlling invasive plant species, and providing an ecological resource that is significant and valuable to the SRPMIC and to the region.

2.3 Study Area

The study area is geographically located in Maricopa County, Arizona, and includes portions of the SRPMIC and the City of Mesa, 18 miles east of the City of Phoenix (see Figure 2). The study area is approximately 14 miles long, extending from immediately downstream of the Granite Reef Dam to the Pima Freeway (SR101), and averages approximately 2 miles wide and consists of approximately 17,435 acres. The study area lies within the sovereign Salt River Pima-Maricopa Indian Community and the jurisdiction of J.D. Hayworth of the Arizona 5th Congressional District.

The Va Shly'ay Akimel project is one of four ecosystem restoration projects that are at various stages of progress, from the planning phase to construction, conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam. Figure 3 shows the location of the Va Shly'ay Akimel project relative to these other projects.

The Rio Salado project, just downstream from Va Shly'ay Akimel, was the first of this series of projects to be authorized. This project is currently under construction. The Rio Salado Oeste project is immediately downstream of the Rio Salado project and is currently in the feasibility study phase as well. The Tres Rios project, just downstream from Rio Salado Oeste, is currently in the engineering and design stage.

2.4 History of the Investigation

In response to the study authority, the reconnaissance phase of the study was initiated in November 2000. This phase of the study resulted in the finding that there was a Federal interest in continuing the study into the feasibility phase. The SRPMIC and the City of Mesa, as the non-Federal sponsors, and the USACE initiated the feasibility phase of the study in August 2001. This is the first USACE ecosystem restoration study undertaken with a sovereign Native American Indian community as a non-Federal sponsor.

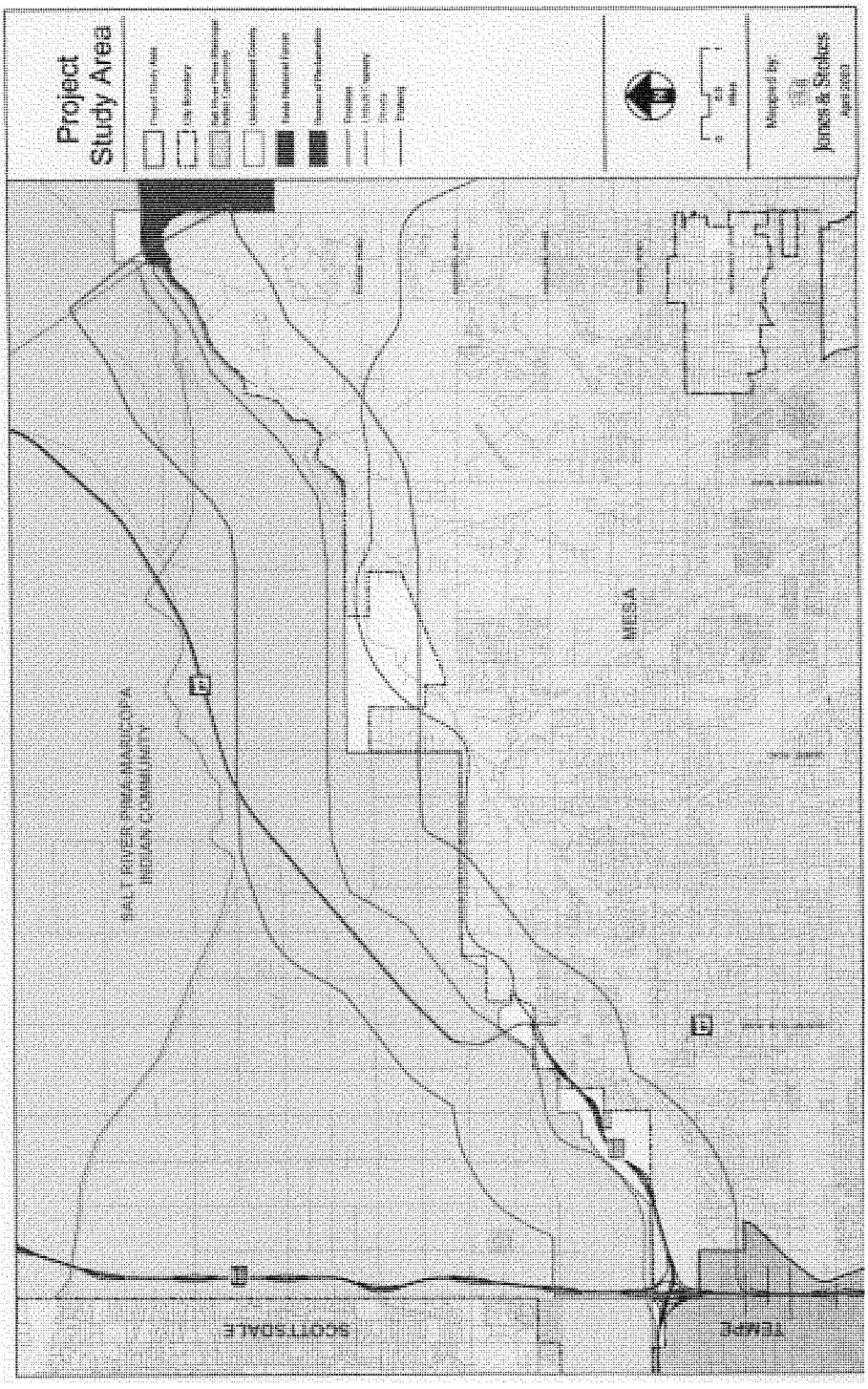
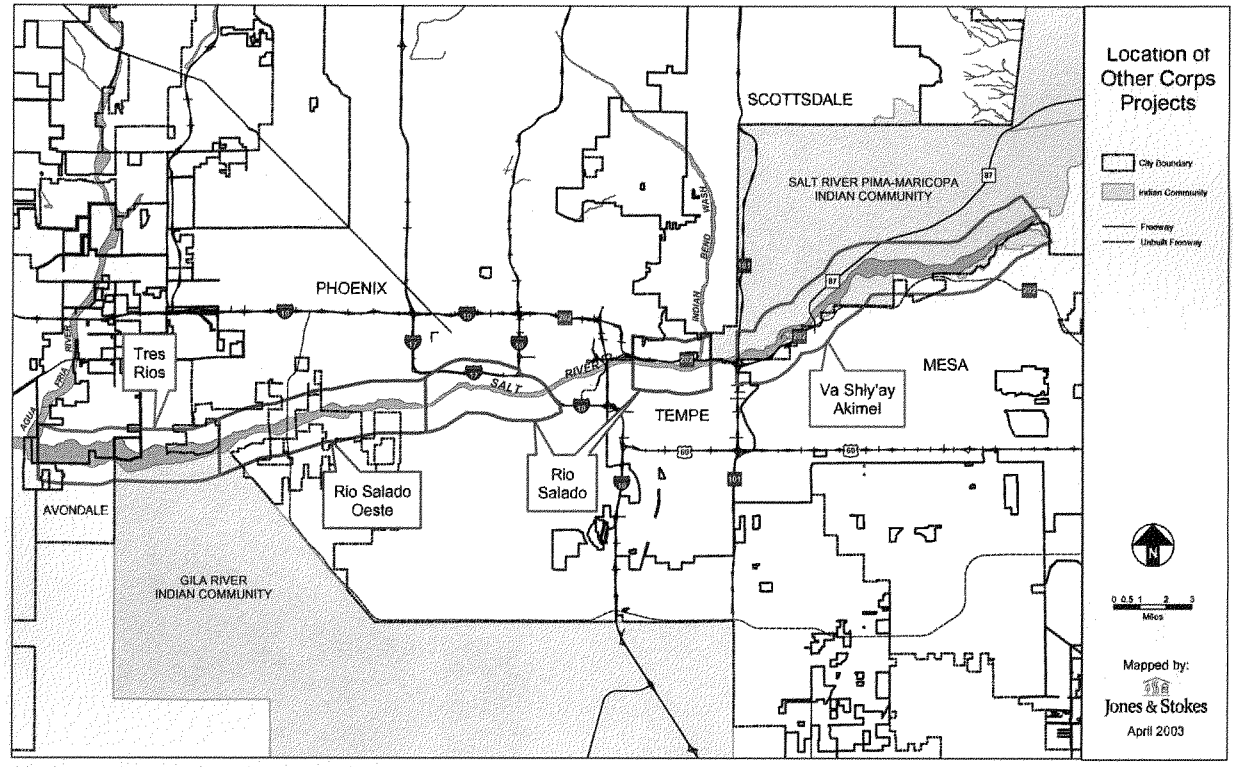


Figure 2. Project Study Area

Figure 3. Location of Other Corps Projects



2.5 Planning Process and Report Organization

The Corps planning process consists of six steps defined in the Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies established in 1983 by the Water Resources Council. The process identifies and responds to problems and opportunities associated with the study objectives and specific Federal, state, and local concerns. The planning process culminates in the selection of a recommended plan or the alternative of no action. The process involves a systematic approach to making determinations at each step so that the interested public and decision-makers are fully aware of the basic assumptions employed. The data and information analyzed, the areas of risk and uncertainty, the reasons and rationales used, and the significant implications of each alternative plan are all exposed through this process. The six steps listed below are addressed in this report and are contained in the chapters shown. These steps are further described in Chapter V, Plan Formulation.

(1) Specify water and related land resources problems and opportunities (Chapter V)

(2) Inventory, forecast, and analyze water and related land resources conditions within the study area (Chapter IV)

(3) Formulate alternative plans (Chapter V)

(4) Evaluate the effects of the alternative plans (Chapter V)

(5) Compare the alternative plans (Chapter V)

(6) Select the recommended plan based upon the comparison of the alternative plans (Chapter V and presented in Chapter VI)

The final product of this feasibility study is this Feasibility Report and an Environmental Impact Statement (EIS) that will serve as the basis for obtaining Congressional authorization of the plan components determined to be feasible and cost-effective.

The requirements identified in this report may change as project features are further refined during the Pre-construction Engineering and Design (PED) Phase of the project. The project features including actual lands required and estates to be acquired in those lands may change after approval of the feasibility report. As project features are further refined in subsequent implementation efforts, the USACE will review the siting determination for the various project features set out in the report in accordance with established policies. This review may result in changes in design or land requirements

for specific project features, while maintaining the overall benefit levels presented in the recommended plan. If there are substantive changes in the recommended plan and/or the requirements of this project based on more detailed analysis, then the Los Angeles District will prepare necessary documentation.

CHAPTER III
PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Prior to the beginning of this feasibility study, many efforts had been conducted to identify, quantify, and seek funding to implement solutions to help alleviate flooding and improve environmental quality in the Salt River ecosystem. This chapter discusses these studies and reports that have been prepared on issues relating to the Salt River study area. Also included in this chapter are existing projects and structures located within the study area.

3.1 Prior Studies and Reports

The Salt River has been the subject of numerous water resource and environmental resources studies. Past efforts of interest to this feasibility study have been conducted by the USACE and other Federal, state, and local agencies. These studies focused on issues including flood protection, water conservation, recreation and urban development, environmental assessments, and fish and wildlife habitat restoration. Recent, ongoing, and planned studies that lie within the Salt River study area have been identified and are described in the following sections. Relevant information contained in these studies is incorporated into this feasibility study.

3.1.1 Water Resources Studies or Reports

In 1974, the Maricopa Association of Governments (MAG) completed an overall conceptual plan for a Salt River redevelopment. The plan outlined water use and implementation recommendations and called for specific plans for two demonstration projects.

In 1978, the USACE conducted a study that extended along the Salt River from the Gila River confluence to Granite Reef Dam. The study evaluated problems and alternative possibilities relating to flood damage reduction, wastewater, floodwater conservation, and fish and wildlife recreation. The study focused specifically on the 16-mile reach between 27th Avenue in Phoenix and Country Club Road in the City of Mesa.

In 1981, the USACE investigated water and related land resources issues in the Phoenix Metropolitan area as a result of severe flooding along the Salt and Gila Rivers. Issues

discussed included water quality, flood damage reduction, water conservation, and fish and wildlife enhancement. None of the projects proposed by local agencies, with the exception of flood damage reduction along the Salt and Gila Rivers, were found to warrant Federal interest. The flood damage reduction measures presented included flood proofing, relocation, floodplain regulations, preparedness planning, channel excavation, and evaluation of hydraulic structures.

A Rio Salado Development District was created in the late 1970s and early 1980s. Their function was to investigate and implement a regional redevelopment of the Salt River. Maricopa County voters defeated the resolution to create a continuing tax authority for the District, so that it no longer exists. However, several studies were conducted by the District before its dissolution, one of which was a published memorandum in 1982, which provides a basis for the determination of a source of water for the redevelopment project. The memo identifies potential sources, gives general background on these sources, and provides a preliminary analysis of each.

In 1982, Water Resources Associates, a private engineering consulting firm, conducted a study that evaluated the potential water sources and flood damage reduction options for a regional redevelopment of the Salt River. Sources for domestic water included obtaining Central Arizona Project (CAP) allotment and obtaining water rights from surface and groundwater and from lands within the district. The source identified for aesthetic and recreational water was low quality groundwater. Flood management plans were based on an existing condition scenario and of an upstream flood damage reduction design condition.

In 1982, Carr, Lynch Associates, a private engineering consulting firm, also conducted a study, which evaluated the potential water sources and flood damage reduction options for a regional project within the Salt River. This study included discussion on the physical structure of the project and its surroundings, the social structure, the economic situation, water supply, and flood damage reduction.

In 1989, Simons, Li & Associates, Inc., a private engineering consulting firm (now Tetra Tech, Inc.), prepared a report on the channelization of the Salt River through Tempe, Arizona. The study addressed issues related to channel design, determined appropriate hydraulic design criteria, and presented several alternative design concepts. The engineering analysis included the evaluation of alternative river sections, alignments, and profiles. In addition, the study identified potential impacts due to the proposed changes.

In 1989, the USACE completed the *Salt-Gila Reconnaissance Report.* This study focuses on the flooding problems and associated solutions downstream from the confluence of the Verde and Salt Rivers to Gillespie Dam. No analyzed solution was economically justified; therefore, the study did not proceed to the feasibility phase.

In 1992, the USACE completed the *Central Maricopa County Reconnaissance Study.* This study described and analyzed flooding problems and water resource opportunities within the Phoenix metropolitan area to develop a wide range of alternatives that would reduce the severity of or totally eliminate flooding problems. Twenty-three flooding problems were identified within Central Maricopa County. Two areas determined to have Federal interest included a flood damage reduction project on the Dysart Drain near Luke Air Force Base, and water quality and environmental restoration project on the Salt River near 91st Avenue. The restoration project was Tres Rios, which was not recommended to proceed to the feasibility phase at that time.

In 1993, the U.S. Bureau of Reclamation (USBR) completed the *Conceptual Design for the Tres Rios Demonstration Wetlands.* The design was completed in cooperation with the City of Phoenix, Arizona Game and Fish Department (AGFD), Arizona Department of Environmental Quality (ADEQ), Maricopa County Parks and Recreation, Maricopa County Flood Control District, and the U.S. Environmental Protection Agency (USEPA). The study evaluates methods for reclaiming water from sewage effluent from the 91st Avenue regional wastewater treatment plant and develops plans for using the reclaimed water directly or through exchange mechanisms. This report presents a conceptual design for a constructed wetland demonstration project designed to improve the quality of treated effluent currently being discharged to the Salt River.

In 1994, Arizona State University (ASU) completed a geomorphic assessment of the Salt River for the USACE. The assessment supports a reconnaissance-level geomorphologic evaluation of the lower Salt River and a portion of the Gila River. The study discusses the environmental history, hydrologic system, geomorphic system, and engineering features of the Salt River.

In 1994, the USACE completed a bank stabilization study on the Salt River. The study focused on that portion of the Salt River located entirely within the Salt River Pima-Maricopa Indian Community, east of Scottsdale, within Maricopa County. Flood events in 1992 and 1993 caused erosion of landfill material into the Salt River. Several flood protection measures and alternatives were considered. The study concluded that there was no Federal interest in participating in installation of bank stabilization at this location. With funding from the Federal Emergency Management Agency (FEMA), the SRPMIC initiated construction of bank stabilization of two of the landfill sites.

In 1994, the Flood Control District of Maricopa County completed a land use and structures inventory. The inventory was published in a report, which listed the various structures, utilities, and land use conditions along the Salt and Gila Rivers from Granite Reef Dam to Gillespie Dam

In 1995, the USACE completed the reconnaissance phase of the Rio Salado, Salt River, in Arizona, which included an assessment of the problems and opportunities and an evaluation of alternatives for a 33-mile portion of the Salt River. In April 1998, the USACE completed the *Feasibility Report and Environmental Impact Statement for the Rio Salado, Salt River, Arizona.* This report identified plans that provide environmental restoration benefits and serve the public interest. The project is currently in the PED phase with construction of some components underway.

In 1996, the USACE, in cooperation with USBR, completed an analysis of various release plans for the operation of the modified Roosevelt Dam. As a result of this effort, new hydrology, which showed significant reductions in discharge downstream, was developed for the lower Salt and Gila Rivers.

In April 2000, the USACE completed the *Feasibility Report and Environment Impact Statement for Tres Rios, Arizona.* This study examined a portion of the Salt River and Gila River from 83rd Avenue downstream to the Agua Fria River. The study selected a plan that includes environmental restoration and flood damage reduction components. The project is currently in the PED phase.

The USACE is currently conducting a feasibility study that is examining the water resource opportunities along the Salt River, in Phoenix, Arizona, between 19th and 83rd Avenues. The study area is located between the authorized Rio Salado project area and the Tres Rios feasibility study area. The project, Rio Salado Oeste, is approximately eight river miles in length. The non-Federal sponsor is the City of Phoenix. The study

area includes portions of the City of Phoenix, Maricopa County, as well as state and Federal lands.

The Flood Control District of Maricopa County (FCDMC) has teamed up with the cities of Phoenix, Tolleson, and Avondale to prepare an area drainage master plan (ADMP) for the southwest valley area of Maricopa County. The *Durango ADMP* quantifies the extent of flooding problems and develops a solution to the identified flooding problems. This master plan addresses much of the land to the north of the project area and potential for flooding problems due to interior drainage. The following is a website link to the ADMP: http://www.fcd.maricopa.gov/Projects/DurangoADMP/

The FCDMC has also completed the *Laveen Area ADMP*. The study area is in the southwestern portion of the metropolitan Phoenix area within Maricopa County, Arizona, and is 39 square miles in the City of Phoenix and unincorporated Maricopa County. The focus area for this portion of the ADMP is the 16 square miles west of 43rd Avenue. The entire area bounded by the Salt River on the north, 7th Avenue on the east, South Mountain Park on the south, and the Gila River Indian Reservation boundary on the west is the contributing area for the hydrology. The project has been completed and components of it are in planning and pre-design. The following is a website link to the ADMP: http://www.fcd.maricopa.gov/Neighborhood/ProjectDetails.asp?wPROJECT=32

3.1.2 Recreation and Urban Development Studies or Reports

In 1985, Carr, Lynch Associates, a private engineering consulting firm, completed a master plan for a regional redevelopment of the Salt River corridor. The master plan involves a major reclamation of nearly 10,000 acres of land, including transformation of the present riverbed into a regional park and development of its banks, cultural, and educational uses. This master plan document was never implemented.

In 1997, as required by state law, Maricopa County prepared a comprehensive plan "to conserve the natural resources of the County, to ensure efficient expenditure of public funds, and to promote the health, safety, convenience, and general welfare of the public" (Maricopa County, 1997). The plan provides a guide for decisions made by the planning and zoning commission and the Board of Supervisors concerning growth and development. The Salt River itself is identified as "Proposed Open Space" on the land use map. This designation recognizes that natural resources and open spaces are important to the quality of life in the county and, if acquired, are intended to be planned

and managed to protect, maintain, and enhance their intrinsic value for recreational, aesthetic, and biological purposes.

There is strong support for protecting natural and cultural resources and for environmental education in Arizona. In the 1994 Statewide Comprehensive Outdoor Recreation Plan (SCORP) survey, 94 percent of respondents stated that parks and recreation areas are important to their everyday lifestyles. Seventy-five percent favor preserving rivers and stream-side habitats, even if it means limiting some uses of privately-owned lands. A separate study conducted by the Arizona Game & Fish Heritage Fund (*Attitudes Toward Urban Wildlife Management, Volume 1, May 1995*) supports these statistics. A statewide survey was conducted of 1,200 residents. In the Heritage Fund survey, 89 percent of respondents stated that the continued presence of wildlife in their town is important to them. The importance placed on protecting water-based habitat and recreation areas can be attributed to the limited amount of surface water available. Arizona has approximately 113,642 square miles of land surface, but only about 360 square miles are water-covered.

In 2002, the City Council and voters within the City of Mesa approved a Master Plan for the city of Mesa titled, "Mesa 2025-A Shared Vision." The *Mesa 2025* publication provides feedback on the attitudes of local residents regarding recreation. Surveys conducted for the study concluded that residents desire more parkland, particularly more passive recreation facilities. Participants support the City taking an active roll in identifying and pursuing a variety of partnerships with public and private entities to create new recreation facilities.

3.1.3 Environmental Assessment Studies or Reports

In accordance with the requirements of the National Environmental Policy Act (NEPA) and the Council on Environmental Quality, environmental assessment studies have been prepared for a number of studies or reports previously described. These include feasibility studies that were conducted or being completed by the USACE for ecosystem restoration projects along the Salt River from Granite Reef Dam. The studies include the Rio Salado (1995), Tres Rios (2000), and Rio Salado Oeste (current).

3.2 Existing Water Projects

The following projects and structures are located within the Salt River watershed. Figure 4 shows the location of the Va Shly'ay Akimel project relative to these other projects.

3.2.1 Salt River Project System

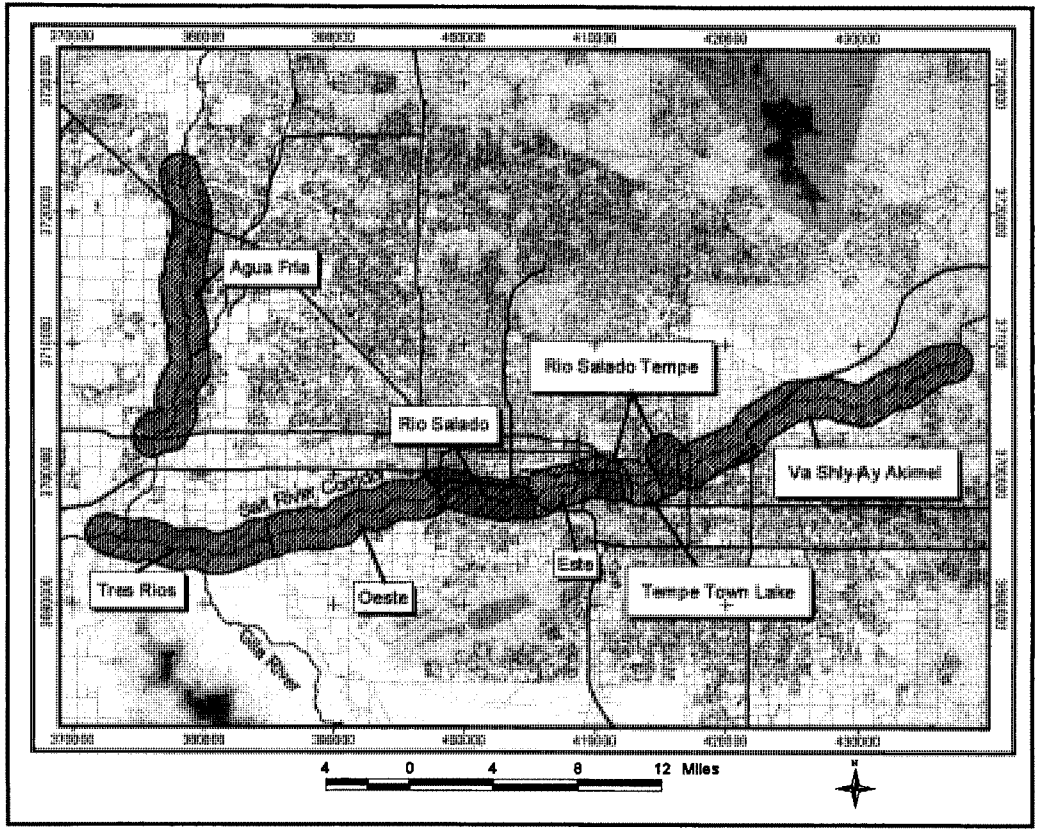
Flows in the Salt River are controlled by a series of upstream dams built by USBR and operated by the Salt River Project (SRP). The SRP system is comprised of six reservoirs and seven dams on the Salt and Verde Rivers. The dams include Roosevelt Dam, Horse Mesa Dam, Mormon Flat Dam, Stewart Mountain Dam, and Granite Reef Dam on the Salt River. On the Verde River, the dams are Horseshoe Dam and Bartlett Dam. The reservoirs receive runoff from a combined watershed of more than 12,600 square miles.

Roosevelt Dam is the oldest and largest in the SRP system. Congress originally authorized it in 1903 for water supply and power generation. The construction of the dam was completed in 1911. In 1978, Congress authorized the modification of Roosevelt Dam. The modifications were to include a new storage allocation for flood damage reduction. The modifications to the Dam began in 1989 and were completed in 1996. Roosevelt Dam has been operated under a new Water Control Manual since 1997.

3.2.2 Tres Rios Demonstration Project

The Phoenix Metropolitan area is serviced by a regional wastewater treatment plant located at 91st Avenue and the Salt River. The plant discharges approximately 154 million gallons per day (mgd) of effluent to the Salt River. The treatment plant is operated by the City of Phoenix on behalf of the Multi-City Subregional Operating Group (SROG). The SROG represents a consortium of cities including Phoenix, Mesa, Glendale, Tempe, Scottsdale, and Youngtown. In 1992, USBR was authorized by Sections 1605 and 1608 of Public Law 102-575 to participate in the development of a demonstrations wetlands project at the 91st Avenue plant. In 1995, the SROG and USBR built the Tres Rios Demonstration Project within the floodway of the Salt River below the 91st Avenue plant. The project provides final treatment of approximately 2 mgd of effluent within 10 acres of constructed wetlands.

Figure 4. Existing Water Projects



3.2.3 Salt River Channelization

In 1996, the Arizona Department of Transportation (ADOT) and the MCFCD completed channelization of the Salt River from 48th Street to Price Road, a distance of approximately 7.5 miles. The channelization included soil cement and gabion bank protection with grade control and drop structures. The channelization is designed to convey floodwaters and eliminate erosion and channel migration. The design capacity is 250,000 cubic feet per second (cfs) with one foot of freeboard at Rural (Scottsdale) Road Bridge. The construction also included construction of a defined confluence with Indian Bend Wash.

3.2.4 Tempe Town Lake

The City of Tempe, together with private developers, constructed Tempe Town Lake on the Salt River. The project includes two inflatable dams within the Salt River bed, which serve to confine approximately 3,500 acre-feet of lake water. The project features also include an extensive seepage control system, which consists of multiple groundwater pumps. As the lake infiltrates into the riverbed, the pumps recover the water and convey it back into the lake.

CHAPTER IV
EXISTING CONDITIONS

In conducting this feasibility study, a wide range of technical issues were analyzed with the goal of developing an accurate description of historic, existing, and future without-project conditions in the Va Shly'ay Akimel study area. Available information was initially collected about existing studies and projects that could assist in the preparation of the inventory of historic and existing conditions and the forecasting of future without-project conditions to characterize the baseline conditions for the study area. Without a good understanding of the existing condition, one cannot understand what constitutes an improvement from a degraded condition. The information presented under baseline conditions is used to formulate alternative measures that address the watershed problems and opportunities discussed in Chapter V, Plan Formulation. Major technical areas of focus for the study include hydrologic and hydraulic studies, environmental studies related to biological resources, cultural resources, economic analysis, and recreation.

4.1 Historic Conditions

The Salt River has diverse characteristics and is considered by many to be the most vibrant natural feature of the Phoenix metropolitan area. It originates at Mount Baldy in the White Mountains where streamlets of water from the Black River form its eastern sides, while the White River begins on the western side of the mountain. Over the next hundred miles, the Salt River, unregulated, gathers up the waters of smaller streams, such as Carrizo, Canyon, and Tonto Creeks, before manmade structures control its flow. Eventually the Salt River joins the Verde River before merging with the Gila River. The Salt River watershed drains approximately 14,500 square miles. The water's brackish taste, acquired by the stream flowing over salt beds, gave the river its name.

During the past 150 years, the lower Salt River has undergone natural and artificial modifications beginning with Native American settlements and continuing to present day urban growth. The river's present form is the result of both natural climatic variations occurring during these years and human activities that manipulated the river. To study the sequence of changes to the Salt River, the following discussion is broken into periods that reflect unique combinations of human activities and natural climatic variation.

Native American Use (circa 500 B.C. to 1867 A.D): Native American peoples developed simple, small-scale agriculture along the Salt River. This gradually evolved into large agricultural irrigation systems, drawing water from the Salt River into an extensive canal system. Salt River Valley populations rose steadily and then fell in the 1400s when inhabitants largely abandoned the canal system and local towns. Reasons for this depopulation are still debated, but some archeologists have speculated that extensive drought periods, punctuated by damaging floods, proved to be too great a strain on the local irrigation system. From the late 1400s to 1867, human use of the lower Salt River was sporadic and small in scale.

Farming Settlements and Canal Companies (1867-1911): Non-Native American settlement of the Salt River Valley began in the late 1860s when immigrants began irrigating lands near the Salt River to grow hay for the U.S. Army at Fort McDowell. The number of both local canal systems and cultivated acres increased steadily for the rest of the nineteenth century until the extremely severe drought of 1898-1904. One response to the drought was to begin building a huge upstream water storage dam at the confluence of the Salt River and Tonto Creek, about 60 miles east of downtown Phoenix. During this period, farmers' diversion drastically reduced the river's summer flow. The effects on river flows from late fall through spring would have been modest. Annual winter and spring high flow would have been largely unaffected. Exotic phreatophytes began establishing themselves along the river during this period.

Salt River Project (SRP) and the Capturing of the Salt and Verde Rivers (1911-1941): During this period, people constructed the infrastructure to capture water above the valley and to divert water more efficiently from the river into the canal systems. The view of the time was that this avoided "wasting" the water by leaving it in the river. The Federal Government built Roosevelt Dam (1904-1911) to store and regulate Salt River flows on behalf of the local landowners who organized themselves as the Salt River Valley Water Users Association (later the SRP). The USBR also built Granite Reef Diversion Dam to divert water from the Salt River into a now unified and re-plumbed system of irrigation canals. The SRP built three more storage dams on the Salt River from 1923 to 1931. These dams now controlled the river in all but the wettest years, and SRP released from the reservoirs only the amount of water needed for diversion to canals at Granite Reef Dam.

Until the 1930s, there was no upstream storage on the Verde River. High Verde flows in winter and spring continued to send water past Granite Reef and down the Salt River channel through the valley. The completion of Bartlett Dam on the Verde in 1938 finally cut off this unregulated source of flow. In the 1920s, Waddell Dam cut off flows into the Salt-Gila from the Agua Fria River, and farmers built Gillespie Dam downstream on the Gila. Gillespie Dam allowed efficient diversion of irrigation return flows and groundwater seepage from the Gila for use of farmland to the south and west.

Dams now captured most river flows upstream, but groundwater tables along the river remained high. These two factors combined to support increasingly extensive and dense stands of riparian vegetation, dominated by phreatophytes. This was also a relatively wet period for the Salt and Verde watersheds, with many years of above average precipitation and few droughts. A very wet 1941 marked the end of the period with major river flows released from overfilled storage reservoirs upstream.

Mid-Century Drought, Groundwater Development, and Urban Growth (1942-1977): A prolonged series of slightly-to-very dry years characterized much of 1942 through 1977, with only a couple of notable exceptions in the 1960s and 1970s. At the same time, the Phoenix area saw unprecedented urban growth alongside a still extensive agricultural economy. High water demands and low surface water supplies prompted a rapid increase in the number of groundwater wells. The rapid rise in the amount of groundwater pumped resulted in a rapid fall in groundwater levels. There was increasing concern about long-term water supplies and insufficient water conservation. With water tables falling below the phreatophytes' root zone and with no surface flows in the river, much of the riparian vegetation disappeared. This prolonged period without much water in the river also encouraged the construction of unbridged river crossings and bridges designed to handle only small floods. Short memories and dry rivers also encouraged encroachment into the floodplain by buildings and landfills.

Flood Flows, Effluent Supplies, and Increased Water Management (1978-present): Heavy rain and flooding in 1978, 1979, and 1980 broke the severe drought of 1976 and 1977 across much of the western United States. This proved to be the beginning of an abnormally wet period that ran through 1995, although there were two very dry years in the early 1990s. In many river segments, these major floods in 1978, 1979, 1980, 1983, 1993, and 1995 scoured away accumulated sediments and caused some lateral shifting of channels. The floods also destroyed many inadequate bridges and prompted construction of many new and larger replacements. There was significant damage to commercial

structures and a few residential areas that had encroached on the river. Renewed awareness of the river's potential also prompted channelization and bank protection in some areas. These floodflows raised groundwater tables near the river, at least temporarily.

For decades, the Arizona legislature had unsuccessfully wrestled with the problem of increasing water demand and declining groundwater tables. The legislature finally agreed with Federal agencies that this long-term problem deserved state government intervention. It enacted the Groundwater Management Act of 1980, providing some controls on groundwater pumping, requiring water conservation measures, and encouraging effluent re-use. The Act generally forced water providers to be more sophisticated in their water management and ultimately resulted in a highly organized structure of controls, credits, procedures, and regulatory permits governing conveyance, use, and storage of groundwater.

Urban growth had a significant effect of increasing one source of water supply to the river: effluent-based streamflow. Treatment plants returned a portion of treated effluent to the Salt River channel in southwest Phoenix, causing the river to support riparian vegetation once again. Finally, Tempe and then Phoenix began projects to use the broad, largely barren river channel in the center of the metropolitan area. These projects feature artificial lakes and streams for recreational use and enhanced development.

4.2 Existing/Baseline Conditions

Existing conditions are defined as those conditions that exist within the study area at the time of the study. The future without-project condition, which is the same as the "no action" alternative, is a projection of how these conditions are expected to change over time and form the basis against which plan formulation alternatives are developed, evaluated, and compared. Baseline conditions refer to the without-project conditions expected at the time that a project would be implemented, sometimes 2 to 5 years subsequent to completion of the feasibility study.

4.2.1 Geology, Topography, and Geomorphology

The Salt River floodplain is located within the gentle, flat slopes of the Phoenix basin of the Salt River Valley. The area is geomorphically located within the Gila Lowland Section of the Sonoran Desert Subprovince, a part of the Southern Basin and Range Physiographic Province. This province is characterized by broad, gently sloping, connected alluvial valleys (basins) bounded by moderately high, rugged, northwest- to southeast-trending mountain ranges. During the late Miocene epoch (Tertiary period), the mountain ranges were extensively dissected, uplifted, and downdropped by northwest- to southwest- and east- to west-trending sub-parallel normal faults. Extensive volcanic activity accompanied the faulting. These sedimentary and volcanic rocks lie unconformably upon an ancient Precambrian igneous and metamorphic basement complex. The complex is composed predominantly of igneous granite and diorite, metamorphosed schist, gneiss, and volcanic rock and underlies basin terrace and alluvium at depths of 10,000 feet or greater. The Tertiary rocks are made up of volcanic basalt, andesite, rhyolite, sedimentary sandstone, siltstone, and conglomerate.

From the late Miocene until the late Pliocene, the ranges deeply eroded and filled their downdropped areas (basins) with sediments, which were later consolidated into sedimentary rocks. From the end of the Pliocene until recent (Holocene) time, the basins, including the Salt River Valley, filled with unconsolidated and occasional semi-consolidated sediment eroded from the ranges. The thickest accumulations of valley alluvium formed during the early to middle Quaternary period.

The predominant surface materials within the Va Shly'ay Akimel project area consist of Quaternary-age river sediment deposited as alluvium and terraces and, to a lesser extent, sheetwash-deposited alluvium and slope-deposited colluvium. Quaternary sediments consist of:

- Salt River Valley alluvium and terraces – unconsolidated to well-cemented gravel and boulders interbedded with irregular silt, sand, and gravel lenses.
- Colluvium – loose- to well-cemented silt, sand, clay, and gravel.

The Quaternary alluvium and colluvium deposits range in thickness from about 275 to 4,500 and 5 to 250 feet (east to southwesterly across the site), respectively. Thick layers of alluvium have accumulated within the major streams, tributaries, and floodplains of the Salt River. Streambed alluvium and terraces are

flanked, covered, and underlain by thinner layers of wind- and sheetwash-deposited alluvium and bedrock colluvium. Terrace deposits range from about 5 to 250 feet thick and also consist of unconsolidated silt, sand, gravel, and boulders to highly cemented caliches. Terrace deposits are considered older than the alluvium within the Salt River. The contacts between the two types of deposits are gradational at depth (undifferentiated) and overlie the thick Tertiary sedimentary and volcanic rocks that lie beneath the basin as discussed earlier. They interface with Tertiary rocks along mountain ranges and inselbergs. Salt River Valley terrace deposits lie exposed above the Salt River channel in locations throughout the project area.

The Va Shly'ay Akimel study area extends a total of approximately 14 miles along the Salt River, which flows west into the Phoenix Basin from the Superstition and Goldfield mountain ranges. The study area extends west from Granite Reef Dam to the Pima Freeway (SR101) and is characterized by relatively flat terrain with slopes ranging from 0 to 2 percent. The width of the Salt River floodplain in the project area ranges from approximately ¼ mile to 1.0 mile wide.

4.2.1.1 Soils

As discussed above, the interior floor of the Salt River Valley is comprised of thick layers of alluvium. This land is nearly level and generally has a hummocky appearance. The alluvium consists of stratified, recently deposited stream sediment in the channels of the Salt River. The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) categorizes the soils in the vicinity of the river channel in a group known as the hyperthermic torrifluvents association, a group of soils that are well-drained to excessively well-drained soils that exist on nearly level or gently sloping surfaces. The texture of the surface layer ranges from gravelly sand, or very gravelly sand, to fine sandy loam. The material beneath the surface layer is very gravelly sand to very fine sandy loam or loam. These soils are often redistributed by blowing wind and the shifting of stream channels, making mapping of individual areas as soil units infeasible. Permeability ranges from very rapid to moderate; runoff is slow and soils are fine enough that they may become airborne during wind events.

4.2.1.2 Gradient

The average gradient of the lower Salt River between Granite Reef Dam and the confluence with the Gila River is about 9.5 feet of vertical drop per mile of horizontal distance, although there are numerous local variations. The gradient has decreased to a small degree because of erosion in the upper reaches and deposition in the lower reaches.

4.2.1.3 Faults and Seismicity

Faults in central Arizona are generally short, discontinuous, normal faults, some of which have been interpreted to displace Quaternary formations. Most fall within the Jerome-Wasatch Structural Zone, an approximately 47-mile-wide band that extends from Utah into Mexico. In Utah, the zone is associated with current earthquake activity and displays evidence of abundant Quaternary faulting. In Arizona, the zone includes the Main Street Fault in the northwest corner of the state and the Verde Fault, located approximately 56 miles north of the Va Shly'ay Akimel study area.

The Va Shly'ay Akimel study area is located in an area of low seismicity as referenced in Zone 1 of the Seismic Zone Map of the Contiguous States (U.S. Army Corps of Engineers, 1983). DuBois, *et al.* (1982) list 29 earthquakes with maximum epicentral intensities between II and VI on the Modified Mercalli Intensity Scale (MM) which have occurred within a 100-mile radius of the study area from 1870 through 1980 (I-III represent slight shaking; and IV-VI represent non-damaging, widely perceptible shaking). The largest of these known earthquakes occurred southeast of Ajo in 1961, northeast of Globe in 1969, and northwest of Prescott in 1976. The 1961 event, 95 miles from the study area, had a Richter magnitude of 4.7 (no known reports from the Phoenix area). The 1969 event, 72 miles from the study area, had a Richter magnitude between 4.4 and 5.1 (assigned an MM intensity of II at Phoenix). The 1976 event, 81 miles from the site, had a Richter magnitude of 5.1 (assigned an MM intensity of IV at Phoenix).

From 1980 through 1998, numerous small earthquakes are listed within a 100-mile radius of the project. All of these are at the extreme limits of the search area, including the Jerome-Prescott area to the north, and the Mogollon Rim area to the northeast. The highest Richter magnitude quake occurred along the Mogollon Rim in 1989, registering a 3.4 value.

The largest known earthquake to occur in Arizona was of Richter magnitude 5.7 recorded in 1959 near Fredonia, 240 miles from the study area. The seismic historical record for the last 125 years indicates that only one major damaging earthquake (1887 Sonora, Mexico) has occurred and was located outside the 100-mile radius. This earthquake measured a Richter magnitude of 7.2, and was located more than 255 miles from Tempe, AZ, causing rockfalls (MM VI) near the study area. The most recent (1974) nearby events, the "New River earthquakes," located 15 miles north of the study area, had recorded Richter magnitudes of only 2.5 and 3.0 (DuBois, *et al.*, 1982).

In conclusion, the study area is located within a region of low seismicity and ground rupture and shaking are not expected to significantly impact the restoration project.

4.2.1.4 Subsidence

Earth fissures and subsidence are both produced by groundwater withdrawal or pumping of groundwater, where the ground compresses (subsides) as water is withdrawn and the soil loses the support of water between soil particles (pore space). Earth fissures develop when the soil subsides differentially and separates. Available information suggests that subsidence in the project area has not occurred. The area has not been affected by subsidence due to its upstream location and the presence of two recharge facilities.

4.2.1.5 Sources of Construction Materials

Two stone borrow sites have been identified as sources of construction material and are available for use. The two quarries have produced stone for previous USACE flood damage reduction projects at the Arizona Diversion Canal and Indian Bend Wash areas. Stone from both quarries exhibit a good service record and passed all rock quality compliance tests. These two quarries are the Sun State Rock and Materials and the Salt River Sand and Rock.

4.2.2 Hydrology and Hydraulics

4.2.2.1 Surface Water Hydrology

In the lower Salt River Valley, the annual average rainfall is approximately 8 inches; rainfall at the highest elevations of the watershed maximizes at a mere 14 inches annually (U.S. Geological Survey, 1991). Compound the low annual precipitation rates in this arid region with the increased demands from the urbanization and population, and it is not surprising that Federal, state, and local agencies, communities, and private industry have

made large investments over the years in engineering projects to gain some measure of control over water resources.

(a) Dam System

During the 20th century, as mentioned earlier, the Phoenix metropolitan area has changed from an agricultural region to an urban region, resulting in significant changes in the physical characteristics of the rivers in the area. Agricultural and urban activities have given rise to an intricate network of structures associated with the river used for irrigation, drainage, erosion protection, and flood damage reduction. Numerous upstream dams on the Salt and Gila Rivers have radically altered the natural hydrologic regime of the rivers. Table 1 provides a listing of the major dams and reservoirs in the Gila River Basin.

Table 1. Major Dams and Reservoirs in the Gila River Basin

Dam	River	Reservoir	Date of Origin	Storage (acre-feet)
Waddell	Agua Fria	Lake Pleasant	1927	165,000[a]
Bartlett	Verde	Bartlett Lake	1939	182,000
Horseshoe	Verde	Horseshoe Lake	1949	141,000
Stewart Mountain	Salt	Saguaro Lake	1930	71,000
Mormon Flat	Salt	Canyon Lake	1938	59,000
Horse Mesa	Salt	Apache Lake	1927	248,000
Roosevelt	Salt	Roosevelt Lake	1911	1,600,000[b]
Coolidge	Gila	San Carlos Lake	1928	1,222,000
Painted Rock	Gila	Painted Rock Lake	1959	2,500,000

[a] Indicates original storage capacity before modifications that is presently underway to expand capacity.
[b] Black, pers. comm.
Source: Graf, *et al.*, 1994.

The SRP operates seven dams and storage reservoirs within the Salt River watershed. Stored water is allocated for hydropower, municipal and industrial supply, and agriculture. Modifications to the Theodore Roosevelt Dam also include an allocation for flood damage reduction. The total space for water-supply storage behind these dams is approximately 1.9 million acre-feet (ac-ft), with an additional 560,000 ac-ft for flood damage reduction behind Roosevelt Dam. Before 1938, an average of 413,000 ac-ft of water flowed through the channel annually (U.S. Army Corps of Engineers, 1997). The

estimated pre-development, average annual watershed yield was about 1,250,000 ac-ft (U.S. Geological Survey, 1991). Since 1965, the channel has carried an average of only 293,000 ac-ft of water per year, with less than 10,000 ac-ft in almost three-fifths of the years (U.S. Army Corps of Engineers, 1997). The Modified Theodore Roosevelt Dam is the largest facility and receives drainage from approximately 5,800 square miles. The Verde River is the principal tributary and watershed of the Salt River (6,700 square miles). Its flows are partially controlled by Horseshoe Dam (located furthest upstream) and Bartlett Dam (approximately 25 miles upstream of the confluence with the Salt River), which provide an additional 310,000 ac-ft of storage. New Waddell Dam is located on the Agua Fria River northwest of Phoenix and downstream of the project study area.

Since Bartlett Dam began operating on the Verde River in 1938, the lower Salt River has contained water only as a result of controlled or uncontrolled releases from the Granite Reef Diversion Dam. Granite Reef Diversion Dam is located about 3 miles downstream of the Salt-Verde confluence and is the most downstream SRP dam. The purpose of this facility is to divert upstream reservoir releases into the Arizona Canal (for the area north of the Salt River) and the South Canal (for the area south of the Salt River). The canals crisscross the Phoenix metropolitan area for water delivery to agricultural, municipal, and industrial uses. There are no releases during climatically drier years, such as the period between 1942 and 1964, and the Salt River is dry during those times except for local stormwater and irrigation runoff, groundwater emergence, and effluent.

Hydrologic modeling used to develop a water-control plan for the Modified Theodore Roosevelt Dam indicates that water would have spilled over Granite Reef Diversion Dam in only 34 of 105 years under the current configuration of dam operations (U.S. Army Corps of Engineers, 2000). The resulting frequency of spills is approximately once every three years. When water is spilled over Granite Reef Diversion Dam, the flow is typically sustained for several days or more and is of significant magnitude. Since 1965, there have been about two releases per year, and they have lasted an average of 22.5 days, with a peak mean daily flow of 13,960 cfs. The median predicted spill pattern at Granite Reef Diversion Dam has a peak discharge of 28,000 cfs, a 5-day average flow rate of 15,000 cfs, and a 10-day average flow rate of 10,000 cfs (U.S. Army Corps of Engineers, 2000).

Under historic natural conditions, flows peaked in late winter (February and March), supplied by storms and snowmelt. Flows were lowest in June, averaging only 6 percent of the mean high flows in February. Data for 1965 through 1993 show flows occurring most frequently during March and April and least frequently during July and August, much like the natural flow pattern. The system of dams upstream of the study area effectively delays the flows by one month. This delay becomes insignificant, however, compared to the overall effect on the length of periods without flow in a river that is perennial under natural conditions.

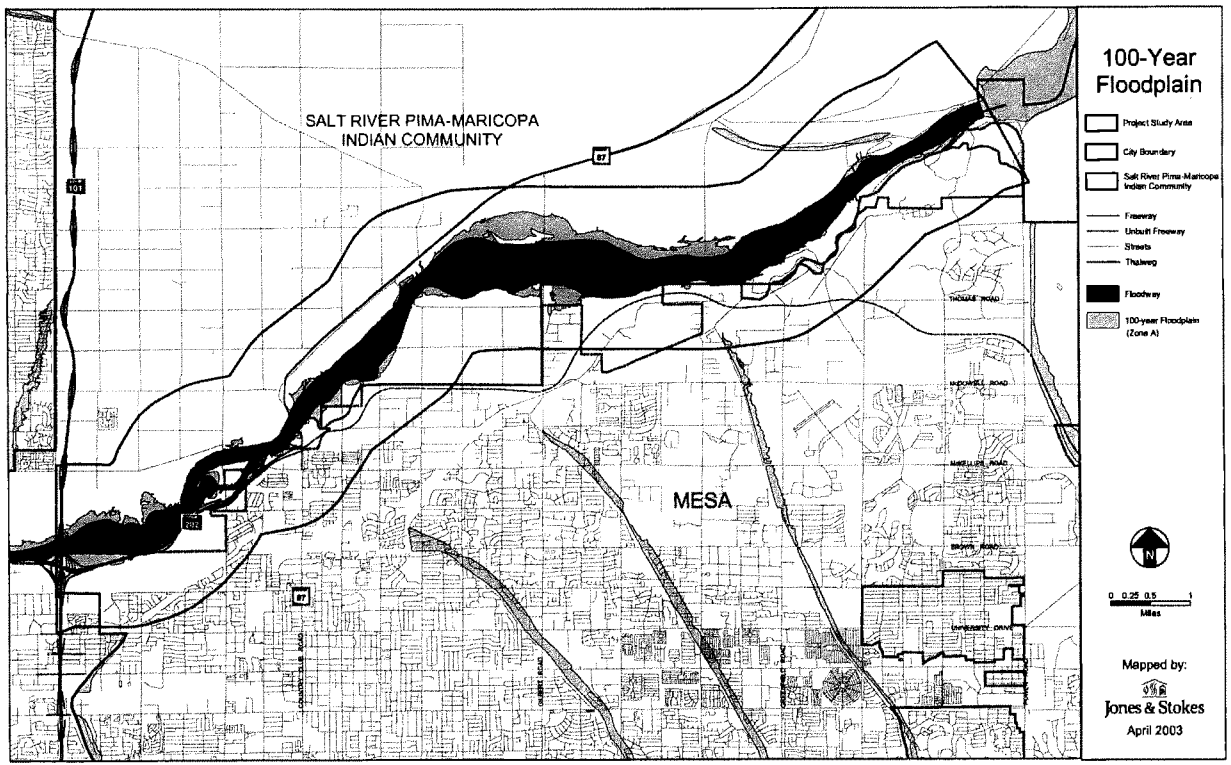
(b) Discharge Rates

During periods of serious flooding, large volumes of water are released from upstream dams and may cause flood damage in the study area. Recent damaging floods with flows exceeding 100,000 cfs occurred in the lower Salt River in 1978, 1980, 1983, and 1993. These floods resulted in damages to residences and agricultural areas in and around the study area. Figure 5 shows the limits of the 100-year floodplain within the study area.

Previous studies show that the magnitudes of peak annual discharges on the Salt River are comparable to those of peak flows before Bartlett Dam began operating, but high flows have occurred less frequently since 1938. The mean peak annual discharge was 32,000 cfs before 1938 and has been 16,500 cfs from 1938 to the present (Jones & Stokes, 2000). Since 1938, the peak discharge has been greater than 10,000 cfs in only a quarter of the years, whereas before 1938, flows exceeded 10,000 cfs in two-thirds of the years. Upstream dams have exacerbated the high-flow conditions that have occurred by delaying the release of runoff into the river. Prior to damming, a peak annual discharge greater than 100,000 cfs occurred in only one year on record, while three such flows have occurred in the past 22 years. Table 2 shows estimated flow values for various frequencies and durations within the Salt River at Granite Reef Dam and downstream in the Phoenix metropolitan area at Central Avenue (U.S. Army Corps of Engineers, 1997).

The peak 100-year flood flow at Granite Reef Dam is 175,000 cfs, which is slightly larger than what would occur in downstream reaches due to channel infiltration. The data also indicate that the 5-year frequency flow produces measurable flow in the channel downstream of Granite Reef Dam, but the channel would remain dry in the Phoenix area due to upstream storage in the watershed and channel infiltration.

Figure 5. 100-Year Floodplain within the Study Area



Although flooding is a natural and even vital process in natural riparian systems, it is of particular concern in downstream reaches of the Salt River because of the prevalence of saltcedar, an exotic nuisance species. Saltcedar is very effective at spreading into disturbed areas and can generally establish itself more rapidly than native riparian species with one exception. If flooding occurs during spring when cottonwood and willow are dispersing seeds, native vegetation can outcompete saltcedar whose germination period is May to September. As an example of this process, after the 1993 flood, additional native vegetation established itself in the river downstream of Phoenix.

Table 2. Frequency-Duration Values for the Salt River

Duration	Frequency (Years)						
	500	200	100	50	20	10	5
	Discharge (cfs) Exceeded for Specified Duration, Salt River at Central Avenue [1]						
Peak	240,000	202,000	166,000	135,000	87,000	53,000	20,200
1 Day	190,000	145,000	100,000	70,000	40,000	21,000	8,000
3 Day	100,000	75,000	60,000	40,000	22,000	11,000	3,500
5 Day	70,000	55,000	40,000	29,000	15,000	7,000	2,100
10 Day	46,000	33,000	25,000	18,000	10,000	5,200	1,500
30 Day	25,000	19,000	15,000	10,000	5,300	2,700	800
60 Day	14,000	9,000	7,000	5,000	2,800	1,400	(0) [2]
	Discharge Exceeded for Specified Duration, Salt River at Granite Reef Dam						
Peak	250,000	210,000	175,000	150,000	100,000	60,000	22,000

[1] Discharges exceeded for specified frequencies, with durations greater than or equal to 1 day, are approximately equal throughout the Rio Salado Project reach. Central Avenue is used as a reference location.

[2] During the 5-year event, the upstream release from the Salt River Project reservoirs does not last for 60 days. A flow rate of approximately 200 ft^3/s is exceeded for 53 days during this event. Results are based upon simulation of Balanced Hydrographs.

Source: U.S. Army Corps of Engineers, 1997

(c) Interior Drainage

Interior drains that discharge into the Salt River between Granite Reef Diversion Dam and the Pima Freeway (SR101) may have implications on a project. In general, there are two concerns for how these drains affect the project. The first involves potential damage to the restored habitat caused by high discharge velocities or frequent inundation. The

second consideration is that interior drains may provide a water source for habitat restoration.

Two types of interior drains were evaluated in this analysis: canal drains and storm drains. The interior drains were evaluated to assess the potential damage that their flows may cause to a habitat restoration project. A summary of the interior drains identified within the project area and their locations is provided in Table 3. Detailed information is presented in the Interior Drainage Appendix (Knight Piésold and Co., 2002a). In general, it is determined that the peak flow rates and discharge velocities from the interior drains are sufficient to create localized damage at the outlet of each drain. However, this damage is not expected to extend beyond the immediate vicinity of the pipe outlet. There is little evidence to suggest that flows from these drains have historically done more than wet the riverbed in the immediate vicinity of the drain outlet. Additionally, the maximum flow rates that could potentially discharge from these drains are significantly smaller in magnitude and occur less frequently than Salt River flood flows. The Salt River is expected to spill over Granite Reef approximately once every three years, and the 5-year peak discharge from these spills is expected to exceed 20,000 cfs (U.S. Army Corps of Engineers, 1998). In comparison to this, there is little advantage to providing extensive protection from the interior drainage discharge.

The interior drains were also evaluated to assess the potential for using these flows as a water source to support and nourish the restored vegetation. For this evaluation, these drains were each evaluated based on the quantity, reliability, and quality of flow that is or may be available for habitat restoration. The water source analyses are described in further detail in the Water Budget Appendix (Knight Piésold and Co., 2002c). The average monthly and annual volumes of water released from some of the interior drains are of sufficient magnitude to be considered as a potential water source. The three canal drains have historically supplied a significant amount of water to the Salt River. These drains, however, do not flow consistently, and releases into these drains may not be reliable. The Price Drain has historically supplied a relatively consistent flow to the river. However, long-term records are not available to measure this supply. The Evergreen Drain, Hennessey Drain, Tempe Drain, and Price Drain are all included in the water budget analyses.

Table 3. Summary of Interior Drains

CANAL DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Evergreen Drain	trapezoidal channel	23	T2N	R5E	Horne Road at Arizona Canal	Yes
Hennessey Drain	trapezoidal channel	28	T2N	R6E	Between Val Vista and Greenfield	Yes
Tempe Drain	trapezoidal channel	17	T1N	R5E	Between Dobson and Alma School	Yes
SRP Laterals	open channels	Throughout study area				No
SRPMIC Laterals	open channels	Throughout SRPMIC				No
RWCD Laterals	open channels	Outside of study area				No

STORM DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Price Drain	trapezoidal channel	18	T1N	R5E	East side of Price Road Freeway	Yes
Tempe Drain	trapezoidal channel	8	T1N	R5E	Between Val Vista and Greenfield	Yes
Price Road Freeway Local Drainage	72-inch pipe	18	T1N	R5E	West side of Price Road Freeway	No
Dobson Road Storm Drain	72-inch pipe	8	T1N	R5E	Along Dobson Road	No
McLellan Road Storm Drain	48-inch pipe	8	T1N	R5E	Along McLellan Road	No
Country Club/McKellips Storm Drain	72-inch pipe	4	T1N	R5E	Country Club Drive	No
Red Mountain Freeway Local Drainage	N/A	Along Red Mountain Freeway				No
Natural Drainage	N/A	East of Gilbert Road				No
Alma School Storm Drain	60-inch pipe	5	T1N	R5E	Alma School Road	No

Source: Knight Piésold and Co., 2002a

4.2.2.2 Surface Water Quality

Contaminants in the surface waters and groundwater of Arizona fall into seven categories: volatile organic compounds (VOCs), pesticides, metals, nutrients, ions, microorganisms, and radiological substances. Water quality issues exist for all water sources in the lower Salt River, namely contamination by VOCs and various metals, ions, nutrients, and herbicides. As previously discussed, surface water naturally provides the main source of recharge for groundwater. Shallow groundwater in other reaches of the river often emerges in the channel, creating surface flows. Effluent from wastewater treatment plants (WWTPs) and other industries contribute to both surface and subsurface flows. Thus, contaminants do not remain in one part of the system and may affect all water sources.

The quality of water from storm drains varies depending on the length of time between storm events, the amount of flow, and the source of storm water runoff. Runoff often contains a significant amount of sediment that is washed from undeveloped land and other sources, as well as chemical contaminants or pollutants. The types of chemical pollutants would vary depending on the land uses within the particular drainage area. Potential water quality impacts associated with runoff from industrial sites are projected to be minimal because the compliance requirements of storm water NPDES permits require each industrial site to have a storm water pollution prevention plan (SWPPP). Runoff from turf areas has the potential to contain pesticide and fertilizer residuals. Runoff from paved areas can contain hydrocarbon products, metals, and anything spilled on the pavement (Jones & Stokes, 2002).

Flows in the Salt River originating upstream of the project area are generally of good quality. However, local Salt River flows maintain high amounts of mineral content and total dissolved solids (TDS). When flood flows do occur, they can contain pollutants of concern derived from tributary stream inflow, erosion of sediments, and landfills. Large quantities of water in flood flows can dilute the concentration and transport the contaminants through the study area downstream areas. However, there is very little information on the chemical constituents in flood flows (Jones & Stokes, 2003).

The Salt River water contains a sodium chloride character both above and below the SRP system dams due to salt springs upstream of the lakes. Verde River water has a lower amount of TDS than found in the Salt River water, so it tends to dilute higher TDS concentrations from the Salt River when the flows combine. The quality of water would

be sufficient to support native fish species if historic base flows were still available within the river. However, local stormwater entering the Salt River at numerous locations in the study area has the potential to degrade the surface quality of water in the system due to the contaminants listed in Table 4. Additional water quality data can be found in the EIS.

Table 4. Types of Water Contaminants in the Lower Salt River

Contaminant Category	Principal Contaminants	Typical Sources	Potential Health Impacts
Volatile organic compounds (VOCs)	Organic solvents Trichloroethene (TCE) Tetrachloroethylene (PCE) 1,1,1 Trichloroethane (TCA) Chloroform 1,1 Dichloroethane (DCE) 1,1 Dichloroethane (DCA) Benzene	Landfills Underground storage tanks Airports High technology industry	Carcinogen
Pesticides	Dibromochloropropane (DBCP) Ethylene dibromide (EDB)	Agriculture (soil fumigants) Urban runoff	Toxics Carcinogen
Metals	Arsenic Barium Boron Chromium Copper Iron Lead Manganese Selenium Zinc	Landfills Mines Metal finishing Natural origin	Toxics Carcinogen
Nutrients	Nitrate	Agriculture (fertilizers) Wastewater treatment Septic tanks Industrial manufacturing	Methemoglobinemia (blue-baby disease)
Ions	Total dissolved solids (TDS) Sulfate Chloride Fluoride	Mines Agriculture Natural origin	Taste, hardness Laxative effect Toxics
Micro-Organisms	Fecal coliform	Septic tanks Wastewater treatment	Infectious disease
Radiological		Mines Natural origin	Carcinogen

Source: Graf, *et al.*, 1994

Concentrated animal-feeding operations (CAFOs) can produce very poor quality runoff if the site drainage is not controlled. Animal wastes can drain from the site into storm drains or irrigation systems, including both water supply laterals and drainage canals. The principal pollutant of concern from such operations is nitrate. Bacterial pathogens and other microbiological pollutants, biochemical oxygen demand (BOD), total suspended solids, and nutrient loads can also be generated at a CAFO site. CAFO sites are not located within the Salt River channel; however, uncontrolled runoff from CAFO operations can enter the Salt River through canals and storm drainage systems adjacent to the river and within sub-area watersheds.

Regulations are in place to require control of CAFO discharges by means of an agricultural general permit of the Arizona Aquifer Protection Permit program (Arizona Administrative Code, Title 18, Chapter 9, Article Z [R18-9-201 to 203]). CAFO discharges are also regulated through NPDES permits under the Clean Water Act. The NRCS has a pilot program to provide funding to control CAFO discharges at selected sites.

4.2.2.3 Groundwater Hydrology

Groundwater resources are most affected by geologic conditions that determine infiltration capacity, water-bearing characteristics, confinement boundaries, and subsurface flow. As discussed in the Geology Section, the Salt River Valley lies within the basin and range physiographic province and is characterized by broad alluvial valleys separated by rugged mountains. The valley is underlain by a wide variety of unconsolidated to variably consolidated sedimentary deposits that are several thousand feet thick in places. The sediments include unconsolidated clay, silt, sand and gravel, caliche, gypsum, mudstone, siltstone, sandstone, conglomerate, and anhydrite. Discontinuities in lateral lenses and interbedded deposits may exist in older units where high-angle faults exist. Rainfall on the valley floor is generally insufficient to contribute to groundwater recharge (U.S. Geological Survey, 1991).

Groundwater is regulated by the Arizona Department of Water Resources (ADWR), and the groundwater basin underlying lower Salt River Valley is identified as the Phoenix Active Management Area (AMA). The Phoenix AMA comprises two distinct but interconnected alluvial groundwater basins: West Salt River Valley (WSRV) and East Salt River Valley (ESRV). These two units are divided by subsurface geologic outcroppings located near Priest Road in Tempe. Both basins generally comprise three

separate hydrogeologic aquifer-layer units. The USBR, the USGS, and ADWR have independently identified these units, although the descriptions and nomenclature used by these agencies differ slightly. The three hydrogeologic units are (1) the Lower Alluvial Unit (LAU), (2) the Middle Alluvial Unit (MAU), and (3) the Upper Alluvial Unit (UAU). Groundwater within the aquifer units is generally unconfined. Composed mainly of deposits of gravel, sand, and silt, the UAU typically ranges in thickness from 100 to 300 feet under the Salt River but thin out at contacts with exposed bedrock. The unit is thinnest near mountain fronts and bedrock outcrops, such as Tempe Butte and lower Papago Park. The MAU is overlain by the UAU and comprises mainly of clay, silt, and mudstone with some interbedded sand and gravel especially developed near margins of the basin. The LAU underlies the MAU and consists mainly of conglomerate and sand near basin margins and mudstone and anhydrite distal from edges of the basin. Volcanic rocks are interbedded within the stratigraphic section (Knight Piésold and Co., 2002b). Historically, surface flows from streams and washes provided most of the water that recharges the UAU. Presently, minor recharge sources such as seepage from canals and irrigated land, underflow along major streams, and rainfall have become more important.

(a) Groundwater Depths

Depth to groundwater has fluctuated greatly since development of the Salt River Valley began in the late 1890s, as demonstrated below in Table 5. Initially, diversion of water from the river for irrigation led to a rise in the water table. Canal seepage locally raised the water table as much as 20 feet above the natural water table. As development proceeded, groundwater became an important water source for agriculture. More than 75 percent of the pumped groundwater in the Salt River Valley is now used for agriculture. Drought conditions and pumping between 1895 and 1905 caused a decline in the well levels of 8 to 20 feet in the Mesa-Tempe area. The water table declined steadily from the 1930s into the 1960s as a result of increased pumping. Long-term groundwater withdrawal since the 1940s has resulted in a general decline in water levels from 200 to 300 feet throughout the Phoenix Basin. However, water-level declines have usually been less than 50 feet near the Salt River. The magnitude of declines varied spatially from a few feet in some places to a few hundred feet in others. Where shallow bedrock forces water to the surface, depth to groundwater is only 10 to 30 feet greater than in the early 1900s. Figure 6 presents the depth to groundwater contours for the project area.

Table 5. General Depths (feet) to Groundwater near the Lower Salt River

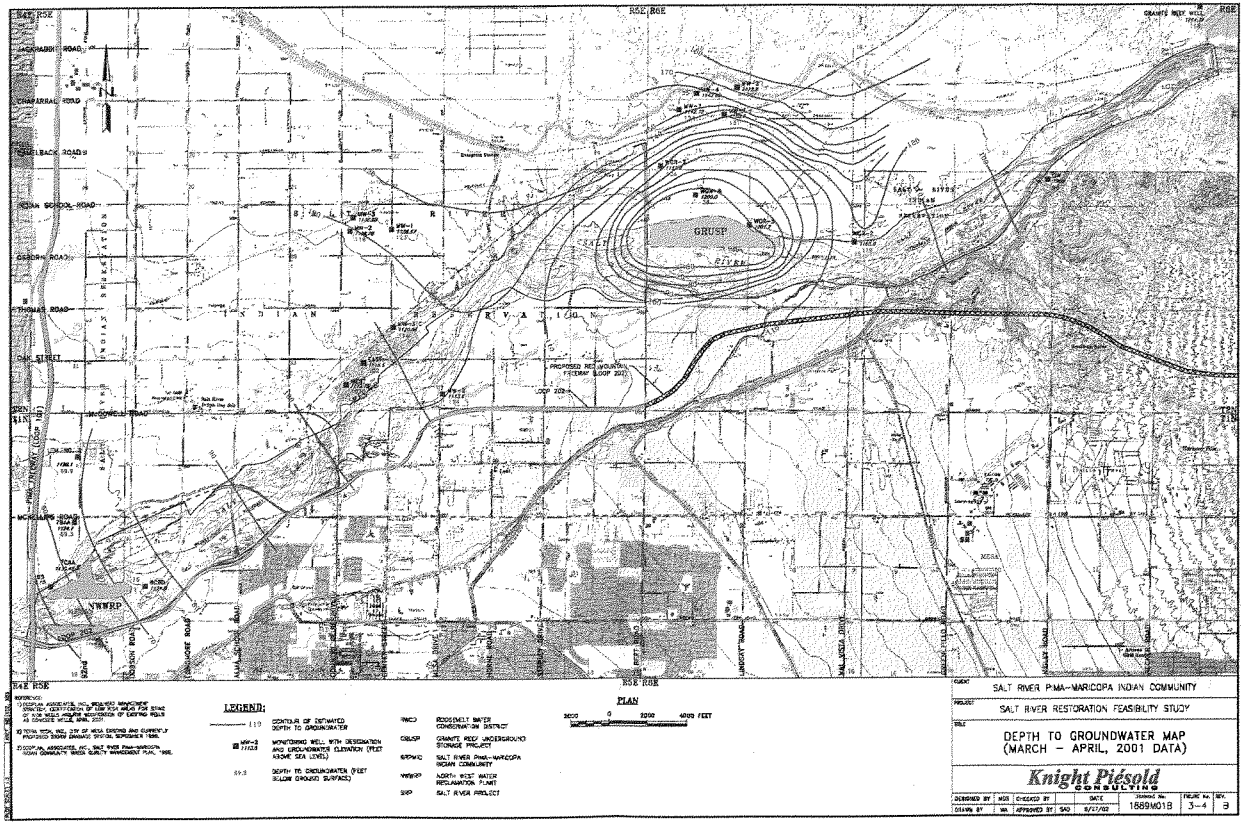
Year	Granite Reef Dam to McKellips Road	McKellips Road to Mill Avenue	Mill Avenue to I-10	I-10 to 23rd Avenue	23rd Avenue to 91st Avenue	91st Avenue to Agua Fria River
1900	0–40	0–10	0–40	ND	ND	ND
1913	10–50	0–10	0–10	0–10	0–10	0–10
1945	50–150	0–50	0–10	10–50	10–50	0–10
1952	100–140+	20–80	40–60	40–60	20–40	<20–40
1964	ND	ND	ND	80–100	60–80	40–60
1972	ND	ND	ND	60–80	40–60	<20–40
1986	190–250	90–140	10–60	ND	ND	ND

ND = no data.

Sources:
1900 and 1986: Thomsen and Miller, 1991
1913 and 1945: McDonald, *et al.*, 1947
1952: Wolcott, 1952
1964 and 1972: U.S. Bureau of Reclamation, 1976

During the 1980s, pumping of groundwater declined in the Salt River Valley. Data for seven wells along the Salt River for 1987 through 1992 indicate that, while recent groundwater levels have not exhibited a distinct upward or downward trend, they have fluctuated considerably. Depth to groundwater decreases downstream, from an average of approximately 260 feet near Granite Reef Dam to less than 10 feet near Buckeye. For the period from 1987 to 1992, upstream water levels fluctuate the most from year to year, on average 7 to 19 feet, and exhibit the greatest range in levels.

Figure 6. Depth to Groundwater Map



The groundwater flow direction is predominantly east to west in both the ESRV and WSRV, although withdrawals have affected the flow of groundwater and even reversed its direction from historical patterns in some cases. In the ESRV, groundwater flows from the Salt River towards cones of depression located north of the Santan Mountains, east of Mesa, and in the Scottsdale–Paradise Valley area. In the WSRV, groundwater flows from the Salt River toward a major cone of depression near Luke Air Force Base, approximately 15 miles west of Phoenix. To a lesser extent, groundwater also flows in a northwestward direction toward a second cone of depression in the Deer Valley area. Drawdown in the Deer Valley and Queen Creek areas in the 1940s and 1950s caused groundwater to flow away from the Salt River rather than toward it. The Deer Valley low persisted into the 1980s, at which time the extensive low near Luke Air Force Base in the WSRV became more prominent. Before these pumping effects began, the movement of water toward the river channel and flow within the channel created a mound of groundwater under the channel, which was accessed by a variety of riparian plants. Deflecting flow away from the river contributes to the water-table decline near the river and reduces the groundwater mound.

Groundwater is a significant controlling factor in the location and survival of phreatophytic vegetation and its associated wildlife populations. Knowledge of the subsurface water level at a riparian site may be critical to interpretation of vegetation data and can be a valuable monitoring tool.

According to the ADWR well registration database, dated July 2001, depth to groundwater in the project area varies from around 10 to 440 feet below ground surface. Local drainage features that may alter or influence the groundwater depth and flow direction include wastewater treatment recharge ponds, Granite Reef Underground Storage Project (GRUSP), quarry operation distribution ponds, water well pumping, and canals.

(b) Groundwater Modeling

To guide development of habitat and riparian restoration along the Salt River, a numerical groundwater model of the Salt River Restoration Feasibility Study project area was developed. This model was constructed to specifically evaluate how groundwater levels have changed over time by modeling and calibrating the steady state conditions, as a basis for prediction and feasibility assessment of future changes in response to the with-project alternatives. The groundwater model for the study was developed by refinement

of the regional ADWR numerical (3D MODFLOW) groundwater model (Corell and Corkhill, 1994). The ADWR model covered an approximately 2,240-square-mile area within the Phoenix Active Management Area, including a major portion of the Salt River Valley. Its purpose was, in part, to provide a regional framework upon which groundwater management scenarios could be tested. The model incorporated grid-cells of one square mile. This grid was refined to be more site specific so that it now represents a subdivision of the regional grid in the area of interest into cells of $^1/_8$ x $^1/_8$ mile dimension.

The refined model encompasses approximately 85 square miles centered on the Salt River. The model area extends from the Pima Freeway (SR101) (the R4E-R5E boundary) on the west to the area of intersection of the Salt and Verde Rivers on the east-northeast. At the south edge, the model area occurs approximately 5 miles south of and generally parallel to the Salt River channel. Along the north edge, the model area generally follows the T2N-T3N boundary and includes much of the SRPMIC. The model created for this area has been developed through refinement of the model grid, model layers, vertical leakage, recharge, compilation of wells, and assessment of boundary conditions as defined in the ADWR regional model. The recharge component in the model relates to several aquifer recharge sites within the study area. In the model, rates of recharge are related to land use. Three primary sites of focused recharge include:

- *GRUSP:* The GRUSP represents an aquifer recharge system where canal surface water is recharged to the UAU aquifer through approximately 135 acres of recharge basins operated by the SRP.
- *Wetlands below Granite Reef Dam*: Recharge is also considered within the refined model to occur in wetlands immediately down gradient of the Granite Reef Dam in the vicinity of T2N, R6E, Section 13. This represents infiltration of leakage through the dam.
- *Northwest Water Reclamation Plant (NWWRP) Ponds:* Infiltration of treated wastewater effluent from the NWWRP occurs through percolation ponds or directly into the adjacent Salt River channel near the southwest end of the model area, near the interchange between the Pima and Red Mountain Freeways. Two sets of ponds occur including:
    - Five ponds operated by the SRPMIC located north of the Salt River
    - Four ponds operated by the City of Mesa located south of the Salt River.

Based on available records (Haws, 2002; Lluria, 2002; Corell and Corkhill, 1994), the current annual rates of recharge at these three sites of focused recharge are shown in Table 6.

Table 6. Annual Recharge Rates

Site	Recharge Rate (ac-ft/yr)
GRUSP	90,000
Granite Reef Wetland	475
NWWRP	18,000

In addition to sites of focused recharge, aquifer recharge in the model is also considered to occur from irrigation, with rates dependent on land use. Three categories of land use are defined in the model: (1) urban, (2) agricultural, and (3) mixed agricultural and residential. Urbanized land use occurs primarily south of the Salt River Channel and immediately west of the SRPMIC in the cities of Mesa, Tempe, and Scottsdale. Agricultural land with heavy irrigation occurs in the southeast end of the model area, and within the SRPMIC north of the Evergreen Canal. Land immediately north of the Salt River channel in the western portion of the Community is used primarily for mixed agricultural/residential use.

Based on the available records (Corell and Corkhill, 1994), the annual rates of recharge used in the model are shown in Table 7.

Table 7. Recharge Rates Used in Model

Site	Recharge Rate (ft/yr)
Urban	1.00
Agricultural	1.87
Mixed Agricultural/Residential	0.94

Effectively no recharge activity has occurred during the model period 1998 through present within the channel of the Salt River itself (except for recharge associated with the NWWRP), as the river channel is dry in the area of interest. Also, no infiltration is considered within natural open space areas.

4.2.2.4 Groundwater Quality

At present, all of the Hazardous and Toxic Waste (HTW) contamination to the groundwater within or near the project has been attributed to VOCs leaching into the groundwater. VOC leaching has occurred from either mismanaged storage, pumping into groundwater, or improper dumping of VOCs and related chemical compounds at Superfund sites located within or near the project boundaries. VOCs have been detected within the UAU and MAU, but not the LAU or Red Unit. There is no direct evidence that surface water recharge from the Salt River has contaminated the three alluvial aquifers with HTW unless such recharge has been associated with the Superfund sites (U.S. Army Corps of Engineers, 2000).

4.2.3 Water Budget and Sources Analyses

In streams in the western United States, almost all the water is fully appropriated for a wide range of uses outside the stream channel, such as irrigation and municipal water supplies. However, the presence of water within streams is now recognized as having an important value. Most natural resource values in riparian areas derive either directly or indirectly from streamflow conditions. Direct benefits derive from the existence of surface water in channels and include such things as aquatic habitat, wildlife drinking water, recreation water, and aesthetics. Examples of indirect benefits include moist riparian soils, which in turn support water-dependent vegetation, and habitat benefits associated with the morphology and physical composition of channels and floodplains.

The water budget within the study area consists of various types of inflows, outflows, and consumptive uses. Table 14, presented at the end of this section, presents a summary of the analyses.

4.2.3.1 Inflows/Water Sources

The success of any habitat restoration project is largely dependent upon the amount and quality of water that is available to sustain project features and activities. A sufficient and reliable source of suitable water must be developed to support the aquatic, wetland, and upland plant habitat that historically existed in the study area. Several potential water sources were identified for the Va Shly'ay Akimel study area. Two of these involve groundwater resources, while the remaining six involve primarily surface water. The identified potential groundwater and surface water sources are summarized below (Table 8).

Table 8. Potential Sources of Water

Groundwater	Surface Water
- In-situ groundwater	- Salt River flood flows
- Pumped groundwater	- Stormwater discharges
	- Effluent, irrigation return flows
	- Canal drains
	- Discharges from sand and gravel mining operations
	- SRP water

Each source is assessed based on various factors, including the quantity, reliability, and quality of flow available for habitat sustainability. In general, the sources were classified into the following four categories.

- *Dependable source.* A source is dependable if it is available on a continuous basis to meet the water demands of the habitat area and has acceptable water quality. Dependable sources constitute the baseline water supply.

- *Supplemental source.* A source may be considered supplemental if it is available to augment the dependable baseline source. This could include infrequent and unreliable flows that can be put to beneficial use when they are available but cannot be relied upon as a dependable base flow. The supplemental flow must also have good water quality.

- *Problem Source.* Problem sources must be accounted for but may not be suitable as a water supply for the Salt River Restoration Project. These flows may inhibit the restoration project by potentially damaging restored vegetation or hindering the water quality within the Salt River.

- *Unacceptable Source.* A source is considered unacceptable if it has poor water quality or is not desirable for riparian habitat restoration.

In this report, water rights are discussed as related to the SRPMIC and as related to non-Indian lands. The difference is that water rights established by the State of Arizona do not apply to the SRPMIC lands, but Federal water rights and court adjudications do apply. Non-Indian lands are subject to state water rights, Federal water rights, and court adjudications.

In the analysis of potential water sources below, each section relates the water source to the following topics:

- Description of source
- Quantity analyses
- Quality analyses
- Water rights
- Assessment of source

(a) In-Situ Groundwater

Description of Source

In-situ groundwater is defined as groundwater that can be utilized, in place, by riparian vegetation. For this to occur, the groundwater table must be within the root zone depth of the desired plant species. The depth to groundwater, as well as the water table fluctuations, is an important factor for establishing and maintaining riparian habitat.

In a few areas downstream from Granite Reef, the water table is still sufficiently close to the surface so that riparian vegetation can access this water through its root systems. These habitat areas in the Salt River suggest that in-situ groundwater may be a potential source of water for a project. Figure 7 shows the Salt River upstream of Granite Reef; this area is similar to the historical conditions throughout the Salt River Valley.

Figure 7. Salt River Upstream of Granite Reef

Quantity Analyses

The water table is variable throughout the study area and is impacted by both hydrogeologic and anthropogenic factors. One of these anthropogenic factors is Granite Reef Dam. The dam was constructed to divert Salt River water into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the study area. Although not intended to be a storage reservoir, this dam incidentally retains some water at all times.

Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP has reported that water seeps through the radial gates because they do not form a tight seal with the granite bedrock. The result is a continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records. Figure 8 shows the seepage downstream of Granite Reef.

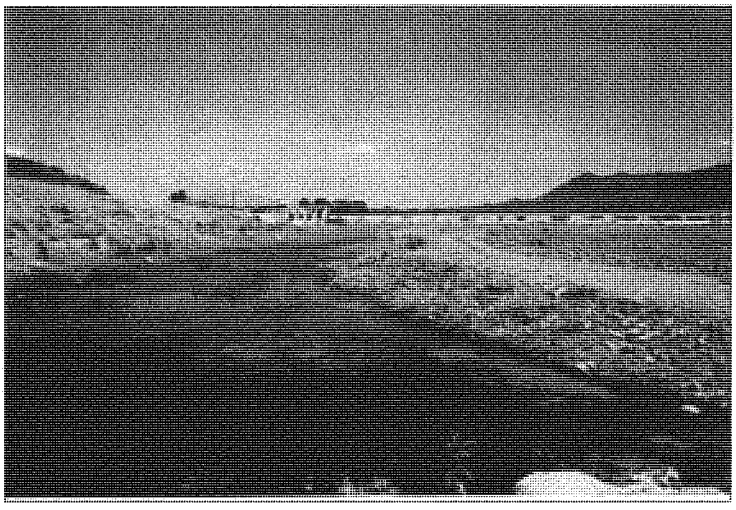


Figure 8. Seepage Downstream of Granite Reef

The local geology maintains this seepage as a surface flow. A bedrock shelf overlain by a veneer of sedimentary materials extends downstream from the dam. The seepage is sufficient to saturate these alluvial sediments to maintain a continuous surface flow. This flow has been sufficient to establish and support abundant wetland vegetation. In addition, areas of open water provide riparian and aquatic habitat. This pattern continues for approximately one mile downstream. The existing wetland areas are shown on Figure 9. Figure 10 shows the wetlands areas that extend for approximately one mile downstream from the dam.

The depth to bedrock shelf rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream. As the bedrock depth increases, the surface flow that supports wetland vegetation upstream becomes subsurface water. Regional groundwater pumping has resulted in a general lowering of the water table throughout the area. In addition, dams located on the Verde River and Salt River upstream prevent perennial flow in the river channel and limit natural recharge. The result is that the general groundwater depth beneath the Salt River ranges from 60 to 80 feet below the surface for the majority of the study area (Knight Piésold, 2002a). Figure 11 shows the Salt River near Greenfield Road.

Figure 9. Water Budget Map

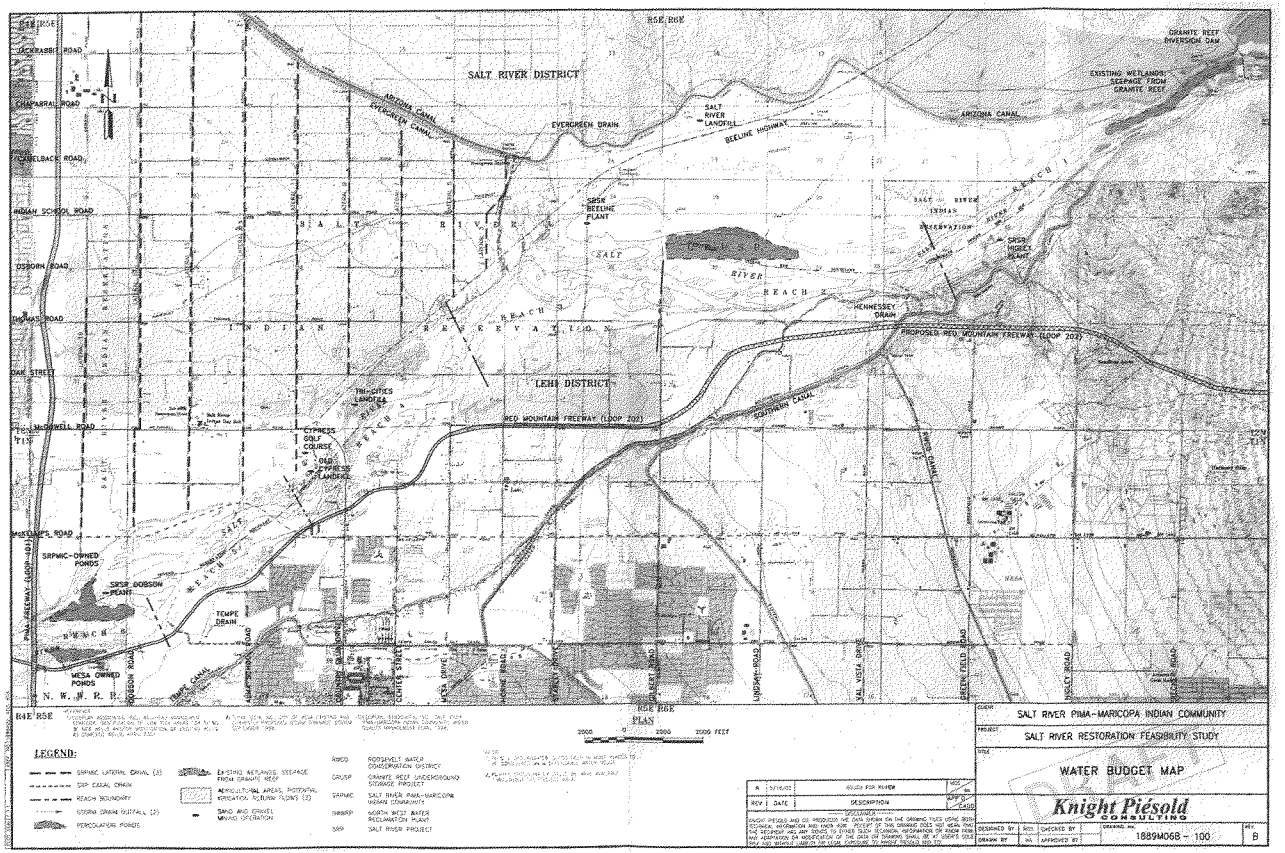


Figure 10. Wetlands Downstream of Granite Reef

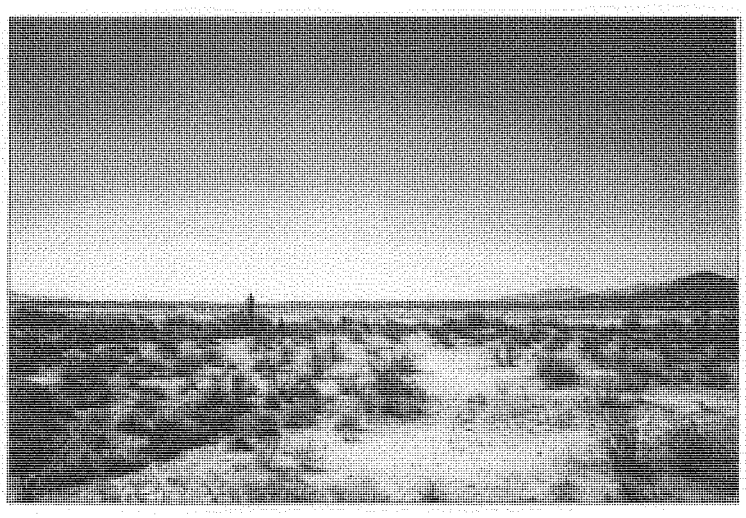


Figure 11. Salt River near Greenfield Road

There are two groundwater recharge projects in the study area that have local impacts on the groundwater table. Toward the downstream end of Reach 2, SRP is recharging water into the upper alluvial aquifer through the GRUSP. SRP is recharging nearly 90,000 ac-ft of water annually. These recharge ponds encompass an area of approximately 216 acres.

Their recharge permit allows them to recharge as much as 200,000 ac-ft/yr; however, this rate would produce a groundwater mound that could impact other facilities. SRP has to limit the amount of water recharged in order to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87. This results in a water level that is about 50 to 60 feet below the river channel in the immediate GRUSP area. The GRUSP site is shown on the Water Budget Map.

The second recharge project is located near the downstream end of the project area. At this site, effluent from the NWWRP, which is owned and operated by the City of Mesa, is being discharged into a series of recharge ponds where the effluent is allowed to infiltrate into the Salt River sediments. An average of 3,300 acre-feet of water has been recharged annually into these ponds. The SRPMIC owns five ponds on the north side of the river totaling 75 acres. These ponds have received an average of 330 ac-ft of effluent each month since their establishment in May 2001. Mesa owns four ponds on the south side of the river totaling 27 acres; these ponds have received an average of 140 ac-ft of effluent each month since January 2000. The groundwater mound that results from this recharge raises the local water table in this area to within 50 to 60 feet below the river bed. The NWWRP and the percolation ponds are shown on the Water Budget Map.

Quality Analyses

Long-term irrigation practices and landfills within the Salt River Valley have historically influenced water quality in the upper alluvial aquifer. High salinity, chloride, and nitrate concentrations were occasionally found in the shallow groundwater near irrigated or formerly irrigated areas. Also, some landfills have historically caused elevated levels of volatile halocarbons. More recently, the SRPMIC has developed a water quality management plan to protect and enhance surface water and groundwater quality (EcoPlan, 1997; 1998). Since groundwater quality monitoring began in the 1980s, the water quality has significantly improved. Monitoring results from the first quarter of 2002 indicate that maximum contaminant levels for volatile halocarbons were not exceeded in any of the sampled wells (Schmidt and Associates, 2002). In addition, the concentrations of many volatile halocarbons were the lowest since monitoring commenced. It should also be noted that there are no Superfund sites within the study area. In-situ groundwater is generally suitable for agricultural uses and should be adequate for a project.

Water Rights

The SRPMIC owns and controls the groundwater beneath their land as agreed in the Water Rights Settlement Agreement of 1988. The SRPMIC is not governed by state water rights. The Federal government has established this right and has restricted pumping on non-Indian lands to prevent groundwater withdrawals from beneath the SRPMIC lands. SRPMIC groundwater use is also restricted through the Water Rights Settlement Agreement of 1988. Groundwater beneath the non-Indian lands is a state resource, and use is regulated via several groundwater rights and pumping permits.

Consumptive use of groundwater by vegetation (in-situ groundwater) is not included in state groundwater rights categories. There are no water rights to define or restrict the direct use of groundwater by vegetation for habitat restoration projects in central Arizona. In-situ groundwater, when available, can be used as a part of a restoration project water supply.

The seepage at Granite Reef is surface water and, until it percolates into the ground, could be subject to surface water appropriation rights. If this seepage flow is diverted before it percolates and used as a part of the water supply for a project, it is possible that a downstream water user with rights to Salt River flow could protest. A claim by downstream water users would be difficult to uphold because all of the seepage percolates into the ground about one mile downstream from the dam and is currently not available for diversion by downstream water users. If this water were used as a part of a project, it probably would be channeled to support vegetation along the north and south river banks just downstream from the dam, rather than being diverted and delivered to a location further downstream. The channelization is not a diversion and may not be subject to water appropriation regulations. In general, the use of the seepage flow to support in-stream vegetation does not appear to be contrary to existing water rights.

Assessment of Source

In-situ groundwater can provide a reliable source of water for the area immediately downstream from Granite Reef. In this area, seepage from the dam forms a local perched water table near the surface. Currently, wetland plant species are growing along this reach of the river and extend for approximately one mile downstream. This source of water could be used to restore native riparian vegetation in this area. This local supply is considered a dependable water source for Reach 1.

For the remaining study area, in-situ groundwater would not provide a reliable source of water. The intent of a project would be to restore habitat areas for cottonwood, willow, and mesquite trees; these species require that the depth to groundwater be less than approximately 30 feet for survival. The depth to groundwater, however, exceeds 60 feet for most of the remaining area. In-situ groundwater is considered to be an unacceptable source of water for the remainder of the study area.

(b) Pumped Groundwater

Description of Source

Pumped groundwater is groundwater that lies below the root zone of the desired vegetation and must be pumped to the surface to be utilized. After the water is pumped to the surface, a distribution system must be developed to deliver this water to certain areas of the habitat restoration project. There are several legal and institutional implications that pumped groundwater could have for a project.

Quantity Analyses

Groundwater in sufficient quantity to supply water wells is present throughout the majority of the study area. This is demonstrated by the location and number of existing wells. Some of these wells are shown on the Water Budget Map. The only area where groundwater is not present in sufficient quantity to supply a well is the initial two miles of the Salt River downstream from Granite Reef. Bedrock is shallow in that area, and the saturated sediments may not contain sufficient water to maintain well pumping.

Pumped groundwater can be provided using existing wells or new wells. The advantage of using an existing well is that the costs associated with constructing the well have been committed. The constraint is that the location of some wells requires construction of a distribution pipeline and may require a booster pump. The advantage of drilling a new well is that it could be located at a point within a project to minimize distribution pipeline costs. The constraints are the costs associated with constructing a new well and meeting the state regulations if the new well is located on non-Indian lands.

Pumped groundwater is available on a continuous basis and, in sufficient quantity, could provide a dependable supply of suitable water for a project. One implication of using pumped groundwater is the impact that this pumping may have on other nearby groundwater wells. The SRPMIC has flexibility in using groundwater as a source for the

project. For the City of Mesa, the primary impact of using groundwater would be that all pumped groundwater that is committed to this project would have to be replaced in the City's water portfolio with another water source to maintain the City's assured water supply designation.

Quality Analyses

Groundwater quality varies somewhat throughout the upper, middle, and lower alluvial units with the highest quality found in the lower units. As stated above for in-situ groundwater, groundwater from all alluvial units is generally suitable for agricultural purposes and is expected to be adequate for a project.

Water Rights

The SRPMIC regulates pumping of groundwater from beneath its land. They control where wells may be drilled and for what purposes groundwater may be used. The SRPMIC could permit the use of water from existing wells or the drilling of new wells to supply a project. However, the SRPMIC is restricted in the quantity of groundwater it can pump and the total quantity of water it can use in any year through the Water Rights Settlement Agreement of 1988. This means that the SRPMIC can commit pumped groundwater to a restoration project but may need to reduce water use for another purpose.

Similar to SRPMIC, the City of Mesa is also restricted in its ability to use groundwater. Under the Groundwater Management Act, the City of Mesa must maintain an Assured Water Supply designation. The City has already committed all available groundwater resources to maintaining this designation. This means that if the City were to meet any of its pumped groundwater to the restoration project, the City would have to purchase other water to replace the groundwater in its water portfolio.

Assessment of Source

When the physical availability of pumped groundwater is considered, it is a dependable or supplemental water supply. There are no projections that the aquifer would be depleted, and water rights do not prevent its use for a project. However, institutional commitments by the SRPMIC, Mesa, or SRP must be made to allow groundwater pumping.

(c) Salt River Flood Flows

Description of Source

The Va Shly'ay Akimel study area is downstream from Granite Reef, which is below the confluence of the Salt River and the Verde River. In the past, as previously mentioned, both rivers were perennial with consistent flow rates. The construction of dams and water storage reservoirs upstream allowed for the development of water resources to supply water for irrigation and urban use in the Phoenix Valley. Most of the time, all of the flow in the Salt River is diverted at Granite Reef into the Arizona Canal and Southern Canal. The riverbed downstream is typically dry. Figure 12 shows the Salt River at Alma School Road.

Figure 12. Salt River at Alma School Road

The river, however, is still subject to floods because the reservoirs on the Verde River have no dedicated flood capacity, and only one of the four reservoirs on the Salt River has flood capacity. Due to the design of the dams, only limited flows can be released in anticipation of floods. When the water level reaches the spillway at Granite Reef, substantial quantities of water are released, causing the downstream reaches of the Salt River to flood.

Quantity Analyses

The river downstream of Granite Reef can be dry for long periods. For example, the Salt River flooded in 1941 and then was dry until it flooded again in 1966. The next flood occurred in 1973. The periods from 1978 to 1984 and from 1991 to 1995 were wet periods. Since 1995, there have been no flood releases. Figure 3-1 in the Interior Drainage Appendix (Knight Piésold and Co., 2002a) summarizes historic releases at Granite Reef (Tres Rios River Management Plan Water Supply Technical Committee, 1997). This information demonstrates that, in the past, flood flows were more frequent and of less magnitude. Changes in the watershed and construction of additional dams have changed the pattern of flooding. Most of the largest recorded floods have occurred since 1978. Figure 3-1 also demonstrates that there is no pattern to the frequency, duration, or magnitude of the flood flows.

Quality Analyses

The Tres Rios River Management Plan Water Quality Technical Committee (1998) reviewed the water quality records for the Salt River and focused on the Granite Reef sampling location. That study found no chemical water quality issues associated with Salt River water. However, during flood periods, sediments represented a water quality problem; the sediment load exceeded the standard established for the designated uses of the river. However, the problem was not because the sediments represented contamination. There are no known water quality issues that would prevent flood flows from being used as a water source for a project (Knight Piésold and Co., 2002c).

Water Rights

Salt River floodwater is subject to surface water rights for diversion. A right filed with the state or established by adjudication is required. However, during a flood, all diversion rights are typically fulfilled. Generally, all water demands are diverted into the two canals at Granite Reef; a flood typically represents surplus water. Consequently, in order to encourage its use, SRP does not charge water users a fee to use Salt River floodwater.

Assessment of Source

Flood flows do not occur on a regular basis or in predictable quantities; therefore, they do not represent a dependable water source. While the water may be available, it may be difficult to incorporate flood flows into a project. Flood flows do represent a supplemental source because they recharge the groundwater and replicate historic conditions in the river. Aquifer recharge is an indirect use of flood flows. During or shortly after a flood, it is possible that the water table would rise to the point where the vegetation roots can access it. However, when the flood subsides, the water table will return to depths greater than the root zone.

Flood flows have additional benefits to the natural habitat of the river. Small flows will saturate the soils and spread seeds to encourage the seedling germination and development of cottonwood and willow trees. Moderate flood flows will remove some vegetation and maintain open areas in the river channel. The removal of vegetation is a natural occurrence in river systems. These flows can also redistribute sediments in the channel and help to replace nutrients in the riverbed soils.

Large floods, on the other hand, represent a problem source. The magnitude of these flows can damage restored habitat areas, degrade the reconstructed channels, and deposit excessive amounts of debris throughout the project. The peak flow in the vicinity of the study area on the Salt River occurred during the 1980 flood event at Jointhead Dam in Phoenix, AZ. The peak discharge was estimated at 170,000 cfs. This flood caused extensive damage in the Salt River Valley. Flows of this magnitude are neither predictable nor preventable.

(d) Stormwater Discharges

Description of Source

Stormwater discharges represent runoff from urban and rural areas due to rainfall events. In general, stormwater can enter the Salt River through defined outfall points from stormwater drainage systems or as overland flow runoff from areas immediately adjacent to the river, as shown in Figure 13.

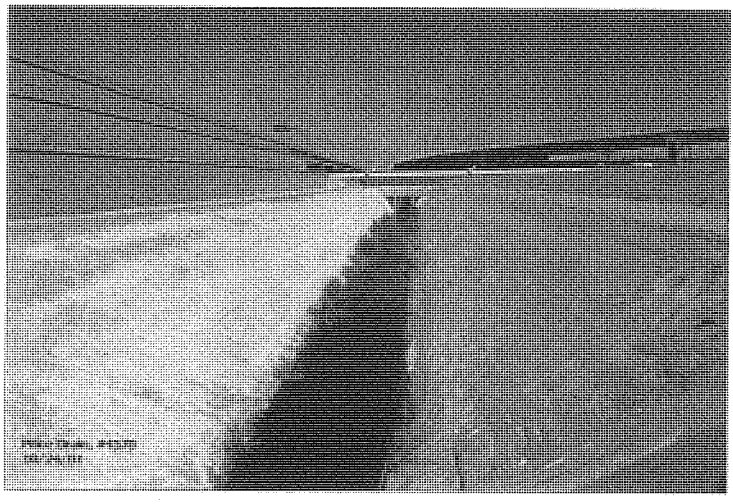


Figure 13. Price Drain

Quantity Analyses

The existence of wetland plant species near the outfall of the SRPMIC storm drain near Alma School Road supports the observation that at least 1 to 2 cfs flows from this drain periodically. However, no flow records for this drain currently exist, and the exact drainage area that contributes runoff to the drain is not known. According to SRPMIC personnel, water rarely flows from this drain as most runoff from the SRPMIC is typically diverted to other water users such as sand and gravel mining operations. However, the presence of wetland plant species indicates that this runoff is sufficient to maintain this vegetation.

Flow records for the Price Drain indicate that the mean flow to the river for the period from February 2001 to April 2002 was approximately 4.4 cfs. The peak flow during this period was 691 cfs. The records also show that there were only 24 days in which the average daily flow was less than 1 cfs, and there were only seven days in which the average day flow was less than 0.5 cfs. Based on these facts, it is apparent that this drain receives flows from sources other than storm water runoff. It is possible that this drain collects lawn irrigation return flows from residential areas as well as return flows from other water users within the tributary area.

To quantify the average monthly and annual volumes of runoff from ungaged storm drains, the approach used in the Rio Salado project (U.S. Army Corps of Engineers, 1998) was used to estimate the average annual volume of runoff. To estimate the average monthly volume of runoff, the annual amount was distributed according to the monthly rainfall distribution in the Phoenix area (Schmidli, 1996). This approach is described in detail in the Interior Drainage Appendix (Knight Piésold and Co., 2002a). Table 9 summarizes the average annual runoff volumes from the storm drains.

Quality Analyses

Stormwater discharges from urbanized metropolitan areas are generally of poor quality. The quality varies depending on the land uses within the tributary area, the magnitude and duration of the storm event, and the length of time between consecutive storm events. Sediment and chemical pollutants tend to accumulate between storms and are washed from the streets, parking lots, ditches, or other features during the proceeding event; this occurrence is termed the "first flush." The quality of the first flush water is generally poor. As the runoff continues, the water quality improves. The City of Mesa has reported that the base flow from the Price Drain may not have this first flush water quality problem

Assessment of Source

Rainfall events are infrequent in the Phoenix area, so stormwater runoff would generally not be considered as a dependable water source for a project. However, the Price Drain may be a dependable water supply. This drain has produced a consistent base flow, which can be incorporated into the restoration project. In addition, the Alma School Drain has produced sufficient flow to support a small area of wetland plant species; unfortunately, there are no records to further evaluate this flow.

The remaining storm drains represent two categories of water supply: problem and supplemental. The first flush runoff generally has poor water quality and may not be suitable to nourish restored vegetation. In addition, the peak flow rates emanating from these drains during major storm events may damage the habitat areas. These flows are both problem sources. After the first flush, the water quality generally improves. This runoff could be a supplemental source. Furthermore, there is potential for cleaning this water with constructed wetlands.

Table 9. Storm Drain Average Annual Runoff Volumes (ac-ft)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[2,3]	31.2	195.7	201.5	257.0	64.3	35.0	38.0	242.4	280.4	251.2	189.8	192.8	292.0	2,240
Tempe Drain[2,3]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[2,3]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[2,3]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[2,3]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club / McKellips Storm Drain[2,3]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[2,3]	unknown							minimal						
Natural Drainage[2,3]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent of Annual Rainfall:		8.7	9.0	11.5	2.9	1.6	1.7	10.8	12.5	11.2	8.5	8.6	13.0	100.0

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
3. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

(e) Effluent

Description of Source

Treated effluent represents a drought-tolerant water supply. During water shortage periods, most water conservation measures control the external use of water such as lawn watering, car washing, and landscape irrigation. These uses do not contribute to wastewater flow, so the amount of wastewater will only be reduced slightly during most drought periods.

Quantity Analyses

The City of Mesa owns and operates the NWWRP located near the downstream end of the study area (Haws, 2002). The NWWRP currently produces about 8.5 to 9.0 million gallons per day (mgd) of effluent; however, the plant was recently expanded to a design capacity of 18 mgd. The effluent will be discharged to three locations:

- Four City-owned percolation ponds on the south side of the river (south ponds)
- Five SRPMIC-owned percolation ponds on the north side of the river (north ponds)
- Directly to the Salt River, just north of the plant site

In the future, a fourth receiving source will be a 36-inch reclaimed water line that is being constructed in conjunction with the Red Mountain Freeway (Loop 202). This reclaimed water line will provide landscape water for the freeway, and potentially other uses, and will eventually deliver water to the Roosevelt Water Conservation District (RWCD) canal system east of Val Vista Drive.

Historically, the plant has discharged an average of 3,300 ac-ft of water into the percolation ponds. The five SRPMIC-owned ponds, totaling 75 acres, have received an average of 3,330 ac-ft of effluent each month since their inception in May 2001. The four Mesa-owned ponds, totaling 27 acres, have received an average of 140 ac-ft of effluent each month since January 2000. Effluent has also been discharged directly into the river.

Quality Analyses

The quality of the effluent from the NWWRP meets aquifer recharge standards, surface water quality standards, and NPDES requirements. Arizona has taken over the NPDES permitting; the program is called AZPDES. Having met all three of these authoritative standards, the quality of effluent is suitable for restoration uses.

Water Rights

The producer of effluent retains ownership until it is discharged and no longer under the control of the producer. If effluent is discharged to a river channel, a downstream water user can file for an appropriation to divert the water just like any other surface water source. The water user may be granted the surface water right to divert the effluent; however, this right does not guarantee that the effluent producer would continue to discharge to the river channel. The producer still has control as to where the effluent is discharged.

Normally, when effluent is discharged to the river, the producer loses control and hence the right to the effluent. However, if the receiving water channel is designated to be a part of the conveyance system, the producer can maintain the right to the flow. This could occur if the City of Mesa (Mesa) discharged effluent to a receiving channel in the Salt River with the intent to transport the flow to the restoration project.

When Mesa discharges the effluent to the recharge ponds, they retain control of the effluent and maintain the right to this water. Once the effluent is recharged, Mesa's right to this effluent is protected pursuant to groundwater recharge legislation statutes.

Assessment of Source

Effluent from the NWWRP could be a dependable or supplemental supply for portions of a project. The water source is drought tolerant and can meet water quality standards for restoration. However, Mesa, which controls the right to the effluent flow, has already committed this water for other uses to meet its assured water supply designation. Currently, Mesa owes a substantial water debt to the RWCD. Once the reclaimed water line to the RWCD canal line is in place, Mesa intends to use the majority of the effluent from the NWWRP to fulfill this debt. Mesa receives long-term storage credits from this delivery as well as from water recharged through the percolation ponds. Therefore, use of reclaimed water for habitat restoration would mean a depletion of the long-term

storage credits that Mesa uses to comply with Assured Water Supply requirements and to meet current and future demands.

The direct use of effluent could be used in the western and central portions of the study area where gravity flow and the reclaimed water distribution system can be used to deliver the effluent. It may not be cost effective, however, to deliver effluent to the eastern portions of the project near Granite Reef. However, indirect use of effluent could be achieved throughout the study area by using recovery wells to pump groundwater accounted for as recharge credits. It must be noted that no effluent would be used within the SRPMIC, or in any way that would cause it to flow into the SRPMIC.

(f) Irrigation Return Flows

Description of Source

The Va Shly'ay Akimel study area lies adjacent to irrigated agricultural lands, therefore, the potential exists to use irrigation return flows as a water source for the ecosystem and habitat restoration. Irrigation return flows constitute the water delivered to the agricultural areas that is not consumed by crops, evaporated, or infiltrated into the soils. These flows can occur under two scenarios, which are explained in further detail in the Water Budget Appendix (Knight Piésold and Co., 2002c).

Quantity Analyses

Under the current configuration, the SRPMIC supplies approximately 60,000 ac-ft of irrigation water to agricultural users annually.

Approximately 14,000 ac-ft of this water are delivered to the areas north of the Arizona Canal. The canal intercepts all runoff from this area; therefore, irrigation return flows from this area are not a potential source of water for the restoration project.

The remaining 46,000 ac-ft are delivered to farms, the Cypress Golf Course, and individual homeowners for lawn irrigation. Table 10 identifies water delivered to these entities.

Table 10. SRPMIC Irrigation Water Use

Water User	Annual Water Use (acre-feet) 1999	2000	2001
Associated Farms	18,511	27,009	27,061
Rogers Farms	9,130	17,731	16,645
Taylor Farms	13,786	0	0
Juan Montiel Farm	57	170	142
Lehi Farm	2,249	1,952	1,892
Cypress Golf Course	177	164	109
Homeowners Lawn Irrigation	125	91	31
Total Irrigation	**44,035**	**47,117**	**45,880**

The amount of irrigation return flow generated from these water users is not currently monitored and is difficult to quantify. SRPMIC personnel have suggested that approximately 10 percent of the water delivered to the farms may become irrigation return flow.

Quality Analyses

The quality of the irrigation return flows can meet the needs of a restoration project in most cases. The water is Salt River water and, as demonstrated previously, the quality is acceptable. In some locations, irrigation drainage water can be saline, but that problem usually occurs far downstream in the western portions of the SRP service area.

Localized water quality problems could occur if surface runoff drainage enters the irrigation drain canals and transports contaminants from surrounding areas into the drain canals. Examples of localized water quality problems include elevated suspended solids, TDS, Fertilizers, or on occasion, herbicides/pesticides. A review of the aerial photographs indicates no concentrated animal feeding operations in the area that could contribute contaminated runoff into the drainage canal system.

Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed for a restoration project, it could be utilized to support wetland and riparian habitat.

Assessment of Source

Irrigation return flows may provide a supplemental source of water for habitat restoration. However, nearly all irrigation return flow from within the SRPMIC are currently diverted to other water users, so this water is not available without an institutional decision to allocate this water to the project by the SRPMIC. In addition, several factors prohibit irrigation return flows from being a reliable source. Typically, only the amount of water necessary for irrigation is delivered to the fields, which minimizes the tail water amount. In addition, storm events that produce significant runoff are rare so that surplus canal water is not available on a regular basis. The irrigation flows that do occur, however, only take place during the irrigation season. When the flows are available, they could be incorporated to supplement the water supply for a project. Since all irrigation within the study area takes place within the western portion of the SRPMIC, irrigation return flows would only be available to Reach 2.

(g) Canal Drains

Description of Source

Canal drains are typically constructed along the major canals in the area to provide a means to discharge water from the canal other than the designated delivery turnouts. During storm events, the canals inadvertently intercept stormwater runoff. If this stormwater runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Also, the major canals occasionally convey more water than is needed by the downstream water users; in this case, the excess water can be released through the canal drains. Three significant canal drains were identified within the study area, namely the Evergreen Drain, Hennessey Drain, and Tempe Drain. Each of these canal drains is operated by SRP. These drains are shown on the Water Budget Map. Figure 14 and Figure 15 show the turnouts to the Evergreen Drain and Hennessey Drain, respectively.

Figure 14. Evergreen Drain Turnout

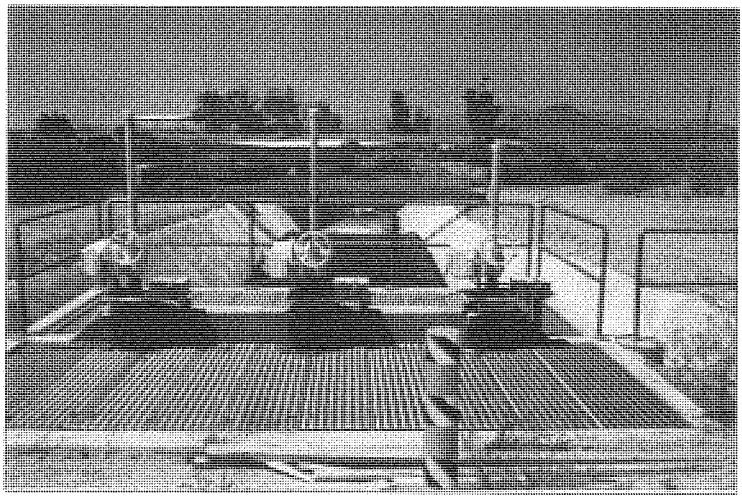


Figure 15. Hennessey Drain Turnout

There are also several lateral canals that could ultimately drain into the Salt River. These canals, however, are generally relatively small and rarely have a surplus of water. There are no flow records available for these canals. Given the size and infrequent water surplus of these canals, they are not considered to be a potential water source for a project. These lateral canals are shown on the Water Budget Map.

The RWCD diverts water from the Southern Canal at a pumping station located approximately five miles downstream of Granite Reef. Irrigation water is pumped from the Southern Canal into the Roosevelt Canal, which then flows toward the southeast. The areas irrigated by the RWCD irrigation water are located in eastern Mesa, eastern Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no canal drains that return water to the Salt River.

Quantity Analyses

Flow records for the SRP drains were evaluated for the period from January 1992 through December 2001. These records indicate that, for the Evergreen Drain, the average monthly volume of flow for this period ranged from 10.9 ac-ft in May to 74.5 ac-ft in September, with an average annual total of 566.5 ac-ft. For the Hennessey Drain, the average monthly volume of flow ranged from 2,264.3 ac-ft in April to 4,937.4 ac-ft in August with an average annual total of 45,930.7 ac-ft. For the Tempe Drain, the average monthly volume of flow ranged from 8.0 ac-ft in December to 2,607.2 ac-ft in January with an average annual total of 10,880.2 ac-ft. Table 9 summarizes the average monthly and annual volumes of flow for these drains for the period of record evaluated.

Quality Analyses

The water discharged from canal drains is generally high quality and suitable for habitat restoration.

Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed into a project, it could be utilized to support wetland and riparian habitat.

Assessment of Source

Canal drains may provide a supplemental source of water for a project. The amount of water released through these drains is relatively consistent from month to month; however, releases typically only occur for a few days each month. These releases are controlled by SRP and are not expected to be reliable. Canal drains are typically only utilized when a surplus of water exists in the major canals. When these releases do occur, however, they could be used to supplement habitat restoration.

(h) Sand and Gravel Mining Operations Releases

Description of Source

There are four mining operations identified within the study area; these operations use water to process aggregate materials. Three of these mining operations are operated by the Salt River Sand and Rock (SRS&R), while the other is operated by United Metro Materials Corporation. The SRS&R Dobson Plant, shown in Figure 16, is located north of the river between the Pima Freeway (SR101) and Dobson Road. The SRS&R Beeline Plant is located south of the Beeline Highway (US 87) between Horne Road and Gilbert Road. The SRS&R Higley Plant is located north of the Southern Canal between Greenfield Road and Higley Road. The United Metro operation is located south of the Beeline Highway on the east side of Country Club Road. None of these operations appear to discharge water to the Salt River (Knight Piésold and Co., 2002c).

Quantity Analyses

The SRPMIC provides water to Salt River Sand and Rock for use in their Dobson Plant. The SRPMIC has provided approximately 450, 800, and 1,200 ac-ft of water to this plant during 1999, 2000, and 2001, respectively. This water is used for processing aggregates and stored in holding ponds when not in use. No water appears to be discharged into the Salt River; however, inspection of aerial photography indicates that ponded water exists in the Salt River channel immediately adjacent to the Dobson Plant. The origin of this water is unknown, but it could be processing discharge, rainwater ponding, or water from another source including groundwater.

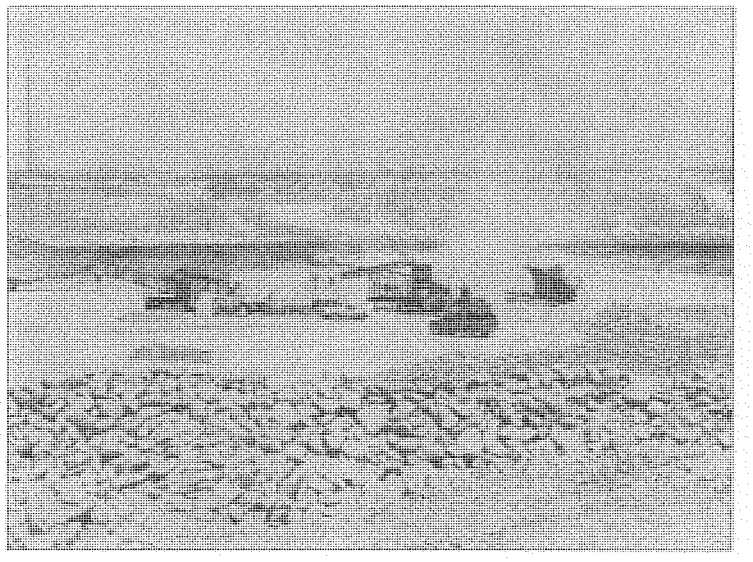


Figure 16. Sand and Gravel Operation at Dobson Plant

Quality Analyses

The quality of water discharged from sand and gravel mining operations is dependant partially on the original water supply. The most significant water quality impairment due to these mining operations is sediment.

Water Rights

Discharges from sand and gravel mining operations released to the river become available for use by other water users. If this water is diverted for restoration purposes, it could be utilized to support wetland and riparian habitat.

Assessment of Source

Discharges from sand and gravel mining operations are not considered to be a potential water source for a restoration project. There are no operations that currently appear to discharge excess water into the Salt River.

(i) Salt River Project and Central Arizona Project Water

Description of Source

SRP delivers water to the SRPMIC lands as well as non-Indian lands. SRP canals are subject to a two- to four-week dry-up period every year to allow for maintenance activities. The Arizona Canal and Southern Canal have separate dry-up periods. Figure 17 and Figure 18 show the Arizona Canal and Southern Canal, respectively.

CAP water is diverted from the Colorado River and transported across Arizona. The CAP system crosses the Salt River immediately downstream of Granite Reef, and there are turnouts that allow CAP water to be diverted into the SRP system. The CAP canal is not subject to periodic dry-up periods, but because the SRP system is needed to transport to the project area, the SRP dry up can impact the delivery.

Quality Analyses

The quality of both SRP and CAP water is suitable for use in a project. Quality is not a constraint.

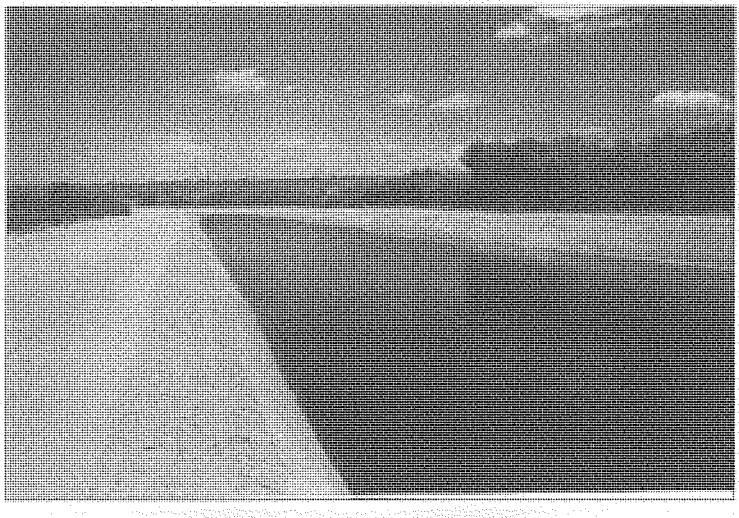


Figure 17. SRP's Arizona Canal

Figure 18. SRP's Southern Canal

Water Rights

SRP is a delivery organization. The water rights associated with lands within the SRP area are tied to the land. These water rights were established by the Kent Decree and relate to normal flow of surface water and stored water. SRP lands also have pumped rights gained when a landowner has funded the development of wells. Lands in the Salt River do not have SRP rights, and SRP could not provide water to these lands. SRP delivers water to the SRPMIC, and the rights for this water were also established by the Kent Decree. There may be more flexibility to allow use of SRPMIC water on lands within the river.

Rights to CAP water are established by allocations made by the Secretary of Interior. The SRPMIC has a contract with the Federal Government for CAP water. Mesa has a subcontract with the Central Arizona Water Conservation District (CAWCD) and the USBR for delivery of CAP water.

Assessment of Water Source

SRP water delivered to non-Indian lands should not be considered as a potential water source, as it is already committed. CAP water delivered to Mesa should also not be considered as a potential water source, as it is also committed. Use of Mesa's CAP subcontract water for habitat restoration would mean a depletion of the water the City

uses to comply with Assured Water Supply requirements and to meet current and future demands. In addition, excess CAP water supplies are not projected to be available in the very long term.

There is a potential to use water delivered by SRP to the SRPMIC and the SRPMIC's CAP allocation to supply a project. These are institutional decisions that must be made by the SRPMIC rather than a water supply issue. If committed to a project, this water could be diverted at Granite Reef or via a pump station to supply the eastern portion of the project area. Deliveries to the central and western portion of the project could use the SRPMIC's irrigation water delivery system.

If SRP or CAP water is committed to a restoration project, it would be a dependable supply for most of the year. However, a supplemental supply may be needed to augment the flow during the SRP dry up periods. The need for a supplemental supply can be defined in the plan formulation stage when habitat alternatives are developed and the vegetation mix is proposed. The water demand of the vegetation may be very low when the dry up occurs, and the demand for supplemental water may be small or eliminated.

4.2.3.2 Outflows

Two primary water demands were identified that are associated with a river restoration project. These include consumptive use by wetland vegetation and evaporation from open water bodies. Consumptive use is defined as the water needed to account for plant evapotranspiration, which is the water required by the plant for growth and the water that may be evaporated from the plant itself and the soil in the immediate area surrounding the plant.

The following information quantifies the average annual and monthly water demands associated with the water uses. When the project alternatives are finalized, the total demands can be projected by multiplying the per acre demands by the number of acres of vegetation and open water.

(a) Evapotranspiration

Water Demands of Vegetation

The water demand of vegetation varies depending on the individual and mix of species within a habitat unit. In the Tres Rios project (U.S. Army Corps of Engineers, 2000), the average annual evapotranspiration of river vegetation was projected to equal 3.7 acre-feet

per acre (ac-ft/ac). This general rate accounted for a mix of vegetation species that is similar to the expected mix for this project (Greeley and Hansen, 2001). The monthly demand is calculated as a percentage of the annual demand and defines the seasonality of the required water supply. The values shown in Table 11 below are based on water demand projections for the Tres Rios project.

Table 11. Consumptive Use for Salt River Habitat

Month	Percent of Annual Demand (%)	Consumptive Use (ac-ft/ac)
January	5	0.19
February	5	0.19
March	5	0.19
April	10	0.37
May	10	0.37
June	15	0.56
July	15	0.56
August	15	0.56
September	5	0.19
October	5	0.19
November	5	0.19
December	5	0.19

The root zone depth of vegetation is also an important criterion when assessing the adequacy of water supplies to meet demands. If the roots of plants have access to groundwater, it reduces the irrigation demand. Plants have different requirements depending on the phase of development, seeding, sapling, and maturity. Table 12 (Wass, 2002) presents the root zone information for several species common within the Salt River channel environment. The table also presents the desirable ranges of depth to groundwater (or depth of inundation for aquatic plants) for establishment and growth. These data will be used in assessments of in-situ groundwater and to calculate irrigation demands during alternative development.

Table 12. Riparian and Constructed Wetland Vegetation Requirements

	Vegetation Type	Seedling Establishment	Sapling Growth	Mature Survival
	Trees (Groundwater Depth Requirements)			
Cottonwood	Populus fremontii (Fremont cottonwood)	Moist soils in March/April	0.66 to 6.6 feet	16.5 feet
Willow	Salix gooddingii (Gooding willow; black willow)	Moist soils in April/May	0.66 to 6.6 feet	10 feet
Mesquite	Prosopis sp.	< 4 inches	3.3 to 33 feet	< 33 feet
Salt Cedar	Tamarix sp.	Moist soils in May to September	0.66 to 8.2 feet	33 feet
	Common Aquatic Plants (Inundation Depth Requirements)			
Shallow Emergent Marsh	Scirpus validus, Scirpus americanus, Scirpus acutus, Sagittaria greggii, Sagittaria latifolia, Alisma triviale, Typha latifolia	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 2.6 feet
Deep Emergent Marsh	Typha domingensis, Scirpus californicus, Phragmites australis	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 4.9 feet
Floating Aquatic	Hydrocotyle sp., Ludwigia palustrus, Polygonum hydropiperoides, Potamogeton sp. Rorippa, Nasturtium-aquaticum	Moist soils to 4 inches	Moist soils to 8 inches	Moist soils to 8 inches
Transitional Marsh Plants	Eleocharis parishii, Eleocharis macrostachya, Equisetum laevigatum or similar sp., Cyperus niger, Cyperus laevigatus, Cyperus erythorhizos or similar sp., Juncus balticus, Juncus bufonius, Juncus tenuis var. Dudleyi, Juncus interior, Juncus torreyi, or sim	Moist soils to 4 inches	Moist soils to 4 inches	Moist soils to 4 inches

(b) Evaporation Losses

A restoration project within the study area may include open water bodies, riparian wetlands, constructed wetlands, and marsh areas. A portion of the water demand is to make up for evaporation losses in these habitat types. In the central Arizona area, the annual evaporation averages 72.4 inches or 6.03 feet per year, shown in Table 13. However, evaporation is seasonal with the greatest evaporation in the summer months (Cooley, 1970).

Table 13. Seasonal Evaporation from Open Water

Month	Evaporation (ac-ft/ac)
January	0.18
February	0.26
March	0.42
April	0.55
May	0.75
June	0.83
July	0.83
August	0.75
September	0.58
October	0.44
November	0.33
December	0.18
ANNUAL	**6.03**

4.2.3.3 Water Sources Assessment Summary

Table 14 summarizes the potential water sources identified and evaluated to support the proposed restoration effort in the study area.

Table 14. Water Sources Assessment Summary

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
In-Situ Groundwater					
Regional water table	Throughout the study area; all reaches	None	Not available	Unacceptable	Regional groundwater is too deep for use by the desired vegetation. Depth exceeds 30 feet, which is the limit for mesquite.
Local or perched water table	Extends from Granite Reef Dam approximately 1 mile downstream; Reach 1	Not measured	Continuous	Dependable	Local supply available at the surface from Granite Reef to about one mile downstream.
Pumped Groundwater					
Community Lands	Throughout the Community; all reaches	Pending	Continuous	Dependable or Supplemental	Requires a reallocation of water resources to project by the Community.
Non-Indian Lands					
Irrigation Grandfather Rights	Tied to specific parcels of land for growing crops.	Not Available	None	Unacceptable	IGR water must be used on a historically specified parcel of land.
Type I Non-Irrigation Rights	Tied to specific parcels of land for changes in land use.	Not Available	None	Unacceptable	Type I water cannot be used off of the specific land parcel.
Type II Non-Irrigation Rights	Pumping for uses not associated with historic farmland.	Pending	Continuous	Dependable or Supplemental	Requires purchase and transfer of Type II right.
Groundwater Permits	Pumping for new uses.	Not Available	None	Unacceptable	Project can not meet permit requirements and conditions.
Service Area Right	Pumping for public water providers.	Not available – already committed	None	Dependable or Supplemental	Pumped water will impact Mesa's overall water resources unless credits to offset the pumping are purchased or developed.
Salt River Flood Flows					
Direct Use	Flow in the Salt River due to spills over Granite Reef Dam; all	Quantity varies with each flood event	Approximately once every 3 years	Problem	Due to the unpredictable nature of the flood flows, they are not a dependable supply, and may cause damage to

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
	reaches				restored areas.
Indirect Use	Groundwater recharge due to flood flows in the Salt River; all reaches	Quantity varies with each flood event	During floods and for a short time after	Supplemental	Recharge of groundwater allows for indirect use; and, surface soil saturation will augment seed germination.
Stormwater Discharges					
Alma School Road Storm Drain	Storm runoff from the Community, outfalls along the west side of alma School Road; Reach 5	1 to 2 cfs estimated (no flow records available)	May be fairly continuous	Supplemental	Wetland vegetation is present indicating a fairly continuous flow; flow monitoring may permit reclassification as a dependable source.
Natural Surface Drainage - SRPMIC	Uncontrolled surface runoff from the Community; all reaches	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Price Drain	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	Averages 4 cfs; ~ 2,500 ac-ft/yr	Continuous	Dependable	Continuous base flow may be a dependable source; however, water quality may be a concern due to storm water runoff.
Tempe Drain (see Canal Drains)	Storm runoff from mesa, outfalls between Dobson Road and Alma School Road; Reach 5	(See Canal Drains)			This drain serves as a canal drain and intercepts storm water runoff from Mesa.
Price Road Freeway Local Drainage	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	~ 30 ac-ft/yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Dobson Road Storm Drain	Storm runoff from Mesa, outfalls along the east side of Dobson Road; Reach 6	~ 140 ac-ft/yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
McLellan Road Storm Drain	Storm runoff from Mesa, outfalls west of Alma School Road; Reach 5	~ 80 ac-ft/yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Country Club/McKellips Storm Drain	Storm runoff from Mesa, outfalls along Country Club Road; Reach 5	~ 300 ac-ft/yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Red Mountain Freeway Local Drainage	Storm runoff from the Red Mountain Freeway (Loop 202); Reach 3, 4, 5, and 6	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Natural Surface Drainage - Mesa	Uncontrolled runoff between Gilbert Road and Granite Reef Dam, south of the Salt River; Reach 1 and 2	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Effluent					
Direct Use	Effluent from the NWWRP discharged directly into the project; Reach 6.	Not available – already committed	None	None	The quantity and availability of effluent water is subject to an institutional commitment by Mesa; Mesa has existing commitments for this effluent.
Indirect Use	Effluent from the NWWRP recharged into the groundwater; Reach 6.	Not available – already committed	None	None	Mesa has incorporated the recharge credits for this effluent into its long-term water plan; it would require a reallocation to the project. Indirect use requires wells to recover the recharged water.
Irrigation Return Flows					
Irrigation Tailwater	Excess water applied to crops within the western portion of the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
Irrigation Drainage	Excess water in lateral canals within the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Canal Drains					
Evergreen Drain	Drains the Arizona Canal, outfalls west of Horne Road; Reach 4	averages < 1 cfs; ~567 ac-ft/yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases only occur once or twice each month and are not reliable.
Hennessey Drain	Drains the Southern Canal, outfalls east of Val Vista Road; Reach 4	averages 63 cfs; ~ 45,921 ac-ft/yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases have occurred frequently in the past but only for two days since Nov. 2001; may not reliable in the future.
Tempe Drain	Drains the Tempe Canal, outfalls between Dobson Road and Alma School Road; Reach 5	averages 15 cfs; ~ 10,880 ac-ft/yr	In-frequent	Supplemental	This canal intercepts storm water so flow is due to controlled releases by SRP as well as rainfall events; releases occur on average 4 times each month and are not reliable.
Sand & Gravel Mining Releases					
	Within the Salt River; all reaches	None	Not available	Unacceptable	No known discharges from these operations.
Salt River Project & Central Arizona Project Water					
	Throughout the project area; all reaches	Pending	Pending	Dependable to Supplemental	The quantity and availability of water supply is subject to institutional commitments by SRP or CAP.

Source: Knight Piésold, 2002a

4.2.4 Vegetative Habitat

Historically, the study area supported significant biological resources including extensive riparian and wetland habitats within the floodplain. Urban development, sand and gravel operations, diversion of water to support agriculture, and domestic livestock grazing have eliminated or altered most of the natural vegetation communities that occupied the project study area leaving only scattered remnants of the original vegetation communities. Modifications of the river system, such as damming and flow diversion, currently allow no natural flow through the project study area except during flood events. The Salt River below Granite Reef Diversion Dam is essentially devoid of vegetation.

At one time, mesquite occurred along the outer bank of the river, at the extreme edge of the natural riparian vegetation. The willow and cottonwoods were located inward of the mesquite, adjacent to the low-flow channel and closer to where there was a more continuous flow of water. Some channel areas were barren, while others had vegetation in strips along the low-flow channels and abandoned high-flow channels. The bottomlands of the Salt River supported a variety of vegetation, including trees, shrubs, marsh plants, and some grasses. Large cottonwood, willow, and alder trees grew along the margins of the river, and mesquite, greasewood, Palo Verde, and sagebrush covered the low terraces. Dense mesquite and other shrubs made crossing the bottomland impossible in places, while in other locations the vegetation was more scattered. Large, dense mesquite forests or bosques are found along abandoned lakes, lake edges, and river floodplains in southern Arizona. Mesquite bosques were once the most abundant riparian type in the Southwest. Most modern mesquite bosques are large (typically one mile long and 600 feet wide), but these are small compared to pre-development bosques, which extended for miles. Mesquite bosques usually are found on the drier habitat types within the riparian continuum. The locations for this setting are floodplains or low terraces several yards above the streambed and up to 45 feet above the water table. There were several species of fish in the waters similar to those found in the Gila River. The river had many channel meanders, sand bars, and backwater areas that were conducive to riparian growth.

These once optimal conditions for gallery forests of cottonwoods and willows no longer exist. The elimination of natural base flows reduced Salt River flows from a distinct seasonal pattern, with highest flows occurring in December and January and lowest flows in October to summer or fall rainfall-related flood events. The groundwater table beneath the river dropped. The soil moisture in the riverbed was virtually eliminated, and the

native cottonwoods, willows, and riparian ecosystem rapidly died out. Most areas of the Salt River are barren today. What little vegetation that does exist is mostly limited to saltcedar, an exotic non-native species with little habitat value. Vegetation communities in the project study area have been highly modified from their original state and currently contain a mosaic of degraded natural communities and man-made artificial communities. Included in this reach of the Salt River are a large number of open water areas, mostly the result of gravel mining. Adjacent to several of these is dense vegetation including some cottonwood and willows as well as the occasional cattail or bulrush.

4.2.4.1 Cover Types

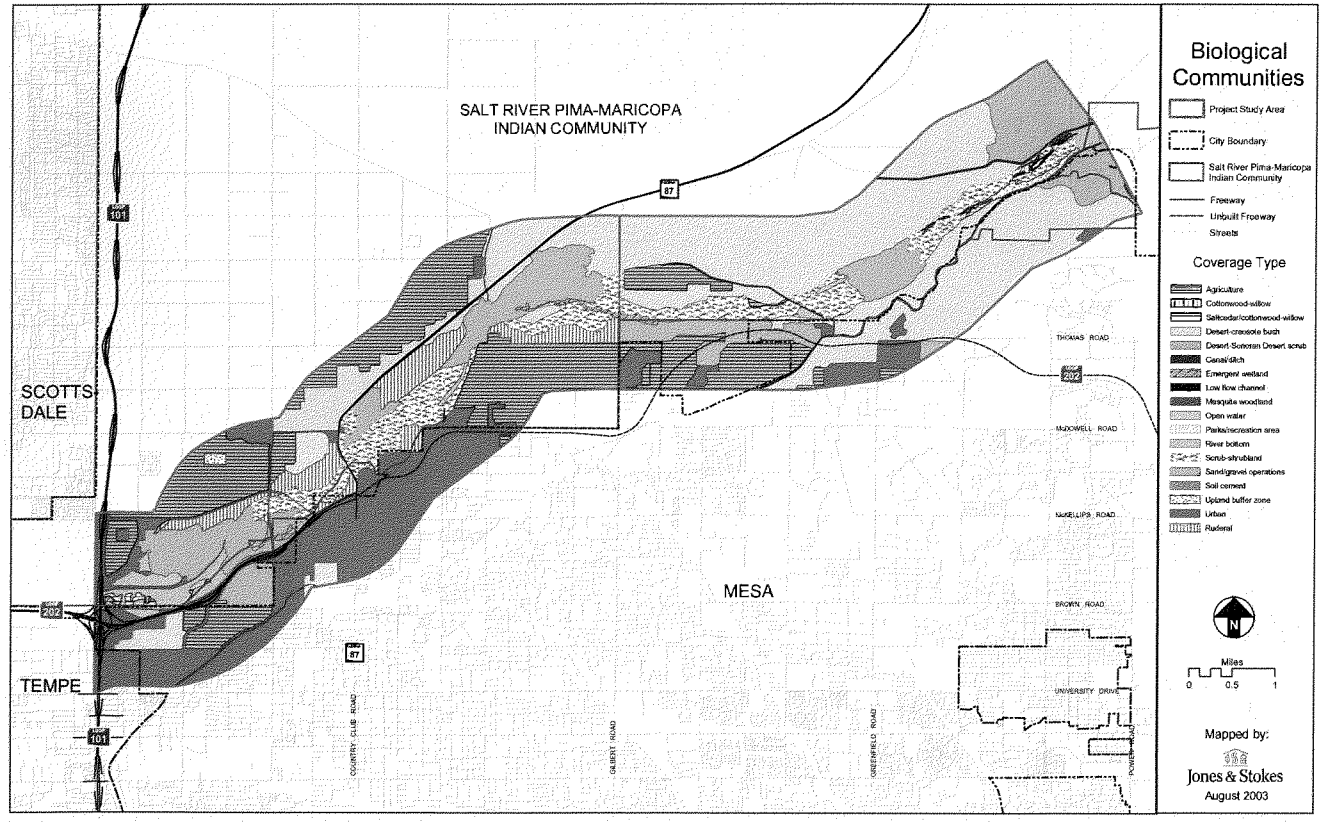
A classification system of cover types was developed for this study and is mainly based upon vegetation cover. For the length of the study reach and one mile on either side of the thalweg, or center of the river channel, cover types were mapped. Figure 19 depicts cover types found within the project area.

Scattered remnants of natural vegetation remain, those cover types include cottonwood-willow forest, mesquite, scrub shrub lands, and emergent wetlands. Of those cover types, scrub shrub lands are the most dominant covering approximately 1,400 acres in the 17,435 acre study area. The scarcest is cottonwood-willow forest, which is found within merely 40 acres, of which 31 acres are dominated by saltcedar.

(a) Cottonwood-Willow Forest

Cottonwood-willow forest is uncommon in the project study area occupying less than 1 percent of the total study area. This cover type is representative of high-quality riparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with adjacent bodies of water (rivers, lakes, or streams) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas.

Figure 19. Biological Communities



Because of the modification of the Salt River system, the lower groundwater elevations compounded by the loss of perennial surface flows have contributed to the decline in cottonwood and willow species. These same conditions have also favored the establishment and dominance of saltcedar. Structural types of most stands of cottonwood-willow within the study area show evidence of disturbed and early successional conditions consistent with past histories of water diversion, infrequent severe floods, and land clearing. These plant species are also found in habitats that are narrow, linear strands of vegetation oriented in the main direction of water flow that may occur in riverine flood channels and along the banks of streams.

In terms of height, basal area, and density, Fremont's cottonwood and Gooding's willow are dominant canopy species in the cottonwood-willow associations in the study area, along with saltcedar. The cottonwood-willow riparian habitat is patchy in the study area and much of the original stands of this habitat have been replaced by the invasive and non-native saltcedar, as shown in Figure 20.

Figure 20. Saltcedar Growth

Cottonwood-willow forest, although uncommon in the study area, stands out as the most important remnant wildlife habitat in the area. This cover type supports the densest and most diverse wildlife communities in valleys and deserts. Cottonwoods and willows provide substantial nesting support for large birds, such as the great blue heron, red-tailed hawk, American kestrel, western screech owl, great horned owl, and northern flicker. The remaining cottonwood-willow habitats are especially important for resident and migratory neotropical songbirds since theses and other native riparian habitats have high wildlife value and have substantially declined throughout the western United States. Furthermore, many native wildlife species, especially riparian-dependent or riparian/marsh-dependent birds, such as the southwestern willow flycatcher, an endangered species, summer tanager, and western yellow-billed cuckoo, require large tracts of native riparian trees and shrubs for cover, nesting, and foraging.

(b) Scrub-Shrublands

Scrub-shrublands, shown in Figure 21, are common and are present within the active channel of the river occupying 8 percent of the project study area. They are dominated by various combinations of burrobush, rabbitbush, quailbush, saltbush, and occasionally by creosote bush. Many of these areas have been highly disturbed from off-highway vehicle (OHV) traffic and gravel mining activities and contain little or no vegetation cover. If the total vegetation cover was less than 10 percent, the area was mapped as unvegetated river bottom; if water was present, it was mapped as low-flow channel.

Scrub-shrublands as they occur in the study area offer moderate wildlife value. The shrub and scrubland vegetation provides foraging and resting cover for small and medium-sized mammals, snakes and lizards, and various terrestrial birds including Gambel's quail, greater roadrunner, loggerhead shrike, curve-billed thrasher, and verdin.

Figure 21. Scrub-Shrublands Dominated by Saltbush and Rabbitbush

(c) Emergent Wetlands

Emergent wetlands are uncommon in the study area, occupying less than 1 percent of the study area on lands in the floodplain of the Salt River near the Mesa wastewater treatment plant, near the Granite Reef Dam, and in scattered areas around gravel mining operation ponds that have been abandoned or are not routinely cleared of vegetation. Emergent wetlands support high-quality wildlife habitat and support a large diversity of wildlife species. In addition, the federal- and state-listed Yuma clapper rail has historically been recorded in small numbers in the emergent wetlands found along the Salt River above and below Phoenix.

(d) Low-Flow Channels

Low-flow channels in the Salt River have been almost entirely eliminated, occurring in less than 1 percent of the project study area. These features are characterized by either seasonal or perennial open water and are generally unvegetated when present. As shown on Figure 22, vegetation, when present, consists of scattered patches of Bermuda grass, salt heliotrope, and sedges. Low-flow channels do not represent a significant value to wildlife and are rare in the study area.

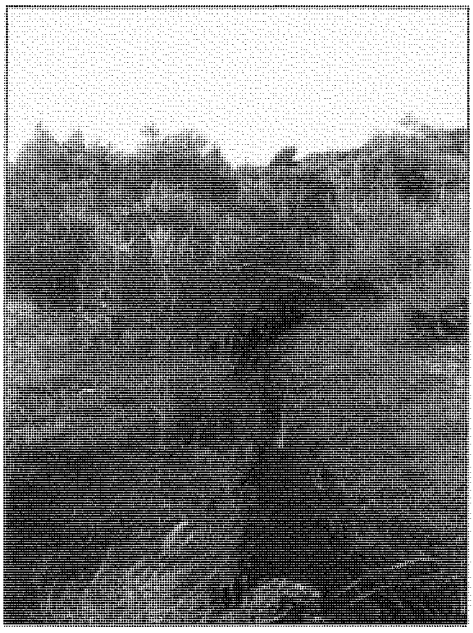


Figure 22. Wetland/Emergent below Granite Reef Dam

(e) Mesquite Woodlands

Mesquite woodlands historically occurred over large areas within the river floodplain and on higher terraces of the river. These communities have been nearly eliminated from the river ecosystem by changes to natural processes. Currently, only small fragmented stands of scattered mesquite woodlands remain along the Salt River. Mesquite is common throughout the region, but has been reduced to remnant patches just below Granite Reef Dam.

(f) River Bottom

The river bottom type was located in one percent of the total study area. This cover type is largely unvegetated and is characterized by cobble in the active channel of the Salt River. River bottom habitat provides low wildlife value since the vegetation is sparse or grows in clumps. However, the habitat is used by many wildlife species, such as snakes and lizards, for foraging or sunning.

4.2.4.2 Habitat Evaluation

(a) Functional Analysis

The Functional Analysis Tool was chosen for habitat evaluation on the Salt River because of its ability to provide an analysis of processes and conditions necessary for restoration and maintenance of riparian and wetland habitat. It examines habitat based on physical and biological parameters. The tool was developed by scientists and the Engineering Research and Development Center's (ERDC) Environmental Laboratory under its wetlands research program. Under this assessment procedure, the focus is narrowed to (1) the functions a particular type of wetland will perform and (2) the characteristics of the ecosystem and landscape controls of those functions.

In arid regions, biological resources are typically concentrated along riparian systems. This feasibility study relies on the results of a broad analysis of processes and conditions necessary for support of riparian habitat. Riparian components including size, substrate characteristics, and species composition are considered in quantification of the biological resource function and value.

This approach treats the biota of an area as being the outcome of an ecological process. It also merges these biological events with hydrologic and geologic processes at work in a region. Wetlands under this method are measured in terms of functional capacity. This concept is based on the inherent capacity of a wetland to perform a function under its physical, chemical, and biological components; the level of functioning is determined by interactions between the wetland and surrounding environment. The inherent capacity of a wetland is dynamic and its functional capacity is based on an assessment model defining the relationship between the ecosystem and landscape-scale variables and functional capacity. The assessment method develops a Functional Capacity Index (FCI). The FCI is a quantitative estimate of functional capacity for a wetland. The ideal goal of an FCI is to quantify and produce an index that reflects functional capacity at the site. The results of an FCI analysis can be quantified based on a standard 0.0-1.0 scale, where 0.0 represents the lowest functional capacity for the wetland and 1.0 represents highest. The Functional Capacity Unit (FCU) is a measure of the ability of a wetland to perform a certain function and is calculated by multiplying an FCI by the corresponding wetland area that is producing that FCI. When evaluating and comparing alternative ecosystem restoration plans or scales of plans, the with-project FCU is compared to the future

without-project FCU. The net change in FCU represents increases in the biological function of the ecosystem directly attributable to the implementation of alternative plans.

Applying this approach, the Salt River was classified as Riverine Overbank. The Salt River is also characterized regionally as arid and Southwestern. As such, the functions developed in an existing Riverine Overbank Subclass model were modified for Arizona low gradient rivers to be applied in the standard approach for this study.

The model for Arizona was further calibrated in a workshop with the ERDC's Environmental Laboratory; the USACE Los Angeles District; local sponsor representatives from the SRPMIC, City of Mesa, City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, AGFD, USFWS; and representatives from the scientific community. Field sampling results based on the calibration of the model during the workshop were utilized in the analysis of alternatives.

As a first approximation, the approach uses seven wetland classes (groups) as shown below. Detailed descriptions of these groups can be found in the HGM Assessment Appendix.

- Depression
- Tidal Fringe
- Lacustrine Fringe
- Slope
- Mineral Soil Flats
- Organic Soil Flats
- Riverine

The level of variability in the classes presented above is still usually too immense to develop assessment models that can be rapidly applied while still being sensitive enough to detect changes in function at a level of resolution appropriate to the USACE planning process in Arizona. As such, the three classification criteria (geomorphic setting, water source, and hydrodynamics) were applied at a smaller, regional geographic range to identify regional wetland subclasses.

The resulting regional riverine wetland subclasses adopted for the Va Shly'ay Akimel project were all associated with low-gradient perennial and ephemeral river systems in Arizona. Within these regional subclasses, homogenous zones exhibiting analogous vegetative species, geographic similarities, and physical conditions that make the area

unique were defined as a Partial Wetland Assessment Area (PWAA). In all, 19 PWAAs were defined for the Va Shly'ay Akimel Project on the basis of species recognition and dependence, soil types, and topography. The dominate vegetative cover types within the PWAAs included Cottonwood-Willow, Wetland Marsh, Mesquite, and Scrub-Shrub. River Bottom was defined as the active channel and included pool/riffle aquatic areas and open areas characterized by sand, cobble, and/or gravel. During the planning and project formulation processes, various combinations of PWAAs were located within the project area and used to develop a range of restoration alternatives.

(b) Wetland Functions Evaluated

A desired result of this study process was to assess the functional values of wetland habitat types (PWAAs) currently existing within the project area. Further, estimates of the functional values were needed for PWAAs at selected times in the future considering the without-project scenario, as well as with-project. Wetlands perform a wide variety of functions, although not all wetlands perform the same functions, nor do similar wetlands perform the same functions to the same level of performance. The ability to perform a function is influenced by the characteristics of the wetland and the physical, chemical, and biological processes within the wetland.

Wetland characteristics and processes influencing one function often also influence the performance of other functions within the same wetland system. The ten functions evaluated with Functional Capacity Index (FCI) models used in this study are found in Table 15.

Table 15. Wetland Functions Evaluated

Wetland Function (symbol)	Description
Function 1: Maintenance of Channel Dynamics (CHANNELDYN)	Physical processes and structural attributes that maintain characteristic channel dynamics. These include flow characteristics, bedload, in-channel coarse woody debris inputs, channel dimensions, and other physical features (e.g. bank vegetation, slope).
Function 2: Dynamic Surface Water Storage/Energy Dissipation (WATSTORENR)	Dynamic water storage and dissipation of energy at bankfull and greater discharges. These are a function of channel width, depth, bedload, bank roughness (coarse woody debris, vegetation, etc.), presence and number of in-channel coarse woody debris jams, and connectivity to off-channel pits, ponds, and secondary channels.
Function 3: Long-Term Surface Water Storage (WATSTORLNG)	The capability of a wetland to temporarily store/retain surface water for long durations; associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, and/or channelized flow from uplands, or direct precipitation.
Function 4: Dynamic Subsurface Water Storage (WATSTORSUB)	Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.
Function 5: Nutrient Cycling (NUTRIENT)	Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
Function 6: Detention of Imported Elements and Compounds (ELEMENTS)	The detention of imported nutrients, contaminants, and other elements or compounds.
Function 7: Detention of Particles (DETPARTICL)	Deposition and detention of inorganic and organic particulates (> 0.45 μm) from the water column, primarily through physical processes.
Function 8: Maintain Characteristic Plant Communities (PLANTS)	Species composition and physical characteristics of living plant biomass. The emphasis is on the dynamics and structure of the plant community as revealed by the species of trees, shrubs, seedlings, saplings, and herbs and by the physical characteristics of the vegetation.
Function 9: Maintain Spatial Structure of Habitat (HABSTRUCT)	The capacity of the wetland to support animal populations and guilds by providing heterogeneous habitats.
Function 10: Maintain Interspersion and Connectivity (INTERSPERS)	The capacity of the wetland to permit aquatic organisms to enter and leave the wetland via permanent ephemeral surface channels, overbank flow, or unconfined hyporheic gravel aquifers. The capacity of the wetland to permit access for terrestrial or aerial organisms to contiguous areas of food and cover.

(c) Selecting and Modifying the Models

As previously indicated, the subclass model used for this study is the Arizona Riverine Overbank Model. In using a functional analysis tool, wetland functions are identified and expressed in terms of a mathematical model, or FCI model. Several FCI models are usually selected for an assessment, and justifications are given that address the applicability of the FCI model to the wetland functions, as well as the regional model. Some models selected are often associated directly with the proposed restoration improvements for the project, such as plant communities or habitat structure. Other models may be selected that focus on water functions, such as water storage or channel dynamics, or biogeochemical functions, such as nutrient cycling or detention of particles.

Models can be single formula, considering only a few variables, or multiple formula, considering many variables. An example of a single-formula model is the dynamic subsurface water storage function, which considers the depth to saturated soil. An example of a multiple-formula model is the dynamic surface water storage and energy dissipation function, which considers water variables such as frequency of flooding and the flood-prone area, as well as habitat variables such as total vegetation volume and coarse woody debris. For the Arizona Riverine Overbank Model, ten FCI models were selected that can be sorted into three general groups. Four FCI models were selected that focus on water functions, three models were selected that focus on biogeochemical functions, and three models were selected that focus on habitat functions. These FCI model functions are listed in Table 16, along with the associated variables, defined in Table 17, for each function formula. The HGM Assessment Appendix provides details of the mathematical calculations used for each function. It is important to note that many of the variables are applicable to several of the functions in all three of the groups.

Table 16. FCI Function Models, Variables, and Performance Target

Function Group	Code	Name	Variable Association
Water	CHANNELDYN	Function 1: Maintenance of Channel Dynamics	FPA Q SED
Water	WATSTORENR	Function 2: Dynamic Surface Water Storage/Energy Dissipation	FPA FEQ TOPO
Water	WATSTORLNG	Function 3: Long Term Surface Water Storage	PORE SUBIN TOPO
Water	WATSTORSUB	Function 4: Dynamic Subsurface Water Storage	DEPSATSED
Biogeochemical	NUTRIENT	Function 5: Nutrient Cycling	CWD DECAY FWD
Biogeochemical	ELEMENTS	Function 6: Detention of Imported Elements and Compounds	FREQ LITTER PORE
Biogeochemical	DETPARTICL	Function 7: Detention of Particles	FPA FWD SED
Habitat	PLANTS	Function 8: Maintain Characteristic Plant Communities	SPECRICH TVV WIS
Habitat	HABSTRUCT	Function 9: Maintain Spatial Structure of Habitat	FWD LITTER VEGSTRATA
Habitat	INTERSPERS	Function 10: Maintain Interspersion and Connectivity	FREQ TOPO TRIB

Table 17. Variables Used in Assessment

Variable Code	Variable Description	Variable Code	Variable Description
AGSA	Algal Growth Surface Area as an indicator of past inundation	LITTER	Abundance of leaf litter and other detrital matter in the FPA
BUFFCOV	Percent of native vegetation cover in the buffer	PORE	Soil pore spaces available for storing subsurface water. Performance is related to soil texture and permeability
BUFFLENGTH	Percent of area with sufficient buffer	Q	Alterations of hydroregime that affect the assessment area
BUFFWIDTH	Width of Buffer (m)	SED	Extent of sediment delivery to the water/wetland from culturally accelerated sources
CONTIG	Contiguous vegetation cover between waters/wetlands and uplands (%)	SHRUB	Abundance as measured through vegetation volume of shrubs (multiple stems, woody species)
CWD	Abundance of dead and down woody debris ≥ 2.5" in diameter (coarse)	SPECRICH	Species richness
DECAY	The presence of coarse woody debris in various stages of decomposition.	SUBIN	Subsurface flow into the water/wetland via interflow and return flow
DEPSATSED	Depth of saturated sediments (m)	SURFIN	Surface inflow to the wetland via sheetflow
FPA	Floodprone area as defined by the projection of a horizontal plane at a level twice the bankfull thalweg depth	TOPO	Macro (large scale) and microtopographic (small scale) relief. Macrotopography generally refers to large-scale features such as secondary channels and in-channel ponds. Microtopography generally refers to small-scale features such as pit-and-mound and hummock-and-hollow patterns
FREQ	Frequency of inundation	TREE	Abundance as measured through vegetation volume of trees
FWD	Abundance of dead and down woody debris < 2.5" in diameter (fine)	TRIB	Presence of connected tributaries
HERB	Abundance as measured through vegetation volume of herbaceous species	VEGSTRATA	Number of vegetation layers present
INVASIVES	Abundance of invasive species	WIS	Wetland indicator score
LANDUSE	Type of adjacent land use		

(d) Environmental Output

Conducting an HGM analysis requires that a baseline inventory be conducted, variable means and/or modes calculated, and cover-type acreages quantified. The next step is to describe the baseline conditions in terms of FCUs. The value of each variable expressed as a mean or mode are applied to the Variable Subindex graphs as dictated by the model documentation. For example, if the percent of ground cover in the PWAAs at Site X were 50 percent on average, the value "20" was entered into the "X axis" on the Variable Subindex curve below, and the resultant VSI score (Y axis) was recorded (VSI = 1.0).

The process is repeated for every associated variable and PWAA per model. The individual VSI scores are then entered into the FCI formula on a PWAA-specific basis, and individual PWAA FCIs are generated. Each result, referred to as the PWAA FCI is then weighted by the relative area (RA) of the PWAA. In this model, the RA is a mathematical process used to weigh the various applicable cover types on the basis of quantity. To derive the relative area of a model's cover type, the following equation can be utilized:

$$Relative\ Area\ (RA) = Cover\ Type\ Area\ /\ Total\ Area$$

where:

Cover Type Area = only those acres assigned to the cover type (or PWAA) of interest
Total Area = the sum of the acres utilized in the model

Results from the remaining associated PWAAs are combined in an additive manner. Mathematically, this can be expressed using the following relationship:

$$FCI_{Subclass\ Model} = \sum (PWAA\ FCI \times RA)_X$$

where:

PWAA FCI = Results of the PWAA FCI calculation,
X = Number of PWAAs associated with the model, and
RA = Relative area of each PWAA

The final step involves multiplying the FCI result by the habitat acres (PWAA acreage associated with the model). The final results (FCUs) quantify the quality and quantity of the wetlands at the site for the baseline conditions (TY0).

Table 18 shows the PWAA cover-type acreages for baseline conditions. Table 19 shows the baseline acreages for other cover types in the study area. Table 20 and Figure 23 and Figure 24 present the baseline condition results for the Va Shly'ay Akimel study area.

Table 18. Baseline Acreages for Partial Wetland Assessment Areas

Cover Type	Acres
Cottonwood-willow Forest	69.50
Mesquite	4.10
Emergent Wetlands	-
Lower Sonoran Desert (Scrub shrub)	2,057.10
River Bottom	334.60
Total	**2,465.30**

Table 19. Baseline Acreages for Other Cover Types

Cover Type	Acres
Agricultural Cropland	249.70
Desert	961.90
Ditches	56.50
Open Water	100.50
Parks	9.60
Sand and Gravel	1,651.60
Soil Cement	33.90
Urban	341.60
Total	**3,405.30**

Table 20. Baseline Conditions Analysis Results

Function	Name	Baseline FCI	Baseline FCU
Fxn 01	Maintenance of Channel Characteristics	0.333	689
Fxn 02	Dynamic Surface Water Storage/Energy Dis.	0.423	955
Fxn 03	Long-Term Surface Water Storage	0.048	72
Fxn 04	Dynamic Subsurface Water Storage	0.083	131
Fxn 05	Nutrient Cycling	0.384	805
Fxn 06	Detention of Imported Elements and Compounds	0.333	726
Fxn 07	Detention of Particulates	0.311	701
Fxn 09	Maintain Characteristic Plant Communities	0.602	1,353
Fxn 10	Maintain Spatial Structure of Habitat	0.399	889
Fxn 11	Maintain Interspersion and Connectivity	0.377	854

Figure 23. Baseline FCIs for Va Shly'ay Akimel

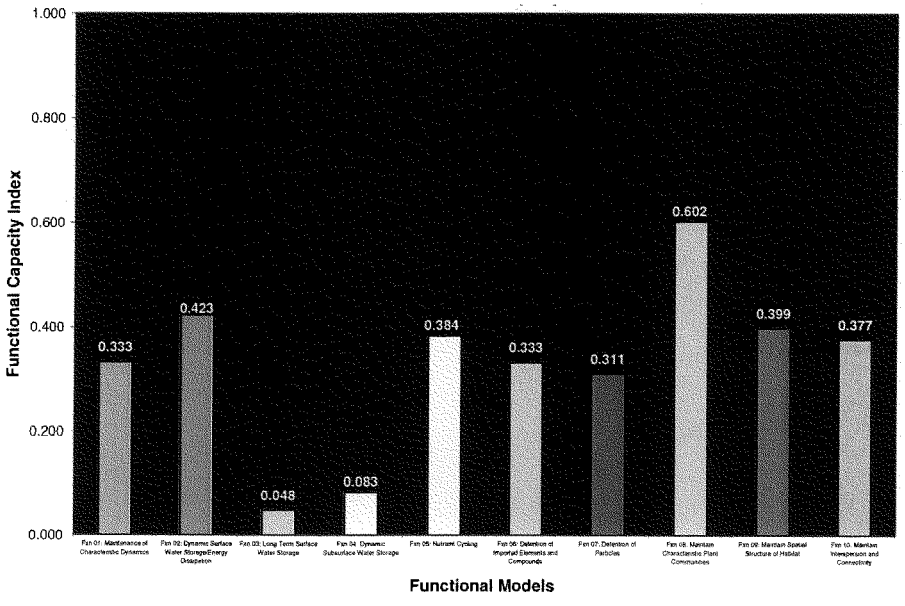
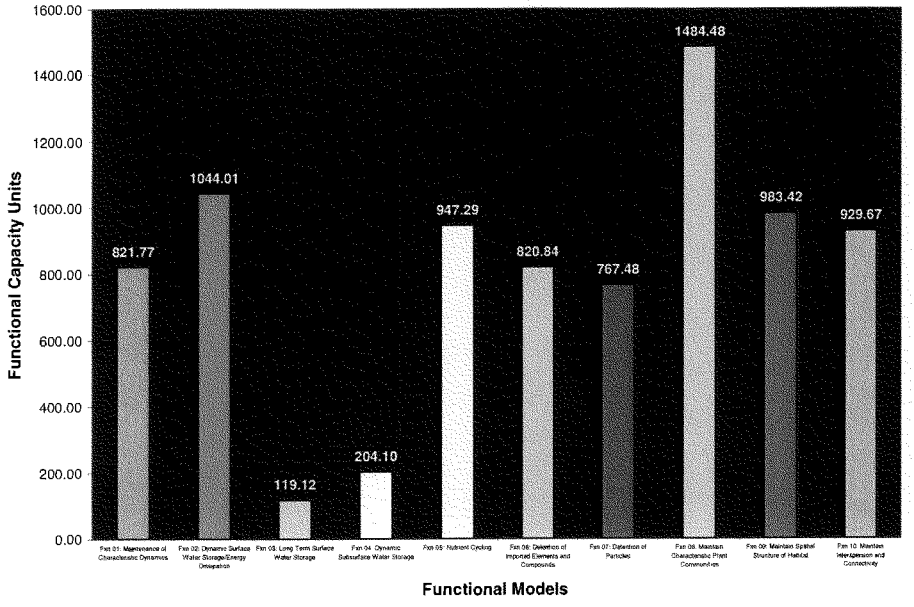


Figure 24. Baseline FCUs for Va Shly'ay Akimel



4.2.5 Hazardous, Toxic, or Radioactive Waste

The presence of hazardous, toxic, or radioactive wastes (HTRW) within the study area was evaluated for this study effort. If conceptual or planned study area activities would require moving or result in mobilizing HTRW-contaminated water or soil, the situation needs to be qualified and quantified. This is done so that associated costs can be estimated and a team decision made regarding the viability of continuing to include suspect or contaminated zones within the overall study plan. General examples of conceptual activities that have to be considered are the increase in groundwater elevation that might result by the direction of irrigation water in such a way that the water reaches and mobilizes previously-immobile contaminants. Actions that could mobilize contaminants in adjoining property must also be considered.

A Phase I Environmental Site Assessment (*hereafter*, "Phase I EA") for this study was completed by Liesch (2002) under contract to SRPMIC, as an in-kind services product. By necessity, a Phase I EA is a generalized document when it addresses a study area of this size in the early stages of conceptual alternative evolution. The Liesch (2002) effort included database searches, aerial photo examination, interviews, a walk-over survey,

visits to some of the businesses and quarries, a listing of all uses of land in the study area, and an assessment of the overall findings. Liesch (2002, p. i), in the Phase I EA, compiled a list of over 50 different sites of "development" and/or "utilization," apparently so as to completely document existing and known past land use and practices in the study area. Because analysis of the entire study area would be problematic, the investigations focused on the areas slated for potential study alternative inclusion, and their adjacent properties, plus those areas that could be potentially affected by project implementation. Liesch (2002, pp. ii, 30, 31) concluded that 14 specific businesses or landfills were "environmental issues," and that an unspecified number of unspecified properties also had "environmental issues" regarding ASTs[1], USTs[2], and potential TSD[3] issues; plus environmental issues at unspecified locations throughout the study area regarding debris dumping, other illegal dumping, and the potential interactions between study area activities and existing irrigation runoff water, wastewater recharge ponds, water wells, septic tanks, water wells. In addition, the Corps' Geology & Investigations Section added several other items to a list of sites that required additional research and assessment.

All Existing Groundwater Recharge Sites

There are three separate, existing groundwater recharge sites in the study area (Sites 4, 17, and 53 on Figure 25). There are existing regulatory controls for at least one of the sites (the GRUSP), and probably for all of the sites, to guarantee that the local recharge-elevated groundwater surface does not increase to within 25 feet of the bottom of an existing landfill. The specific regulations involved were determined. Since all potential alternatives could include irrigation, many for the entire project life, interaction between ongoing groundwater recharge of other projects and irrigation of the study area was considered during the data collection phase. Definition of groundwater interaction with identified HTRW sites, particularly landfill leachate issues, was evaluated. Groundwater impact from irrigation runoff ponds ("Site" 5, of unspecified number and locations) was also factored into this analysis.

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[1] AST is "above ground storage tank".

[2] UST is "underground storage tank".

[3] TSD is "treatment, storage and disposal".

Increase in Proclivity to Overbank Flooding

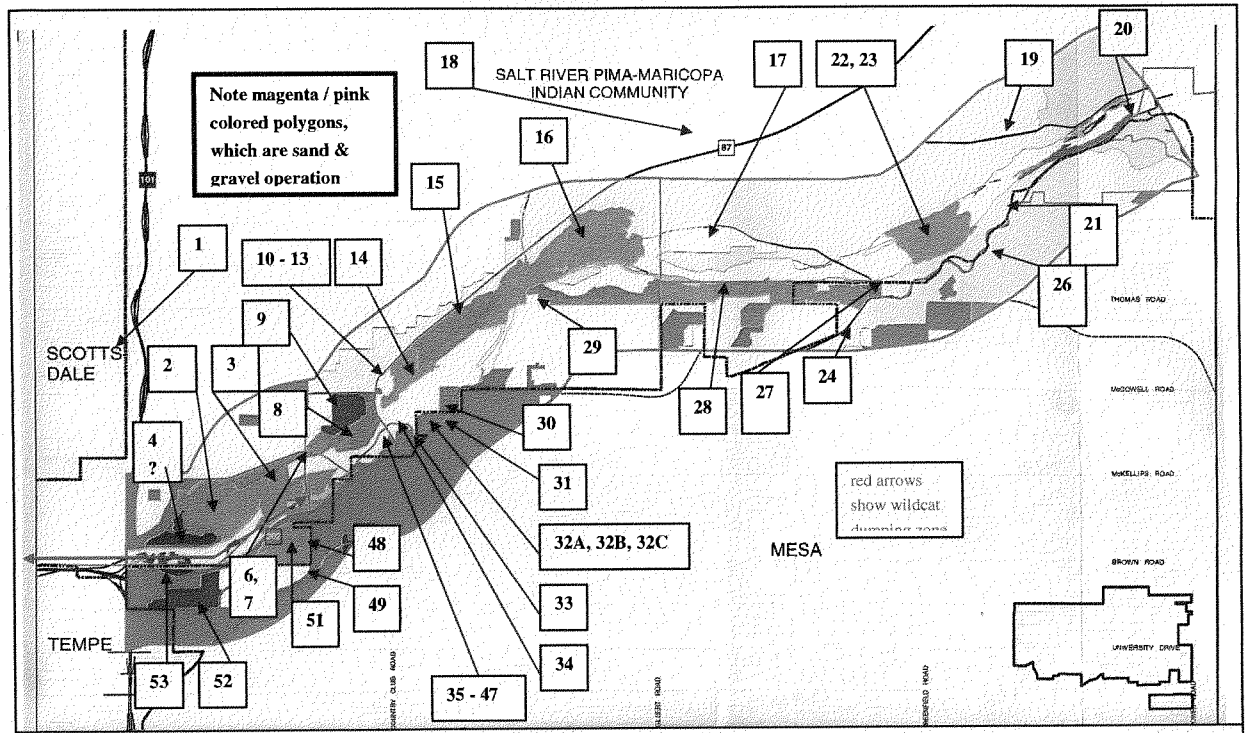
The effect that potential irrigation measures might have on increases in local groundwater elevation, and its potential for decreasing the capacity for infiltration during high-flow events on the Salt River, was also evaluated.

Landfills (Sites 8, 11, 15, 18, 30, 31, 32C)

Nearly all the sites are *formerly* used landfills; Site 18, the active Salt River landfill, is the lone exception (location provided by SRPMIC staff, May 2003). The sites are on or near the banks of the Salt River and, in some instances, in the river bottom a small distance outward from the banks. Some multiple locations, administratively, may be part of a ingle landfill, as noted by Liesch (2002), who recognizes five different landfills, but provides documentation suggesting two others. One of the landfills is being petitioned for Brownfields funding and another is a younger Resource Conservation and Recovery Act (RCRA) illegal dump site (dumped drums, at least partially cleaned up). All sites for which there is any information are unlined, so there is concern regarding what might be leached from them if restoration plantings on top of them are irrigated or if the water added to this study area to support wetlands, etc. raises the local groundwater surface elevation.

Two other landfill-related issues exist. Potential riverbank erosion needs to be addressed. There may or may not be riverbank hardening now or in the conceptual plans for those landfills that might be at risk of bank breaching at higher river flows. This needs to be specified. A reported debris pile at Site 2 (Salt River Sand and Rock quarry) is the load from one such breach. The risks of others to be breached are not addressed. These data gaps should be filled.

Figure 25. Activities in and near the Study Area with Potential Environmental Concerns



Land use activities in and near the Va Shly'ay Akimel study area, reported in the Phase I EA (Leisch, 2002). These include e some that are or at one time had potential to be HTRW sites, some that are non-hazardous waste sites, and some that are unrelated to environmental concerns. See Table 21 for Site Names and the Geotechnical Appendix for details on the numbered sites. See Geotechnical Appendix Sections 8, 9 for assessment of potential problems.

Table 21. Site Names for Figure 25

Site	Site Name	Site	Site Name
1	North Indian Bend Wash and South Indian Bend Wash	30	North Center St. landfill
2	Salt River Sand & Rock, MESA OPERATIONS	31	Vulcan demolition debris landfill
3	Vulcan asphalt batch plant and maintenance yard	32A	Mesa Police dept. firing range
4	SRPMIC's 5 groundwater recharge ponds	32B	Mesa (City) storage yard
5	Six or seven irrigation runoff detention ponds	32C	"Old Mesa" North Center St. landfill (under Mesa Police firing range)
6	Arizona Propane	33	ADOT storage yard
7	Saddleback Communications	34	Bingo Hall / Ray station
8	Cyprus landfill	35	Cashway Concrete and Materials
9	Cypress golf course	36	Valley Wide Contracting
10	RV storage facility	37	Alumi-Cover Awning Company, Inc.
11	Dumped drum site	38	Allpride Marble and Granite 556 W McKellips Rd
12	JRs Convenience Store	39	Carports, Etc.
13	Enviro-Systems	40	Superstition Springs Crushing
14	United Metro	41	Redburn Tire Company
15	Tri-Cities landfill and SRP methane gas power plant	42	Pete's Diesel Repair
16	Salt River Sand and Rock Beeline Plant	43	Little Dealer-Little Prices
17	Granite Reef Underground Storage Project	44	Karl Watkins
18	Salt River landfill	45	Contreras Contractors
19	Arizona Canal	46	Car Smart
20	Granite Reef dam	47	Artistic Ice Creations
21	Primate Research Center	48	Tevizo Hay Company
22	Salt River Sand & Rock, HIGLEY OPERATIONS	49	Sunward Materials / BCW
23	Salt River Sand and Rock offices	50	Unspecified other businesses at unspecified addresses
24	South Canal	51	Cemex quarry operations
25	Southern canal	52	Mesa Northwest Wastewater Treatment Plant
26	Talley Defense Systems	53	City of Mesa's 2 groundwater recharge ponds
27	horse farm	54	Non-specific residential property locations
28	Chandler Ready Mix quarry	55	Non-specific agricultural land locations
29	Lehi Cemetery	56	Hwy 202 construction and storage area

Rocket Propellant or Fuel Issue

The Talley Defense Systems site (Site 26) used propellant; was actively testing explosive materials as recently as 2002; has had numerous RCRA treatment, storage, and disposal (TSD) violations; has had a fire in a half ton of undefined materials; is in the watershed; and is less than a quarter mile from the river. It is *possible* that the rocket propellant enhancer *perchlorate*, a regulated substance and troublesome contaminant if it gets into the groundwater, is or has been used there and that some may have been lost into the environment in the processes of use, TSD violations, or the fire. This possibility was investigated and in general, information gathered about the operation and the materials used and tested on the site. The concern to this study would be what contaminants are actually present, if any, and which of those might be mobilized by the study's potential to raise local groundwater elevations. Active explosives testing has ceased (Personal communication, SRPMIC staff, May 2003).

Known and Possible RCRA Sites

A known RCRA site called the "drum site" (Site 11) was investigated. The concern is the documented illegal drum dumping, some with RCRA materials in them, some removed, and some completely disintegrated on site with contents winding up on the surface. The interests include what may have leached into the study area, how deep it has gone, and what might alternative plans mobilize, if anything, by raising the groundwater surface either locally or by irrigating plantings on the surface. It may even turn out to have been remediated during either the expansion of the adjoining SRPMIC golf course or Arizona Department of Transportation's (ADOT) past re-routing of the Country Club Drive Bridge. The Phase I assessment raised but did not address these possibilities. At a separate location, there is an issue with the surface debris scraped off the Arizona Propane site (Site 6); more information should be obtained to verify that it is not an RCRA site.

National Priorities List (NPL) Groundwater Contamination Site

The site may be an important concern. However, the Phase I EA, limited to what is in the NPL general database, does not verify whether this site has been remediated. If remedial actions have taken place, there will be other available documentation, which should be obtained at this stage of the study. The site (Site 1, designated with a large blue rectangle) is the Indian Bend Wash NPL site, with trichloroethylene (TCE) in the groundwater. This site adjoins the downstream end of the study area, where some

alternatives may impact it by increasing the local water table through irrigating proposed plantings. This potential impact needs to be determined. The interaction between the many existing groundwater recharge ponds adjoining or near the NPL site and potential study irrigation impacts could be crucial or could be a non-issue.

"Wildcat" Dumping

"Wildcat," or uncontrolled, random dumping of materials has occurred in and along the river in the study area, including soils, concrete, old tanks, asphalt, household debris, and vegetation waste, according to the Phase I assessment. The debris is found between approximately the Alma School Road crossing and the Hayden Road crossing about 3½ miles downstream (Personal communication, SRPMIC staff, May 2003), totaling about 2¼ river miles as impacted in the study area. The sites, along with precise locations, should be cataloged. At worst, what may reasonably be expected are small RCRA-type issues or some small hydrocarbon-contaminated soil issues. Soil removal likely would be the remediation, if any is needed. Gathering more data would be the first step. Somewhat related, although not wildcat dumping, is a large debris pile reported at the Mesa (Dobson) Operations sand and gravel production area (Site 2). Debris, according to the Phase I assessment, were washed out from landfilled waste that were freed when banks surrounding unspecified upstream landfill(s) were breached during past floods.

Leaking Underground Storage Tanks (LUSTs)

There are eleven LUST properties among the sites of environmental concern. However, according to the regulatory database summary in the Phase I assessment, eight of those properties has been remediated and is "case closed" and no longer under regulatory oversight as an environmental concern. Only one involved any groundwater contamination (Site 33). There is no suggestion that any sites currently are under remediation. Site 48 is classed as "undefined" in the regulatory database reported in the Phase I assessment. However, the status of Site 14 (United Metro) is unclear, as is that of Site 2 (Salt River Sand and Rock, Metro [or Dobson] Operations). Other regulatory file data reportedly exist showing that all three of these sites have been resolved (Personal communication, SRPMIC staff, May 2003). These data have not yet been made available for incorporation into this document. Further research into regulatory oversight files, such as those of the Arizona Department of Environmental Quality (ADEQ), in Phoenix, may be useful in these cases. Five of the LUST sites are clustered in a commercial business district along Country Club Drive at Highway 202 and along McKellips Road

near Country Club Drive; two others are along Alma School Road. Four others are in or adjacent to the Salt River bottom, associated with the sand and gravel quarry or batch plant operations. Those sites in or adjacent to the Salt River include Site 3 (Vulcan), which is "case closed;" Site 28 (Chandler Ready Mix), which is also "case closed;" Site 14 (United Metro), status uncertain; and Site 2, Salt River Sand and Rock, Metro (or Dobson) Operations, status uncertain.

Sand/Gravel/Cement/Asphalt Quarry and Plant Operations (Sites 2, 3, 14, 16, 22, 23, and 51)

These are located in the Salt River or adjacent to it; some have relatively minor, or potential, or anticipated TSD issues according to the Phase I assessment. There are seven such locations, most owned by SRPMIC, but most with three or four operating lessees. Boundaries of the operations (presumably the quarry perimeters) are shown on Figure 25. Most of the sites were defined by Liesch (2002) as having minor TSD issues related to washing and maintaining vehicles and chemical storage. Not all were visited by Liesch and one (Site 16) was not listed in Liesch (2002), so there are unknowns to be addressed. The sites possibly could release chemicals into the environment if flooding occurs; however, the likely impact would be small. Whether this risk is acceptable would have to be determined.

Regulated Materials Use

Numerous sites (among the 56 listed in the Geotechnical Appendix) use some types of regulated materials, which could become hazardous waste if released into the environment. These sites are not listed as problem sites in any regulatory database, and most, if not all, have *no* environmental problems associated with them. For the purposes of USACE criteria, a complete listing of these sites and the materials they use, treat, store, or dispose of was compiled. Much, if not all, of this information is in the Phase I assessment.

4.2.6 Cultural Resources

A complete records and literature search report was submitted by Archaeological Research Services (ARS) on the study area. The report by ARS determined that there are 233 previously identified historic and prehistoric sites located within the study area. Prehistoric agricultural canal systems are also located along and near the river. Although there have been 329 separate cultural resources projects and studies conducted over the years, major areas are yet to be surveyed. Most of these sites have not been evaluated for the National Register of Historic Places (NRHP). In reviewing the map provided by ARS, many of these sites are located near areas likely to be preferred areas for restoration.

In formulating a restoration plan, the SRPMIC has expressed a desire to avoid impacts to their cultural resources. Towards that goal, a field survey was conducted of parcels not previously inventoried. The survey covered 1,000 acres, which included areas selected by the SRPMIC, the City of Mesa, and the USACE. The areas selected appeared to be potential areas for restoration. As a result of this survey, 33 historic and prehistoric archaeological sites were identified. Of these sites, 20 were evaluated as eligible for the NRHP. Thirteen were evaluated as indeterminate, requiring additional studies to evaluate.

Statistical Research, Inc. (SRI) conducted a Class III Cultural Resources Survey and archaeological testing on the Salt River Pima-Maricopa Indian Community in November 2003 of an additional 300 acres. SRI completed the survey in December 2003 and submitted a draft report entitled, *A Class III Cultural Resources Survey and Testing Recommendations for the Proposed Salt River Restoration Project, Maricopa County, Arizona in* January, 2004. This report summarized the survey results and contained a testing plan concerning six archaeological sites, SRPMIC 90, 105, 108, 109, 112, and 113

Only one feature, a historical-period bell-shaped storage pit, was identified in the trench profiles at SRPMIC-109. Excavation of the pit resulted in the recovery of three mid-to-late nineteenth century ollas, a small jar, and two bowls. Each of the ollas was capped with a large metal can. A possible stove pipe, a metal spoon, metal cup, and metal pan were also preserved exposure of a small trash scatter that rested on the same surface into which the storage pit was dug. Artifacts in this trash scatter include four cans and an intact wine bottle with a push-up base and hand-applied finish.

Testing at SRPMIC-105 was negative. No buried features or artifacts were encountered during the testing. One 20-m long north-south trench was also excavated through a large hummock, but again no buried artifacts or features were exposed.

At SRPMIC-108 all artifacts within the surface collection units were collected, along with a small chipping station. Between 10 and 30 cm of sediment were removed and two small shallow pits were exposed. Both pits were excavated. The fill in Feature 15 was ash-stained and collected *en-masse* for flotation analysis. Both backhoe trenches were placed on the lower Lehi terrace along the drainage that bisects the site. No artifacts or features were exposed in the southernmost trench. The northernmost trench, however, contains a cultural deposit that is ash-stained and replete with fire-cracked rock. This stratum is best interpreted as a rake-out accumulation associated with a nearby buried roasting pit or horno. One roasting pit, Feature 1, was visible at the surface during a previous survey. It was bisected during testing and contains large amounts of wood charcoal and fire-cracked rock.

Testing of SRPMIC-90 involved the excavation of two 10-m long trenches in an artifact concentration at the east end of the site, along with the mechanical scraping of a 5-by-25-m area in another artifact concentration at the west end of the site. These excavations were placed in areas containing relatively high densities of surface artifacts. A series of 5-by-5-m surface collection units were placed over the areas to be mechanically excavated. All artifacts within these units were collected. No buried features or artifacts were encountered in the first artifact concentration. Two small, shallow thermal pits, however, were exposed in the 5-by-25-m mechanical stripping unit placed in the other artifact concentration. Both of these pits were completely excavated and the fill from each of them was collected en-masse for flotation analysis.

Testing efforts at SRPMIC-112 and 113 focused on determining the age and function of two ditches that could be followed across the west end of the parcel. Each of these ditches was designated a site number during the survey. Backhoe trenches were excavated across both ditches. Styrofoam was found in the bottom of SRPMIC-112 and no subsurface expression of SRPMIC-113 could be found. The styrofoam in SRPMIC-112 rested on the bottom of the ditch only 15–20 cm below the modern surface. A large gravel deposit was found to exist immediately beneath both ditches. As such, neither of them would have conveyed water, nor could they have held water for long. SRPMIC-112 and 113, therefore, are considered modern drainage ditches.

Prior to project implementation, additional studies may be required. In addition to survey work, sites that could not be evaluated based on survey information would require additional studies. This would probably consist of test excavations to determine their subsurface potential to contain important information.

4.2.7 Socioeconomics

4.2.7.1 Flood Damages

(a) Historical Flood Damages

The highest recorded flow in the vicinity of the study area since the construction of the SRP system occurred in February 1980, when 170,000 cfs was reported at Jointhead Dam. Jointhead Dam is located downstream of the study area at 48th Street in the City of Phoenix. All bridges along the Salt River were forced to close during that flood except the Central Avenue Bridge in the City of Phoenix. Subsequent to that event, most of the remaining bridges crossing the Salt River have been rebuilt to withstand flow rates of 200,000 cfs and greater.

High releases (approximately 130,000 cfs) were also experienced in 1993. Winter floods during the first three months of 1993 caused extensive damage to property and crops throughout Maricopa County. Total flood damages throughout the state during this storm were estimated at over $250 million in current dollars.

Information regarding damage estimates specific to the study reach was not available. However, current hydrologic data for the Salt River through the study area shows that peak discharge for the 100-year event at Gilbert Road is approximately 172,000 cfs. Current hydraulic analysis indicates that there are very few structures in the 100-year floodplain. Therefore, it is likely that damages throughout the study area reach were limited during these storms.

(b) Floodplain Boundaries

Before determining potential damages within the floodplain, an inventory of structures susceptible to damage and estimates of the value of these structures must first be developed. Figure 26 shows the Base Year (2011) floodplain boundaries. As shown on Figure 26, the floodplain is primarily confined within the channel, with the exception of two "breakout" areas (labeled "1" and "2"). Breakout Area 1 extends south of the Salt River and is generally bounded by Lehi Road on the east, Harris Street on the west, and

McDowell Road on the south. This area is rural and comprised primarily of residential properties east of Gilbert Road and agricultural properties west of Gilbert Road. The other area subject to potential flooding, Breakout Area 2, is also located on the south side of the Salt River, west of Mesa Drive and north of McKellips Road. This area includes more dense development, including mobile homes as well as some commercial and industrial properties. Even for most of these two areas, the probability of flooding in any given year is generally less than one percent.

The floodplain is further segmented into sub-areas, or reaches, for analysis purposes. Critical factors used to determine reach boundaries include discharge/frequency characteristics, overflow spatial characteristics, and economic activity. Figure 27 shows floodplain reach boundaries.

As shown in Figure 27, Reaches 2, 3, and 6 contain all of the floodplain structures. Reaches 2 and 3 include large mobile home parks containing hundreds of mobile home units, as well as commercial and industrial structures along the main streets of McKellips, County Club, and Center. Reach 6 includes large agricultural lots west of Gilbert Road with very few structures. Reach 6 east of Gilbert Road includes rural residential development with some agricultural acreage as well.

Figure 26. Base Year (2011) Floodplain Delineations

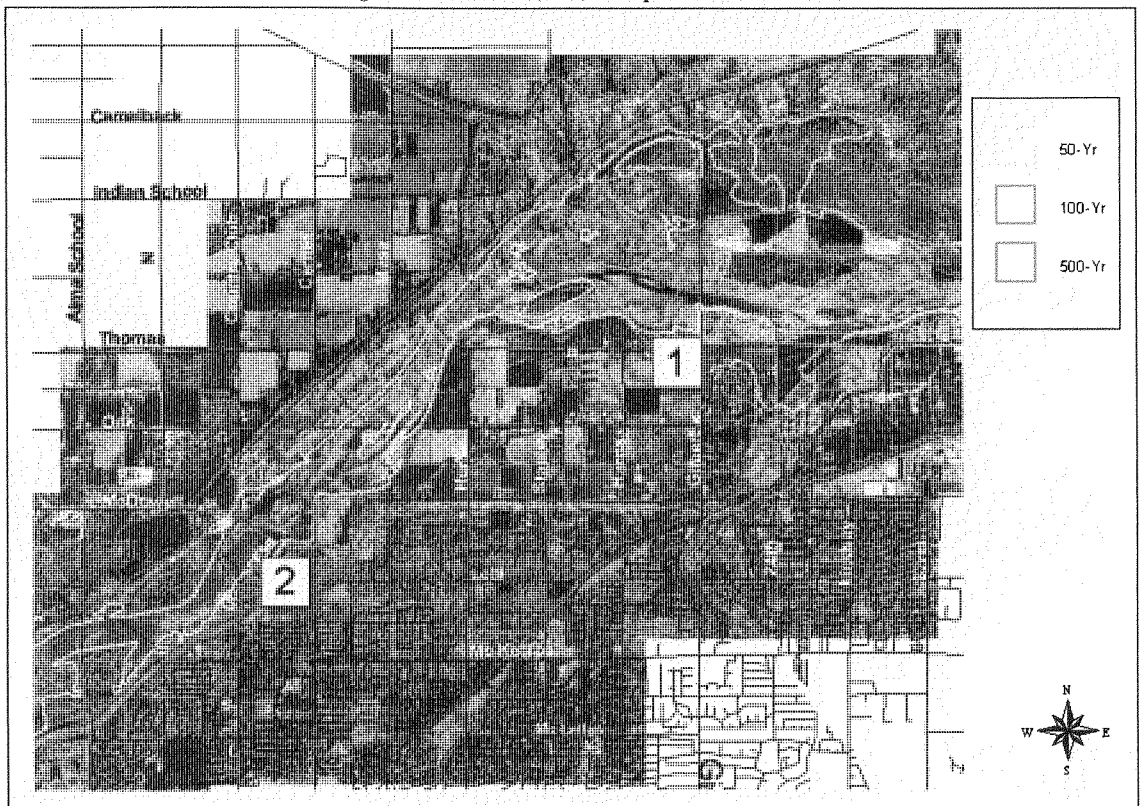
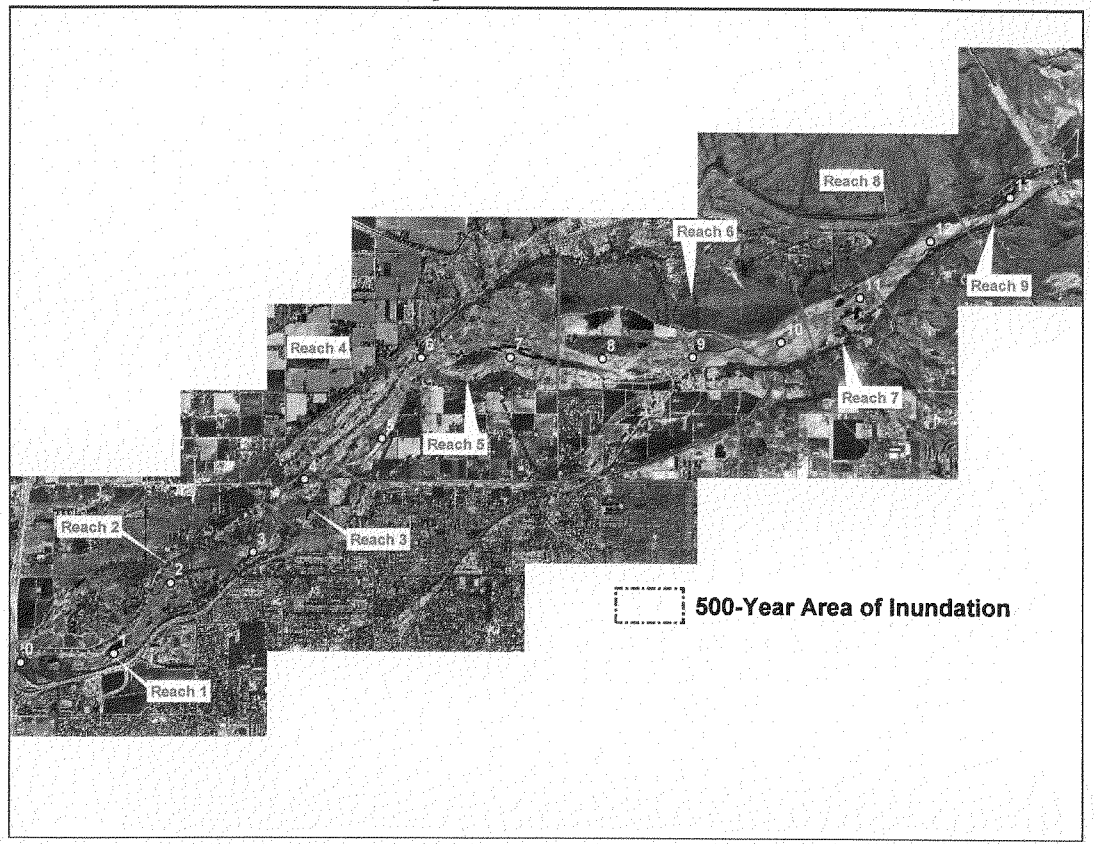


Figure 27. Reach Delineations



(c) Number of Structures

The number of structures in the 100- and 500-year floodplains was determined based upon an analysis of aerial photography, parcel maps, real estate assessor's data, and a site survey. As shown in Table 22, there are approximately 883 structures in the Va Shly'ay Akimel floodplain. Of these, 90 percent are residential (SFR/MH). Roughly 236 structures are located within the 100-year floodplain boundaries (about 27 percent of the structures in the 500-year floodplain). Most floodplain structures are located in the downstream breakout area (Reaches 2 and 3). Most of these structures are residential, primarily mobile homes.

Table 22. Number of Structures

Structure Type	100-Year	500-Year
SFR	66	151
MH	137	636
Industrial	18	57
Office/Commercial	13	35
Public	2	4
Total	**236**	**883**

(d) Value of Structures and Contents

Content values were estimated as a percentage of depreciated structure value for each structure. Content ratios by structure type were based upon values derived for several Los Angeles District feasibility studies. Table 23 provides a summary of floodplain structure and content value by category.

Table 23. Value of Structures and Contents by Structure Type – 500 Year Floodplain
(in $Millions)

Structure Type	Structure Value	Content Value	Total
SFR	17.5	8.7	26.2
MH	14.8	7.4	22.2
Industrial	4.0	6.8	10.8
Office/Commercial	6.1	7.3	13.4
Public	0.8	0.3	1.1
Total	**43.2**	**30.5**	**73.7**

As shown in Table 23, the total estimated value of property in the floodplain is about $73.7 million. Residential properties account for about 66 percent of this total, even though they represent about 90 percent of the total number of structures. This is attributable to the relatively low value of the residential properties (primarily mobile homes) relative to commercial and industrial structures.

(e) Project Structure and Content Damages

Risk-Based Analysis

A risk-based analysis (RBA) procedure has been used to evaluate without-project flood damages in the study area. Guidance for conducting RBA is included in the Corps of Engineers Regulation 1105-2-101 (1 March 1996). The guidance specifies that the derivation of expected annual flood damage must take into account the uncertainty in hydrologic, hydraulic, and economic factors. Risk and uncertainty are intrinsic in water resource planning and design. They arise from measurement errors and the inherent variability of complex physical, social, and economic situations. The focus of RBA is to concentrate on the uncertainties of variables having the largest impact on study conclusions.

The following are the primary sources of uncertainty for flood damage analysis studies.

- Discharge/Probability: Discharge/probability uncertainty for this study has been estimated for each reach using the graphical method, based upon an equivalent record length of 105 years.

- Stage/Discharge: Standard deviations of error for stages associated with a range of discharges were provided for each reach. The error values generally increase in value

from about 0.1 feet for the 5-year event up to about 0.7 feet for the 100- to 500-year events.

- Geotechnical Features: Soil cement levees are located immediately upstream of the SR 101/202 interchange.

- Structure Elevation: Ground elevations for each structure were derived from a 10-foot interval digital elevation in GIS format (used in turn to generate 4-foot contour interval shape files). First floor elevations above ground level were estimated during a field survey. The error associated with the first floor elevation estimates is assumed to be normal, with a mean of 0 and a standard deviation of 2.94 feet.

- Structure Values: The errors associated with structure value estimates are assumed to be normal, with a mean of 0 and standard deviations ranging from 10 to 21 percent (depending on structure type), based upon upper and lower ranges of Marshall and Swift factors.

- Inundation Depth/Percent Damage: Damage percentages for both structures and contents are based upon corresponding structure values.

As calculated by the HEC-FDA program, without-project damages by event for base year (2011) conditions are shown in Table 24. The non-damaging event is approximately the 10-year event. Most reaches do not incur damages until less frequent events. Damages calculated for the 25-year event are approximately $2 million. Damages increase significantly for the 50- and 100-year events, with only a marginal increase for the 500-year event.

Table 24. Damages by Reach and Event (Base Year 2011)

(in $1,000s)

Reach	10	25	50	100	500
2	-	4	223	650	650
3	-	265	2,298	4,344	4,452
6	70	1,293	4,379	5,812	5,812
Total	**70**	**1,562**	**6,900**	**10,806**	**10,914**

Expected annual damages by reach and structure type are shown in Table 25. Damages to residential structures and contents (SFR/MH) represent over 71 percent of total damages. Most damages occur in Reach 6 even though more structures are located in

Reaches 2 and 3. This is due to the higher probabilities of flooding in the upstream reach. In addition, the residential structures in Reaches 2 and 3 are mostly mobile homes, which have a lower value than single-family residences located in the upstream reach.

Table 25. Expected Annual Damages by Reach and Structure Type (Base Year 2011)
(in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	2.4	9.4	3.6	-	15.4
3	53.3	21.0	32.1	1.9	108.3
6	177.7	13.2	2.6	-	193.5
Total	**233.4**	**43.6**	**38.3**	**1.9**	**317.2**

4.2.7.2 Population Trends

The study area is located in Maricopa County and extends through the SRPMIC and adjacent City of Mesa. As of the year 2000, Maricopa County had a population of 3.07 million. From 1995 to 2000, County population grew by over 543,000, representing an average annual growth rate of nearly four percent.

The City of Phoenix is by far the largest in the county in terms of population. Phoenix's population grew from about 1.15 million in 1995 to over 1.32 million in 2000, or by about 2.7 percent on an annual basis. About 43 percent of the County population resides within the City of Phoenix, although this ratio is declining, due to higher growth rates outside the city.

The City of Mesa was incorporated over 100 years ago. Between 1930 and 1960, the City's population and land area grew by about 30,000 and 12.7 square miles, respectively. By 1980, the City's boundaries expanded to over 66 square miles, and the population increased to over 152,000. The City now encompasses over 128 square miles and is Arizona's third largest in terms of population, following Phoenix and Tempe. Mesa's population as of 2000 was 396,375. This value represents an average annual increase of about 3.2 percent over the 1995 population of 338,117.

The SRPMIC is home to the Onk Akimel Au-Authm (Pima) and Xalchidom Pii-pash (Maricopa) Indians, descendants of the Hohokam Indians. The Community covers an area of nearly 84 square miles and shares boundaries with the cities of Mesa, Tempe, Scottsdale, Fountain Hills, and metropolitan Phoenix. The population of the SRPMIC

was 6,405 as of the year 2000, according to the U.S. Census. From 1990 to 2000, population increased by 1,553, or an average annual rate of about 2.8 percent. Thus, the combined population of the communities adjacent to the study area (Mesa and SRPMIC) exceeds 400,000.

4.2.8 Land Use

The land use pattern is made up of a patchwork of jurisdictional and political boundaries between the City of Mesa, unincorporated areas of Maricopa County, and the SRPMIC. Remnant County islands are located in two locations within the study area and are completely surrounded by the City and the SRPMIC. These lands are within the City's sphere of influence and would likely be annexed by the City as growth and development reaches the area.

Several gravel mining operations are located along the Salt River, with processing operations occurring along its banks. The river contains a large groundwater recharge basin in the central portion of the study area, just east of North Gilbert Road.

The land area north of the Salt River is generally within the SRPMIC. Upland areas south of the river are generally within the City's jurisdiction, but islands of unincorporated areas of the County are also present. A clear contrast is evident between the rural and open character of the upland areas north of the river, within the SRPMIC, and the more urbanized area south of the river, within the City's sphere of influence.

Created by Executive Order in 1879, the SRPMIC consists of 52,600 acres, located 15 miles northeast of the City of Phoenix. The SRPMIC is home to nearly 6,000 enrolled members representing two pre-American Sovereign Indian tribes, the Pima and Maricopa. The SRPMIC maintains 19,000 of its acres as natural preserves. The secondary land use is agriculture, which supports a variety of crops, including cotton, melons, potatoes, brown onions, and carrots (SRPMIC, 2002). The majority of the central and eastern portions of the study area that are located directly north of the Salt River are a combination of natural preserve areas and agricultural lands. Gravel mining and processing, two closed landfills, and other industrial operations have a significant influence on land use patterns in the western portion of the study area that is located along the north banks of the river. Other land uses are scattered intermittently throughout the area along the north banks of the river, including a shooting range, a recreational vehicle park, private farms, and a commercial golf course.

The west and central portions of the study area south of the river and within the City's sphere of influence are largely made up of very low-density rural residential uses to higher-density suburban residential uses. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern portion of the study area. The south banks of the river are also scattered with gravel mining and processing operations.

4.2.9 Real Estate

The proposed restoration activities would occur primarily within the Salt River floodplain. Although the proposed project is being undertaken by the USACE, the State, County, City, and SRPMIC have jurisdictions over planning and development decisions within their respective political boundaries in the study area.

State of Arizona

The State of Arizona adopted growth management legislation, known as "Growing Smarter" and "Growing Smarter Plus," in response to concerns about the rates of population growth in communities throughout the state. This legislation requires all cities in Arizona to update their General Plans.

Maricopa County

Portions of the study area are within unincorporated areas of the County and are governed by County planning and development activities.

City of Mesa

The City of Mesa General Plan defines the direction of growth and the type of development that is desired and expected to occur in Mesa between 1996 and 2016.

SRPMIC

The SRPMIC is considered a sovereign nation and is not under the regulatory or political jurisdiction of any of the local governments in the area or the U.S. federal government. All land use activities are guided by the SRPMIC's established procedures and activities. Three general categories of land with their respective estimated values were used in this study:

- River channel land - $5,000 per acre
- Farmland outside and above river channel - $7,500 per acre
- Sand and gravel operations - $15,000 per acre

4.2.10 Recreation

Recreation along the Salt River corridor is highly dependent upon the availability of surface water and riparian habitat, both of which are dependent upon the supply and availability of groundwater. The Salt River through the SRPMIC and the City of Mesa *currently* consists of dry river bottom. As a result, virtually no formal recreation activities take place. The only improved recreation area is Riverview Park, which is adjacent to the Salt River at the west end of the study area. The 51-acre park includes lighted softball fields, basketball and volleyball courts, picnic facilities, ramadas, and a three-acre urban fishing lake. Riverview Golf Course (a nine-hole course) is adjacent to the park. Annual attendance is estimated at approximately one million persons. The SRPMIC has a limited number of outdoor recreation facilities near the study area. The two primary facilities include the Salt River Baseball Field and the Salt River Little League Field. Other existing and planned recreation facilities along the Salt River downstream of the study area include Tempe Town Lake, the Rio Salado Project, and the Tres Rios Project.

Recreation options likely to be considered for this study would be passive in nature, complementing the primary project purpose of providing habitat restoration along the Salt River. Many factors contribute to making the proposed riparian habitat area extremely attractive in terms of recreation potential. They include:

- Potential to integrate a trail system for hiking and biking
- Availability of access roads for joint-use as above

- Availability of suitable areas for bird-watching, photography, and other viewing activities
- Potential use of area for cultural education
- Potential use of area for environmental education
- Advantages of large areal scale of project to provided diverse activities in an un-crowded setting
- Potential to foster stewardship
- Unique opportunities to focus recreation in a riparian-dominated environment

4.3 Future Without-Project Conditions

The future without-project condition is defined as that condition expected to exist over the 50-year period of analysis in the absence of any action taken (by the Federal Government) to solve the stated problems. It consists of the base year (2011) conditions projected to a future year, utilizing reasonable assumptions of how the base year conditions may change if no Federal action takes place. The future condition year for this study is 2060. Forecasting this condition is vitally important to the evaluation and comparison of alternative plans and the identification of impacts (both beneficial and adverse) attributable to proposed Federal actions. The future without-project condition forecast provides a description of anticipated actions external to the project and the anticipated consequences of these actions.

The future without-project condition has several general assumptions. First, the wetland and riparian biotic communities will in general degrade over time with reduced water supply and the influx of invasive/exotic species. Urban encroachment will continue, resulting in loss of buffer and native vegetative communities. Continued commercial activities within and immediately adjacent to the channel disrupt hydrologic regimes and cause the degradation of existing habitat and impact the recruitment of native riparian cover types.

For the purposes of this analysis, it is assumed that no new ecosystem restoration or flood damage reduction projects would be constructed in the absence of a Federally cost-shared and locally supported project.

4.3.1 Hydrology and Hydraulics

The future without-project HEC-RAS model was run to simulate the 5-, 10-, 20-, 50-, 100-, 200-, and 500-year flood events. The models indicate that the Gilbert Road Quarry pit captures all the flows.

The models also showed that under the future without-project conditions, the water surface elevations would be lower between River Stations 0.00 and 10.95 when compared to the existing conditions for all flow events. The long-term scour of the riverbed throughout most of the study area would gradually result in an increase in channel capacity and lead to this lowering of the water surface elevation. Between River Stations 10.95 and 11.99, the models for the 5- through the 50-year events produce higher water surface elevations. The difference ranges from 2 feet at River Station 10.95 to 0.5 feet at River Station 11.99. The reverse of conditions between River Station 0.00 and 10.95 would occur in this reach. Gradual deposition of sediment would result in an increase in the water surface elevation. Upstream of River Station 11.99, the water surface elevations either remain the same or are lower than those in the existing conditions.

Floodplain inundation limits were delineated for the 5-, 10-, 20-, 50-, 100-, 200-, and 500-year flood events. In general, inundation areas for the future without-project condition are smaller than those in the existing condition except between River Stations 10.95 and 11.99 for the 5- through 50-year peak flow events. Detailed maps with the contours, cross sections, and inundation areas are included in the *Hydraulic and Sedimentation Analysis Final Without-Project Analysis Report* (WEST, 2002).

In the short term, gravel mining in the river would cause degradation upstream and downstream of the gravel pits and aggradation within the gravel pits. Long-term channel responses are entirely dependent on future development in and around the channel. Aggradation and degradation would continue to occur as long as gravel mining operations exist in the vicinity of the channel. With no additional gravel mining, the channel would reach a state of equilibrium only after all the gravel pits are accessed through the natural migration of the river system or if restoration activities have been conducted.

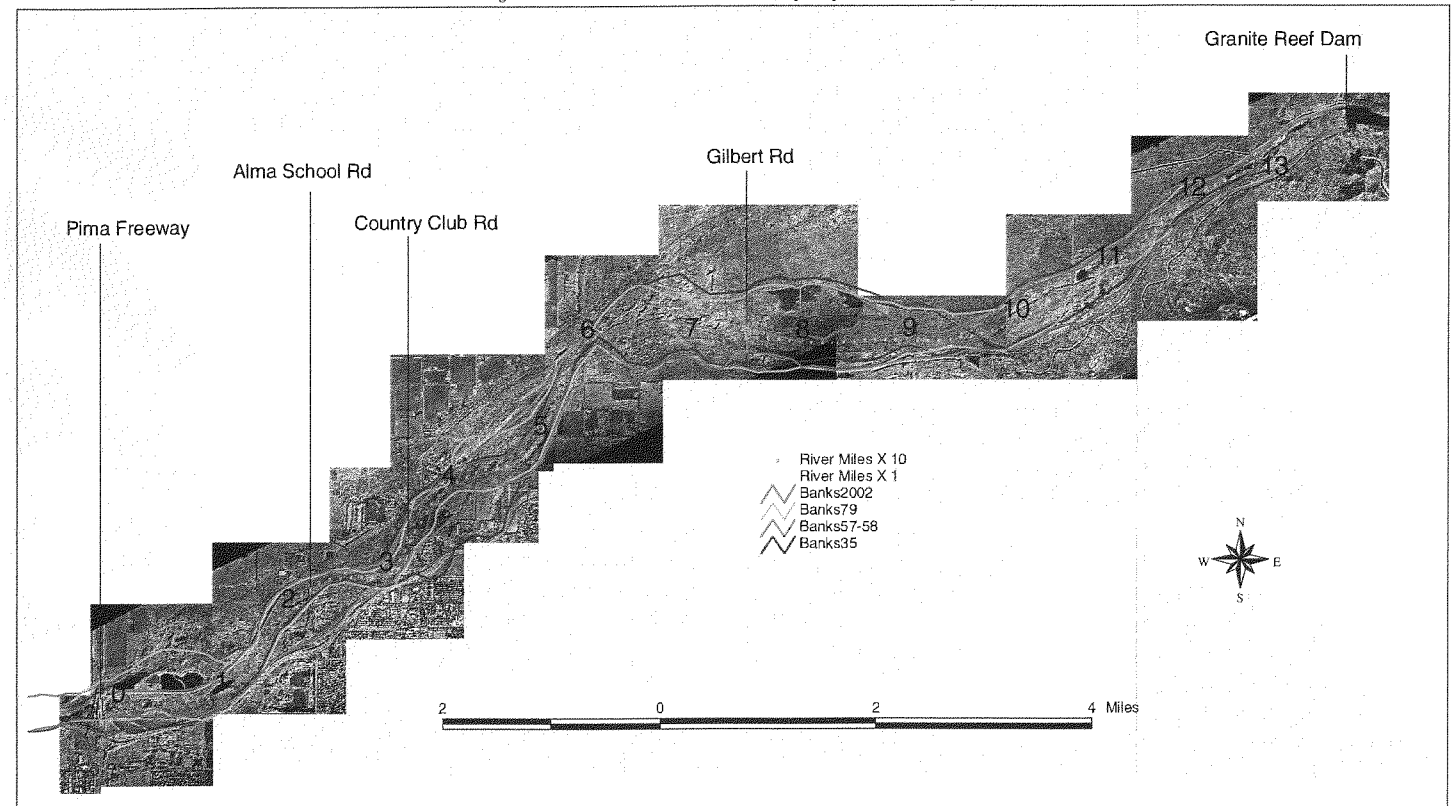
4.3.1.1 Erosion Analysis

The Lehi Cemetery is located on SRPMIC property on the south side of the Salt River just north of Thomas Road. There are concerns that bank erosion occurring near the cemetery would affect or damage it in the near future. To address these concerns, an engineering analysis was conducted to determine (1) if there is erosion occurring at Lehi Cemetery and (2) if so, at the rate at which it is occurring and how long it would take to impact the cemetery.

Based on aerial photos from 1935, 1957, 1979, and 2002, it was determined that the south bank has been migrating south, towards Lehi Cemetery. This migration can be attributed to flow events, which have periodically occurred (on average once every three years) in the Salt River. Mining may have also contributed to the erosion.

Using the location of the bank line position from the aerial photos (Figure 28), the long-term erosion rate was estimated to be, on average, 11 feet per year. This rate is dependent on the frequency, discharge, and duration of flow events and on channel geometry. Due to the current hydrologic condition (continuing drought conditions and increased storage in the Salt River watershed upstream of the Granite Reef Dam), the erosion rate may be less. Based on the estimated erosion rate, Lehi Cemetery would be impacted by erosion in approximately 33 years. That is, the south bank line would reach the cemetery in approximately 33 years.

Figure 28. Historic Channel Bank Locations (Superimposed on 2002 Imagery)



4.3.2 Environmental Resources

4.3.2.1 Biological Resources

In general, the condition and quality of biological resources within the Va Shly'ay Akimel study area are expected to decline. In this particular study, two key factors were used to predict the future without-project conditions: continued urban development and continued sand and gravel mining activities within the channel.

(a) Urban Development

The City of Mesa plans extensive commercial and residential development on land within their jurisdiction, along the entire southern bank of the Salt River. This urban development would increase the demand for local water supply, taxing ground and surface water resources. As other demands for water increase, the availability of water for existing vegetative use, or future vegetation expansion, decreases. The SRPMIC plans for some development on the north side of the river, within their jurisdiction, but it is not expected to be extensive.

Increased urban development increases the amount of treated effluent water and surface runoff available. Currently, the existing vegetation found at the Pima Freeway (SR101) is supported entirely by treated effluent and surface runoff.

Other effects of increased urban development are an increase in building and human encroachment within the river, an increase in trash and debris that makes its way into the channel, and an increase in undesirable recreational activities within the river, such as use of off-highway vehicles.

(b) Sand and Gravel Mining Activities

The sand and gravel mining operations are a vital component of the SRPMIC economic base. Therefore, it can be assumed that these activities would continue through the project life timeframe. High-quality materials exist within the main channel as well as the overbank areas, so mining activities may expand to encompass new areas both inside and outside the main channel.

Mining activities affect the river in two important ways: by changing the behavior of the channel system and by creating disturbances that prohibit vegetation establishment. The process of sand and gravel mining creates large pits, or quarries, in areas where the material has been excavated. These quarries can be up to 50 feet deep and many acres in areal extent. If material is taken from the main channel, the invert level can change dramatically, leaving large reservoirs of water during high-flow events. The instability within the channel created by the uneven invert surface may cause headcutting upstream, excessive rates of deposition within the quarry, and downcutting downstream. As surface area is lost in excavation activities or lost due to erosion as a result of excavation activities, less area with the proper substrate is available for vegetation growth. The deep quarries also keep water flows further from the surface, therefore not available to surface vegetation that might rely upon the soil moisture provided by surface flows.

(c) Vegetation

Cottonwood-willow

Cottonwood-willow stands rely on fine soils near the main channel and currently exist in only disturbed, patchy areas, often dominated by saltcedar. If no restoration efforts are conducted, a continued decline in the quantity and quality of most areas of cottonwood-willow stands will occur due to a continued decrease in available surface water and groundwater and continued surface disturbance caused by the sand and gravel operations. Two exceptions to this are the areas immediately downstream of the Granite Reef Diversion Dam and the area at the Pima Freeway (SR101). The Granite Reef Diversion Dam currently seeps enough water to support riparian vegetation, including cottonwood-willow stands. Although this area has a heavy infestation of saltcedar, it does support healthy, native species. This habitat quality would likely remain high, assuming seepage from the dam continues. The second exception, the habitat found at the Pima Freeway (SR101), is supported by treated effluent and stormwater discharge. As urban development increases, so will these two water supply sources. However, in the absence of Federal action and if surface water needs increase more rapidly than effluent and stormwater discharge rates, this water source may be redirected and used elsewhere. If this occurs, the habitat would lose its water source and decline rapidly.

Mesquite

Mesquite currently exists only in small patches just below the Granite Reef Diversion Dam, likely relying on the seepage from the dam and the relatively high water table level at that location. Given the expected decline in available surface water elsewhere and the extremely low water table in the rest of the project site, mesquite would not expand its range within the project site.

Sonoran Desert Scrub Shrub

Scrub shrub occupies approximately 8 percent of the study area, mostly in the active channel of the river. The quality and quantity of the existing scrub shrub would likely decrease through mining disturbance and human encroachment. Mining activities remove all vegetation as part of the excavation operation; therefore, removal of scrub shrub would occur where mining currently exists and in all areas of expansion. The quality of scrub shrub would also decline given the magnitude of off-road vehicle use and use of the river channel for recreational purposes.

Wetlands

Wetlands occur in less than 1 percent of the study area, and those that exist are of generally poor quality. Again, the two exceptions are the area immediately below the Granite Reef Diversion Dam and the area at the Pima Freeway (SR101). Like the cottonwood-willow stands, if the water remains available to these sites, the wetlands can be expected to remain. Other wetland areas within the project site are of very poor quality and characterized by either seasonal or perennial open water and generally unvegetated. Open water wetlands are often associated with abandoned or stagnant quarry operations. While it is expected that these types of wetlands would remain, they would likely migrate alongside mining activities. Wetlands would be filled with material as others are created. Because of the disturbance associated with these wetlands, little vegetation is expected to establish or flourish, yielding a low-quality habitat.

4.3.2.2 Habitat Value

The Functional Capacity Units (FCUs) for each function were estimated for Target Years (TYs) 1, 6, 26, and 51. These projected values were then converted into average annual FCUs (AAFCUs). As shown in Table 26 and Figure 29, habitat values are projected to decline considerably (by about 13 percent) through TY 51. The AAFCUs for without-project conditions total 718.

Factors considered in the projection of without-project conditions include the continuing degradation of the river by incision, sand and gravel mining activities, and most importantly, urban development. The impacts were forecasted in terms of acreage losses as well as impacts associated with degrading water quality and vegetation composition and structure.

Increased urban development, whether residential or commercial, will lead to habitat degradation (and thus, a decline in AAFCUs) in a variety of ways. The most prominent degrading factors are: overall loss in habitat acreage, changes in the local hydrologic regime, and increases in human disturbance. Losses in habitat acreage would occur through development of land that might otherwise support various habitat types. Urbanization requires land surface, therefore any habitat that once occupied a site will be lost through land clearing, construction related activities, and replacement of the habitat by residences, commercial buildings, streets, and parking lots. What open space remains is generally of highly degraded quality, diversity, and extent. Urbanization also creates an increase in impervious land surface (pavement, asphalt, and concrete replacing pervious open space), which in turn affects local hydrologic regimes. Increasing the amount of impervious surfaces prevents precipitation from penetrating into the ground, thereby increasing overland flow. Overland flow carries pollutants from road surfaces, roofs, and parking lots, into drainage ditches. The debris and sediment it carries as it moves over the land, eventually empties into existing or restored habitat areas or the river channel itself, where it can be carried downstream into other areas. These pollutants and sediments can contaminate existing vegetation directly, or alter conditions enough to prevent new vegetation from establishing. The loss of infiltration also prevents that water from being available on-site to support vegetation, eliminates shallow soil moisture recharge, and decreases the volume of deeper aquifer groundwater recharge. Trees and other vegetation that depends on these water sources is thereby eliminated. Finally, with an increase in development, one can assume an increase in human disturbance, whether through increased noise and activity on the channel banks or through more direct

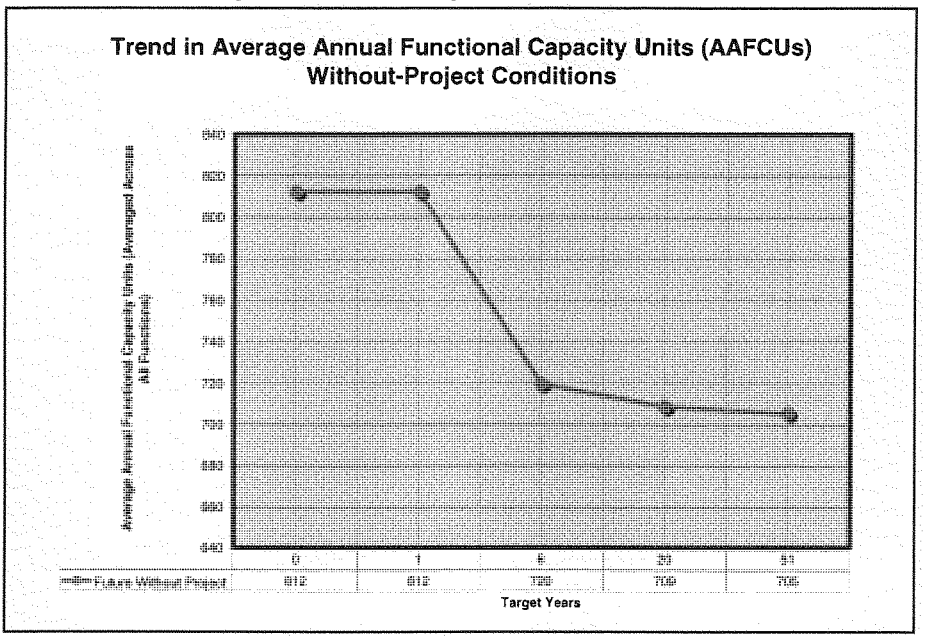
disturbance caused by individuals entering into the channel or riparian zone itself for recreational activities.

In terms of acreage, at TY 6, 288 acres of the existing PWAA would be lost and converted to residential, industrial, and transportation cover types. This includes 50 percent of the 69.5 acres of cottonwood-willow forest PWAA. Cover type acreage does not vary, except for the remnants of the existing cottonwood-willow forest, until the TY 51. Between TY 26 and TY 51, it was assumed that the remaining 30.6 acres of cottonwood-willow forest would become newly developed river bottom areas within the active channel.

Table 26. Without-Project AAFCUs

Function	TY1	TY6	TY26	TY51	AAFCUs
1	822	762	650	648	689
2	1,044	951	951	940	955
3	119	70	70	63	72
4	204	125	125	125	131
5	947	793	794	800	805
6	821	718	718	720	726
7	767	697	698	693	701
8	1,484	1,345	1,345	1,339	1353
9	983	883	883	880	889
10	930	851	851	844	854
Average	**812**	**720**	**709**	**705**	**718**

Figure 29 Without-Project AAFCU Trend Chart



4.3.3 Land Use

An analysis of the City of Mesa's Draft General Plan indicates an average density for residential lands of about five dwelling units per acre, based upon existing land use plans. At this density ratio, about 17,780 acres of residential lands would need to be developed to accommodate future population increases through 2050. The ratio of commercial, industrial, and public land uses relative to residential land uses is about 58 percent, which would correspond to a required additional 10,300 acres of non-residential development. The Draft General Plan indicates that about 23 percent of the city's 172-square-mile planning area (or over 25,000 acres) is currently undeveloped. Hence, it is likely that the City would be built out within the next 50 years. In addition, the SRPMIC lands north of the Salt River downstream of Mesa Drive could see an increase in residential development as well as some commercial development along freeway corridors.

4.3.4 Recreation

Recreational opportunities within the study area would remain substantially unchanged, and recreational experiences would not be enhanced. In addition, land use and planning policies to enhance and restore biological habitat and riparian areas and provide flood damage reduction and recreational opportunities in open-space areas would not be realized.

4.3.5 Economics

4.3.5.1 Structure and Content Damages

Hydrologic and hydraulic analyses were conducted for future without-project conditions to determine the impacts of processes such as sedimentation and channel degradation and the resulting impacts on potential flooding. Updated water surface profiles and stage/discharge uncertainty data were used to determine expected annual damages under future conditions. The results are summarized in Table 27.

Table 27. Without-Project Expected Annual Damages – Future Conditions (2060)
(in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	1.2	5.3	2.1	-	8.6
3	23.5	13.4	19.8	1.0	57.7
6	24.1	1.4	-	-	25.5
Total	**$48.8**	**$20.1**	**$21.9**	**$1.0**	**$91.8**

Without project expected annual damages decrease from about $317,000 under Base Year conditions to about $92,000 under future (2060) conditions, a drop of over 71 percent. As shown in Table 27, the most dramatic decline was in Reach 6, which shows a damage reduction of about 87 percent relative to base year (2011) conditions. In general, water surface elevations are lower throughout the study area under future conditions (refer to Hydraulics and Hydrology Appendix for details). The long-term scour of the riverbed throughout most of the study area produces this lowering of the water surface elevation. Figure 30 presents the difference between the 500-year base year and future conditions.

Equivalent annual damages, shown in Table 28, were computed based upon forecast annual damages using a discount rate of $5^5/_8$ percent. As shown below, equivalent annual damages total approximately $251,000, with over 71 percent of damages associated with residential structures and over 57 percent located within Reach 6.

Table 28. Without-Project Equivalent Annual Damages
(50 Years, $5^5/_8$%, in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	2.0	8.2	3.2	-	13.4
3	44.6	18.8	28.5	1.7	93.6
6	132.8	9.8	1.8	-	144.4
Total	**$179.4**	**$36.8**	**$33.5**	**$1.7**	**$251.4**

4.3.5.2 Emergency and Cleanup Costs

(a) Clean-up, Debris Removal, and Public Infrastructure Repairs

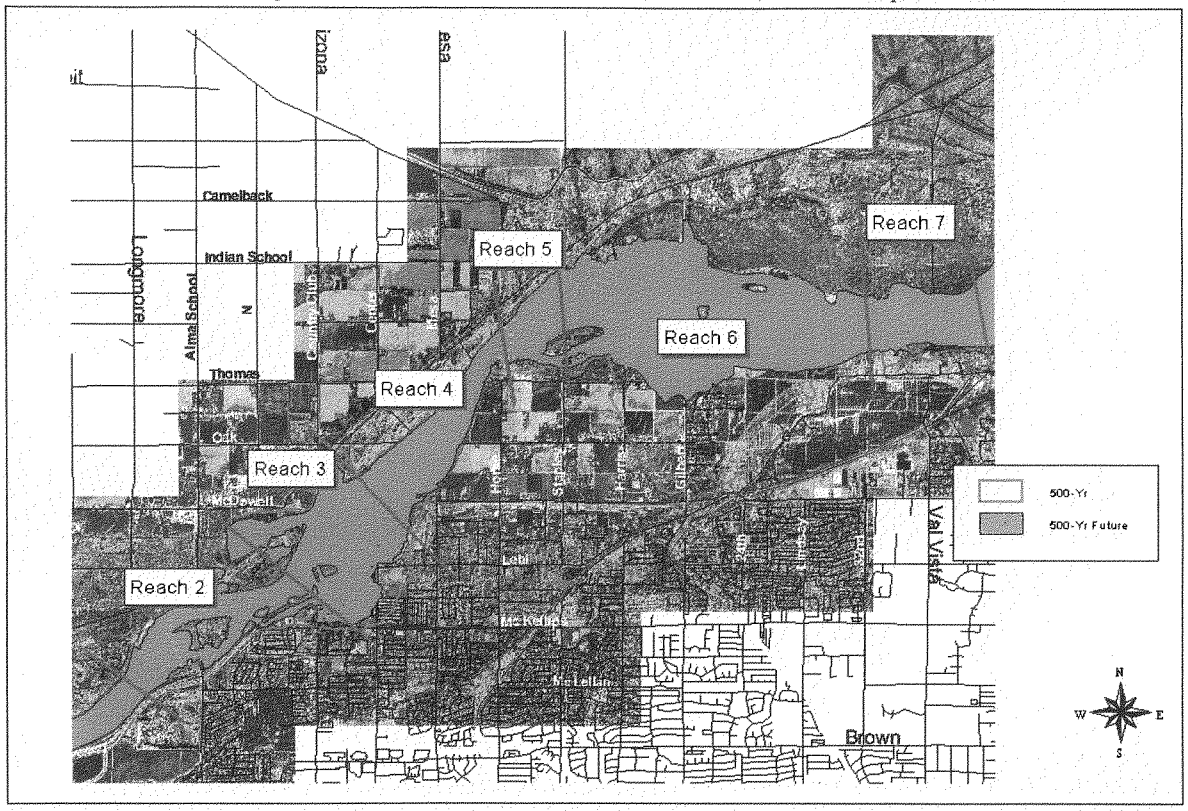
Emergency costs related to public infrastructure repairs, debris removal, and post-flood clean-up have been calculated by applying an average per-acre cost to the number of developed acres inundated by flood events. Based upon several recent Los Angeles District studies[4], per-acre costs for these items may range from $1,250 to $7,500 per acre. In accordance with this range, $5,000 per acre has been assumed for this analysis. Expected annual cleanup costs by reach are presented in Table 29.

Table 29. Without-Project Expected Annual Cleanup Costs by Reach
(in $1,000s)

Reach	Expected Annual Costs ($)
2	1.4
3	5.1
6	38.0
Total – All Reaches	**44.5**

[4] The two primary studies relied upon were the Lower Mission Creek, Santa Barbara County, California, and Rio de Flag Feasibility Studies, Coconino County, Arizona (WRDA 2000 studies), which included per-acre cleanup cost estimates. Other studies analyzed typically included cleanup cost estimates per flood frequency (based upon historical damages in the given study area and not necessarily associated with the number of acres impacted).

Figure 30. Base Year (2011) vs. Future (2060) Conditions 500-Year Floodplain



(b) Temporary Evacuation, Relocation, and Housing Assistance Costs

An Internet database search of FEMA disaster reports for flood and storm damage was performed. Data was collected and analyzed for ten recent flood disasters, including the October/November 2000 flooding in Maricopa and La Paz Counties in Arizona. For these ten disasters, 18,799 housing assistance claims were approved for a total payout of $27.93 million. This represents an average amount per claim of approximately $1,500.

To estimate temporary housing costs by flood event for this study, the number of houses and mobile homes inundated by frequency was ascertained through an analysis of HEC-FDA output files, and the per-housing-unit claim of $1,500 was applied. Table 30 shows expected annual without-project temporary housing costs.

Table 30. Without-Project Expected Annual Temporary Housing Costs by Reach
(in $1,000s)

Reach	Expected Annual Costs ($)
2	1.3
3	4.9
6	2.7
Total – All Reaches	**8.9**

4.3.5.3 Agricultural Damages

The expected annual flood damages upon production losses and factors in the monthly probabilities of major flood events are shown in Table 31. As shown, expected annual damages are minimal when reflecting the low probability of inundation, the seasonal nature of flooding, and a range of potential durations. In addition, the damages to the orchards could actually be lower than the values shown if the durations were short. For purposes of this analysis and based on available information, it is assumed that without-project expected annual damages is $1,600.

These losses do not account for potential income/revenue losses. To accurately assess revenue impacts, it would be necessary to analyze the potential for replanting, as well as whether the replanting would result in reduced yield. Due to the limited flood impacts to agricultural areas, this additional analysis was not conducted. However, estimates of the maximum expected annual losses for each crop under the assumption that flood events occurred after all production expenses were incurred but before any of the harvest could

be sold have been developed. Even with these values, expected annual damages only total $3,100.

Table 31. Estimate of Crop Production Losses by Flood Event – Reach 6
(Adjusted for Seasonal Flood Probabilities and Potential Duration Impacts)

Flood Event	Cotton ($)	Alfalfa ($)	Citrus ($)	Nursery Tree Farm ($)	Total ($)
50	200	700	39,300	0	40,200
100	500	2,000	51,200	0	53,700
200	2,100	7,100	66,200	3,400	78,800
500	2,300	7,600	77,400	30,300	117,600
EAD	**20**	**70**	**1,430**	**90**	**1,600**

In addition to direct production losses, flooding of agricultural areas would also require cleanup. Cleanup costs per acre could vary significantly, depending on the stage of production cycle and the duration and timing of the flood event. Cleanup costs were derived by applying a cost per acre of $1,000 to the acreage estimates shown in Table 32. Resulting average annual agricultural cleanup costs total $5,700. Adding this to the estimated average annual production losses results in total average annual agricultural damages of $7,300.

Table 32. Estimate of Floodplain Crop Acreages – Reach 6
(Acreage within Floodplain Demarcation Line)

Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0
100	38	19	112	0
200	135	67	145	0.3
500	144	72	170	2.3

*Assumed to be $^2/_3$ of the current fallow acres
** Assumed to be $^1/_3$ of the currently fallow acres

4.3.5.4 Flood Damage Analysis Summary

As presented in Table 33, total future without-project equivalent annual damages total approximately $360,000. Nearly two-thirds of the total damages are concentrated in Reach 6. Even though this reach contains fewer structures than the downstream breakout area, this area has a higher probability of flooding. Furthermore, the floodplain boundaries for the 50- through 500-year floods are significantly higher within this reach. As a result, structure/content and cleanup damages are higher in this area. Temporary housing costs are higher in the downstream breakout area due to the much greater number of structures, which is the basis for these costs.

Table 33. Without-Project Equivalent Annual Damages

(in $1,000s)

Reach	Structure & Content	Cleanup	Temporary Housing	Agricultural*	Total
2	13.4	1.4	1.3	0	16.1
3	93.6	5.1	4.9	0	103.6
6	144.4	38.0	2.7	7.3	192.4
Total	**251.4**	**44.5**	**8.9**	**7.3**	**312.1**

*Including direct production losses and cleanup

CHAPTER V
PLAN FORMULATION AND EVALUATION

This chapter presents the results of the plan formulation process used in the development of restoration alternatives for the Va Shly'ay Akimel Salt River study area. This chapter describes the analysis used to arrive at the final set of alternatives as well as the decision making process that leads to the selection of a recommended plan. Alternative plan development includes identification of all reasonable solutions to address the identified problems and an initial screening to eliminate inefficient and ineffective solutions. These solutions include operational changes or project features or "measures," that form the building blocks of an alternative plan.

5.1 Planning Process

This section presents the rationale used in the development of this plan. The Corps of Engineers' six-step planning process specified in ER 1105-2-100 (Planning Guidance Notebook) is used to develop, evaluate, and compare the array of candidate plans that are considered. The plan formulation process includes the following steps:

1. The specific problems and opportunities to be addressed in the study are identified, and the causes of the problems are discussed and documented. Planning goals are set, objectives are established, and constraints are identified.

2. Existing and future without-project conditions are identified, analyzed, and forecasted. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented.

3. The study team formulates alternative plans that address the planning objectives. An initial set of alternatives is developed and is evaluated at a preliminary level of detail.

4. Alternative project plans are evaluated for effectiveness, efficiency, completeness, and acceptability. The impacts of alternative plans are evaluated using the system of accounts framework specified in the Principles and Guidelines and ER 1105-2-100.

5. Alternative plans are compared. Cost-effectiveness and incremental cost analysis is used to prioritize and rank ecosystem restoration alternatives. A public involvement program obtains public input to the alternative identification and evaluation process.

6. The plan with the greatest net benefits is selected for recommendation if at least one plan exists demonstrating Federal interest.

5.2 Problems and Opportunities

Water resources projects are planned and implemented to solve problems, meet challenges, and seize opportunities. In the planning setting, a problem can be thought of as an undesirable condition, while an opportunity offers a chance for progress or improvement. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives. Planning objectives are statements of what a plan is attempting to achieve; they communicate to others the intended purpose of the planning process. Problems and opportunities can also be viewed as local and regional resource conditions that could be modified in response to expressed public concerns. This section identifies the problems and opportunities in the study area based on the assessment of existing and expected future without-project conditions.

5.2.1 Public Concerns

Local experience with similar restoration projects and public input were considered during all phases of plan formulation. The main areas of concern were technical considerations based upon the specifics of the study area; coordination of measures, elements, and alternatives developed under this project with ongoing development within the study area; flood damage reduction considerations in improving or maintaining the existing level of protection; and local efforts in restoration and flood damage reduction. The plan formulation effort included extensive involvement by the local sponsors (SRPMIC and the City of Mesa) and agencies (e.g., U.S. Fish and Wildlife Service, Flood Control District of Maricopa County, Arizona Game and Fish, and Arizona Department of Water Quality). Numerous plan formulation workshops and public scoping meetings were held during the feasibility phase. These workshops and meetings introduced the project to the public, gave individuals and agencies an opportunity to identify issues for consideration in this feasibility report, and solicited input on the project. Public comments recorded at the meetings provided a good sense of the public's concerns and

issues as well as the magnitude of each concern. Below are the initiatives the public and local officials would like to address through the study.

- Increase native riparian quality for both plants and animals.
- Attract migratory birds into these better habitats.
- Gradual creation of a continuous biological corridor.
- Foster the reestablishment of species native to the riparian communities and augment overall species diversity.
- Create physical settings in the river bottom that promote reestablishment of cottonwood-willow gallery forests and mesquite bosques.
- Eliminate invasive and non-native plant species.
- Restore vegetative communities within the river corridor to a more natural state.
- Increase acreage of functional seasonal wetland habitat.

5.2.2 Problems

The analysis of a wide range of technical issues identified a number of problem areas in the study area that have resulted from a variety of natural and human-induced changes. These problems are negatively affecting environmental resources, water resources, and local and regional economies of the area. These problems are summarized below.

- Degraded river and adjacent overbank areas.
- Degraded native riparian plant species and wildlife habitat. Perennial base flow conditions, critical to the needs of native vegetation, no longer exist in the river corridor through the study area.
- Average depth to groundwater beneath the river channel is much greater than historic conditions. Riparian vegetation that depends on groundwater has largely disappeared from the river channel.
- Hydrologic changes in the river system have impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and recruiting riparian vegetation.

- Land use changes, including landfills and mineral extraction (sand and gravel mining), have degraded and contributed to continued degradation of the river corridor.

- Recreation along the Salt River corridor is highly dependent upon the availability of surface water and riparian habitat, both of which are dependent upon the supply and availability of groundwater. The Salt River through the SRPMIC and the City of Mesa consists of dry river bottom. As a result, virtually no formal recreation activities take place on either the SRPMIC lands or the city-owned lands.

5.2.3 Opportunities

Based upon information obtained in the without-project assessment and understanding of public's concerns, opportunities were identified. Opportunities are desirable conditions that can be accomplished to some degree by management actions or policies. These are summarized below.

- There is an opportunity to take advantage of existing open water bodies in the river and adjacent properties as potential restoration sites.

- There is an opportunity to link other upstream and downstream restoration projects to provide a continuous habitat corridor. These include the authorized Rio Salado and Tres Rios Projects.

- There is an opportunity to restore and create conditions for sustainable riparian habitat in and around Va Shly'ay Akimel study area.

- There is an opportunity to increase the acreage of functional seasonal wetland habitat within the study area.

- There is an opportunity to increase habitat diversity by providing a mix of habitats within the river corridor including the riparian fringe and buffer.

- There is an opportunity to promote groundwater recharge.

- The study area provides a unique opportunity to enhance resource-based recreation and environmental education. The restoration of the Salt River would provide an opportunity for visitors to enjoy this unique resource while developing an awareness, knowledge, and understanding of desert riparian habitat and Native American culture.

5.3 Planning Objectives and Constraints

5.3.1 Federal Planning Objectives

Principles and Guidelines state that the Federal objective of water and related land resources project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. Water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways to contribute to this objective. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units.

Ecosystem restoration is also one of the primary missions of the Corps of Engineers Civil Works Program. The Corps' objective is to contribute to National Ecosystem Restoration (NER) through increasing the net quality and/or quantity of desired ecosystem resources. NER measurements are based upon changes in ecological resource quality as a function of improvement in habitat quality or quantity and expressed quantitatively in physical units or indexes (not monetary units).

This feasibility study determines if environmental restoration and recreation in this reach of the Salt River in Maricopa County, Arizona, meets the Federal objectives stated above. This is being accomplished by developing and evaluating measures and alternatives in order to recommend an implementable solution. To be consistent with the Federal objectives, any recommended solution presented in the Feasibility Report must address environmental restoration measures that result in an increase in net value to the NER. The recommended solution may also result in net NED benefits from recreation.

5.3.2 Specific Planning Objectives

Specific planning objectives were identified for this feasibility effort through coordination with local and regional agencies, the public involvement process, site assessments, review of prior studies and reports, and review of existing water projects. The specific objectives for environmental restoration within the study area have been identified as follow:

- Restore the riparian ecosystem to the degree that it supports native vegetation and wildlife through the Salt River from immediately downstream of the Granite Reef Dam to the Pima Freeway (SR 101).

- Establish a functional floodplain in unconstrained river reaches of the study area that is ongoing and mimics the natural processes found in other naturalized riparian corridors in Arizona.

- Provide passive recreation opportunities for visitors of all ages, abilities, and backgrounds that are in harmony with the SRPMIC's management of its culture and native ecology.

- Create awareness through ongoing educational opportunities of the significance of the cultural resources relating to the Salt River.

- Create awareness through ongoing education opportunities of the significance of the Salt River ecosystem.

- Create awareness through ongoing educational opportunities of the ecological connection between other ongoing riparian restoration projects along the Salt River.

5.3.3 Planning Constraints

In order to develop environmental restoration alternatives that will best meet the established objectives, the existing constraints must be considered. The following planning constraints have been identified for consideration in developing alternatives.

- Availability of Water - A principal constraint on many restoration projects in the arid southwest is the limited availability of water to support establishment and maintenance of healthy riparian habitats. In addition, the steady growth in the area surrounding the project creates increasing competition for water and land resources needed for ecosystem restoration.

- Water Rights - Water rights established by the State of Arizona do not apply to the SRPMIC lands; however, Federal water rights and court adjudications do apply. Non-Indian lands are subject to state water rights, Federal water rights, and court adjudications.

- Maintenance of Floodway Capacity - Restoration of the riparian habitat will be done in such a way that the flow capacity of the Salt River can adequately convey high flows and will not significantly increase water surface elevations above the existing conditions.

- Endangered Species - Under the Endangered Species Act (ESA), any potential project would be prohibited from jeopardizing the continued existence of threatened or endangered species or destroying or adversely modifying their habitat. Furthermore, ecosystem restoration projects may potentially attract endangered or threatened species. Projects should be sited so that their habitation by those species does not adversely impact the ability to preserve the flood damage reduction functions and maintenance of the channels.

- Local Acceptability - Any plan must be acceptable to local residents and consistent with local planning efforts.

- Vector Control - Restoration features must be configured to prevent development of a vector control problem.

- Effluent - The use of effluent as a water source may potentially be a consideration for restoration efforts only in the area within the City of Mesa due to cultural constraints within the SRPMIC.

- HTRW - Landfills and associated hazardous and toxic waste issues would need to be incorporated into plan formulation efforts.

5.4 Alternative Development and Evaluation Process

The Va Shly'ay Akimel feasibility study process involved successive iterations of alternative solutions to the identified ecosystem degradation problems. These solutions were based upon the study objectives and constraints and were formulated to address problems and opportunities identified in the early phases of the study process. In the application of Federal guidelines used in the formulation of water resources projects, the following feasibility criteria were used:

Technical Feasibility: Solutions must be technically capable of performing the intended function, have a reasonable certainty of addressing the problem, and conform to USACE technical standards, regulations, and policies;

Environmental Feasibility: Solutions must comply with all applicable environmental laws, including the National Environmental Policy Act;

Economic Feasibility: Solutions must be economically justifiable in that the economic benefits or, in the case of ecosystem restoration NER (non-monetary) benefits, must exceed the economic costs, in accordance with applicable regulations, policies, and procedures; and,

Public Feasibility: Solutions must be publicly acceptable as evidenced by a cost-sharing, non-Federal sponsor and further documented through an open public involvement process that incorporates the public's input into the formulation of the solutions.

In the initial phase of the study, measures were developed to satisfy these four criteria. The initial list of measures (Section 5.5) to be evaluated was based on input from the public and non-Federal sponsors, study team input based on experience with similar restoration opportunities, technical considerations based upon the physical characteristics of the study area, and considerations for maintaining existing levels of flood protection to adjacent properties along the study reach. Preliminary management measures addressed ecosystem restoration, channel stability and maintenance or improvement of flood protection, public education, and recreation. Some measures were quickly identified as inappropriate for the study area, and were not included in the initial group of measures forwarded for combination in the list of preliminary alternatives.

Combination of measures created a preliminary array of five alternative plans addressed in Section 5.5.2. After the initial analysis and screening of the preliminary alternative plans, a secondary array of sixteen more refined alternative plans were developed (Section 5.6 and Section 5.6.2). Key features common to the sixteen alternatives are described in more detail in Section 5.6.1. Each alternative plan was then independently evaluated and compared to the No Action Alternative (Section 5.7). From this evaluation three action plans and the No Action Alternative were carried forward into the final array for further analysis and comparison (Section 5.8) to be used as the basis for selecting the recommended plan (Section 5.9).

5.5 Preliminary Management Measures and Alternatives

5.5.1 Preliminary Management Measures

Management measures are structural or non-structural features, activities, or policies that can be implemented at a geographic site to address one or more planning objectives or constraints. A wide variety of management measures were identified for use in developing full-scale alternatives. The initial list of measures includes:

a. In-Channel Vegetation

- Restoration of riparian habitat areas in the channel.

b. Terracing

- Re-creation of terraces above the channel invert in conjunction with modification or removal of soil cement offers opportunities for habitat restoration, which maintains a connection to the channel.

c. Islands/Sand Bars/Oasis

- Modification of channel inverts to promote formation of sand bars and associated habitat.

d. Low-Flow Channel

- Reconfiguration and/or deepening of the existing low-flow channel with modifications to stabilize it would maintain and/or expand existing in-channel habitat areas.

e. Modify/Distribute Incoming Flows

- Drainage flow modification to distribute flows over a wider area and thereby support more habitats.

f. Drop Structures/Weirs

- Placement of semi-permanent structures with associated weirs in the channel to aid in channel low-flow stabilization and creation of seasonal pools.

- Placement of structures and weirs in or near tributaries for water harvesting.

g. Cultural Education/ Interpretation/ Ecological Interpretation

- Establishment of passive recreation associated with restored areas including trails, viewing areas, and kiosks.
- Establishment of interpretative centers to provide instruction on historic agricultural practices.
- Establishment of interpretative centers to provide instruction on cultural resources and native ecology.

h. Active Recreation

- Sport centers, parks, ball fields, shooting ranges, biking, hiking, and rollerblading trails establishment.

i. Passive Recreation

- Walking, bird watching, interpretive signage to provide instruction on cultural resources, native ecology, and historical agricultural practices.

j. Soil Cement Removal

- Soil cement removal and replacement with banks laid back and stabilized by vegetation.

k. Soil Cement Modifications

- Soil cement modification to allow restoration of banks to a more natural state.

l. Berm or Wall along Buffer

- Construction of a low berm or wall in areas where damages might be induced because of restoration features or where it would benefit wildlife and the riparian areas to have a barrier between the restored areas and restoration features.

m. Open Water

- Restoration of year-round or seasonal pools or channel reaches with flowing water could be established to support restoration of aquatic habitat and benefit migratory waterfowl.

n. Non-Structural Measures

- Allocation of water for restoration
- Zoning controls
- Elimination of gravel mining
- Best management practices
- Land set-asides
- Re-operation of upstream dams

Each measure was evaluated in terms of the feasibility criteria. All criteria must be adequately met since any one criterion can serve to eliminate a measure from further consideration. Those measures satisfying all the criteria were carried forward for additional development and evaluation, while those that were shown not to meet the criteria were eliminated from further consideration. Measures that were carried forward were then combined in various configurations to form a preliminary set of alternatives that were formulated to address the group of goals and objectives established for potential projects. These preliminary alternatives were intended to be subjected to a more rigorous evaluation against the criteria presented above in plan formulation. Some measures became alternatives; others were combined to form alternatives; and some were eliminated from further consideration during the screening process.

Based on the preliminary screening of measures, it was determined that active recreation was not supported by the SRPMIC sponsor. However, passive recreation was determined to be technically, environmentally, potentially economically, and publicly acceptable. The City of Mesa expressed support of both active and passive recreation on city-owned lands within the study area.

Other measures were eliminated as they were determined to be either economically or publicly infeasible. These measures include soil cement removal, drop structures/weirs, and the non-structural elements of elimination of sand and gravel mining and zoning.

As a Native American Community, the SRPMIC does not have the opportunity to support its government functions through a tax base; hence, there is a need to establish corporate enterprises to generate revenues to support public services. Aggregate mining has been a

traditional and important source of employment and income for the Community. Therefore, the "elimination of mining" was removed from consideration of future plans. However, the SRPMIC recognizes that eliminating mining activities would allow the restoration and subsequent preservation of an ecological, historical, and important lineage to the Pima and Maricopas as ancestors of the Salt River. Therefore, while consideration of sand and gravel mining was eliminated from consideration, the formulation considered combinations of structural and non-structural elements of water allocation, best management practices (including mining practices for the sand and gravel operation that is SRPMIC-owned) and land set-asides. Zoning is not a future issue, as the SRPMIC already owns the lands needed and are ready to dedicate them to the project purpose. Finally, the lead cause of degradation of the river is the result of the upstream dams that eliminated the perennial flow of the river. However, re-operation of the dams as a non-structural alternative was eliminated as it was publicly unacceptable because it would significantly adversely impact the regional water supply.

5.5.2 Preliminary Alternatives

Five preliminary alternatives were developed from the screened measures group discussed above. These alternatives were developed to encompass the broadest range of potential alternatives that could be formulated to address ecosystem restoration opportunities within the study area. The alternatives vary with respect to water requirements, habitat focus, and total scale. A discussion of the preliminary alternatives follows.

5.5.2.1 Alternative 1: No Action

Under this alternative, the Federal government would take no action to restore any ecosystem functions or values within the study area, would not implement plans to address recreational opportunities, nor would it develop plans with potential incidental benefits associated with flood damage reduction. The No Action Alternative is the basis for comparison with all other alternatives, as it represents a condition, both current and future, under which nothing has been done to address the identified problems. By comparing the No Action Alternative to each formulated alternative, one may assess the advantages and disadvantages of the study alternatives in relation to current and future "without-project" conditions. All alternatives are evaluated against the No Action Alternative to determine the benefits and risks associated with each of the proposed alternatives.

5.5.2.2 Alternative 2: Restoration Based on Existing Water Budget

This alternative is the smallest-scale alternative and does not depend on new sources of water; rather, it strives to make better use of the available water sources for the purpose of ecosystem restoration. It would include active and passive capture and utilization of stormwater from various drains and utilizing seepage from Granite Reef Dam. Alternative 2 incorporates passive recreation, and provides no incidental flood damage reduction.

- Price Drain and Alma School Drain: Reconfigure drainage areas to allow for establishment of riparian communities, particularly improved cottonwood-willow habitat, and eradicate salt cedar; increase vegetation survival rate during drainage high-flow periods; allow smaller drains carrying stormwater and nuisance flows to be used to establish desert wash communities.

- Granite Reef Dam: Modification to current flow pattern to promote succession, greater habitat connectivity, and a wildlife corridor between upland and riparian areas.

- Recreation: Establish associated interpretive centers to provide instruction on cultural resources and native ecology.

5.5.2.3 Alternative 3: Restoration through Non-Structural Methods (Grade Improvement and Additional Water)

This alternative calls for improving the current cottonwood-willow/mesquite habitat and open water by altering the current gradient and supplying additional water. It would include passive capture of stormwater as well as a commitment of delivered water sources (i.e., SRP water, groundwater from existing and new wells). Recreation components would include passive recreation associated with interpretive signage to provide instruction on cultural resources, native ecology, and historic agricultural practices.

- Storm Drains: Reconfigure Price and Alma School drainage areas to allow for establishment of riparian communities, particularly improved cottonwood-willow habitat, and eradicate salt cedar; increase vegetation survival rate during drainage high-flow periods; allow smaller drains carrying stormwater and nuisance flows to be used to establish desert wash communities.

- Reach 1 – Granite Reef Dam to Gilbert Road: Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Buffer areas would be planted with mesquite and upland communities to promote habitat connectivity and a wildlife corridor between upland and riparian areas.

- Reach 2 – Gilbert Road to Pima Freeway (SR101): Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Interpretive signage would be established to provide instruction on cultural resources, native ecology, and instruction on historic agricultural practices.

5.5.2.4 Alternative 4: Restoration through Structural and Non-Structural Alternatives

This alternative is of a larger scale in that it calls for improving habitat. The nature of the improvements creates incidental flood damage reduction benefits. This alternative calls for improving the current cottonwood-willow/mesquite habitat and open water by in-channel restoration that creates a meandering channel lined with native grasses, cottonwood-willow corridors, and appropriate understory vegetation. In addition, it includes modification of bank protection and a buffer. It would include active and passive capture of stormwater as well as a commitment of delivered water sources (i.e., SRP water, groundwater from existing and new wells). Recreation components would include passive recreation associated with viewing areas and interpretive centers to provide instruction on cultural resources, native ecology, and historic agricultural practices.

- Storm Drains: Reconfigure Price and Alma School drainage areas to allow for establishment of riparian communities, particularly improved cottonwood-willow habitat, and eradicate salt cedar; increase vegetation survival rate during drainage high-flow periods; allow smaller drains carrying stormwater and nuisance flows to be used to establish desert wash communities.

- Reach 1 – Granite Reef Dam to Gilbert Road: Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Buffer areas would be planted with mesquite and upland communities to promote habitat connectivity and a wildlife corridor between upland and riparian areas. In-channel restoration may include meandering and braided channels lined with native grasses, cottonwood-

willow corridors, appropriate understory vegetation when feasible, and a low-flow channel as appropriate. Recharge areas would foster habitat restoration.

- Reach 2 – Gilbert Road to Pima Freeway (SR101): Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Soil cement banks would be reconfigured to create a more natural bank and connection. Soil cement banks would be lowered where feasible with terracing that buffers sand and gravel operations and local community. A bioengineered flood control channel and sediment basin in flood-prone areas would be considered. Interpretive centers would be established to provide instruction on cultural resources, native ecology, and historic agricultural practices.

5.5.2.5 Alternative 5: Comprehensive Restoration

This alternative is of the largest scale and has the greatest water requirement and the greatest habitat focus. This alternative calls for improving habitat and providing incidental flood damage reduction benefits. It includes groundwater recharge areas, modification of bank protection, in-channel restoration, and buffer improvements. Recreation components would include passive recreation on SRPMIC lands and active and passive recreation on city-owned lands.

- Storm Drains: Reconfigure Price and Alma School drainage areas to allow for establishment of riparian communities, particularly improved cottonwood-willow habitat, and eradicate salt cedar; increase vegetation survival rate during drainage high-flow periods; allow smaller drains carrying stormwater and nuisance flows to be used to establish desert wash communities.

- Reach 1 – Granite Reef Dam to Gilbert Road: Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Buffer areas would be planted with mesquite and upland communities to promote habitat connectivity and a wildlife corridor between upland and riparian areas. In-channel restoration includes meandering and braided channels lined with native grasses, cottonwood-willow corridors, appropriate understory vegetation when feasible, and a low-flow channel as appropriate. Groundwater recharge areas would be used to foster habitat restoration. Open water in the form of seasonal pools or channel reaches with flowing water could be established to support restoration of aquatic habitat and benefit migratory

waterfowl. Interpretive centers to provide instruction on cultural resources, native ecology, and instruction on historic agricultural practices would be established.

- Reach 2 – Gilbert Road to Pima Freeway (SR101): Revegetation on terraced areas would be graded from cottonwood-willow on the lowest level to mesquite communities up to desert wash vegetation at the highest level from the river. Soil cement banks may be reconfigured to create a more natural bank and connection. Soil cement banks would be lowered where feasible with terracing that provides a buffer from sand and gravel operations and local communities. A bioengineered flood control channel and sediment basin in flood-prone areas is a possibility. Berms or flood walls would be added at the outside edge of the buffer. These measures would be used for one of two reasons: either where increasing n-values induce overbank flows that may cause flood damages to developed areas or where there is a need for a barrier between restored and developed areas. Berms could be vegetated with appropriate native vegetation. Interpretive centers may be established to provide instruction on cultural resources, native ecology, and historic agricultural practices, as well as viewing areas and trails.

5.6 Screening of Alternative Plans – Second Array

The five alternative plans initially identified were screened on the basis of technical feasibility, economic justification, environmental quality, and public acceptance. The plans were presented to, and coordinated with, the USACE Los Angeles District, the SRPMIC, the City of Mesa, and participating resource agencies. This resulting screening relied primarily on the informed judgment of technical and resource agency staff, use of empirical data, and the degree of acceptability expressed by stakeholders. Based on this screening process, additional ideas and considerations were proposed, and a secondary array of alternatives was developed. Initial alternatives 2 through 5 were reformulated and further developed as more refined alternatives with their primary components incorporated into the second array of alternatives. To avoid confusion, these alternatives were lettered rather than numbered.

In order to provide the level of detail necessary to compare the secondary array of alternatives, more detailed engineering, design, cost estimating, incremental evaluation, analysis of potential project impacts, and the development of preliminary cost-effectiveness analyses, were developed for each remaining alternative. The resulting information was utilized to make plan formulation decisions regarding the potential removal of alternatives from further consideration, or their forwarding into a final array of alternatives subject to further refinement and analysis.

As discussed above, the initial screening of Preliminary Alternatives 1 to 5 resulted in a secondary array of alternatives comprising 14 ecosystem restoration alternatives (Alternatives A to N), as well as the No Action Alternative. Based on coordination and review by the SRPMIC and the City of Mesa of these 14 alternatives, it was recognized that an additional alternative was warranted. This alternative, discussed hereafter as Alternative O, was considered in order to address the opportunity for additional vegetation in Reaches 1 and 2. The secondary array of alternatives, Alternatives A to O, including the No Action Alternative (Alternative P), is presented in Table 34 and discussed in the following sections. Alternatives A to O were developed utilizing two methods of irrigation: drip irrigation and SBIN. Those alternatives developed with drip irrigation have been assigned as Group 1 (e.g. Alternative A1, B1, C1, etc.). Those alternatives developed with a SBIN system have been assigned as Group 2 (e.g. Alternative A2, B2, C2, etc.).

Table 34. Second Array of Alternatives

Alternative	Name	Vegetation Proposed	Level of Vegetation Restoration
A	LOAD	Xero-Riparian Dominate	Minimal
B	MEAD		Moderate
C	HIAD		Extensive
D	MINE	Meso-Riparian Dominate (Cottonwood, Mesquite, and Xero-Riparian)	Moderate
E	VHAD		Extensive
F	MAX		Maximum
G	CWAD	Cottonwood Dominate	Extensive
H	MSAD	Mesquite Dominate	Extensive
I	CHNL	Cottonwood Dominate	Moderate
J	BRAD		Extensive
K	NODL		Maximum
L	POCK	Cottonwood and Mesquite Dominate	Moderate
M	WET	Hydro-Riparian Dominate	Extensive
N	-	Meso-Riparian Dominate	Maximum
O	-		Maximum
P	No Action	-	-

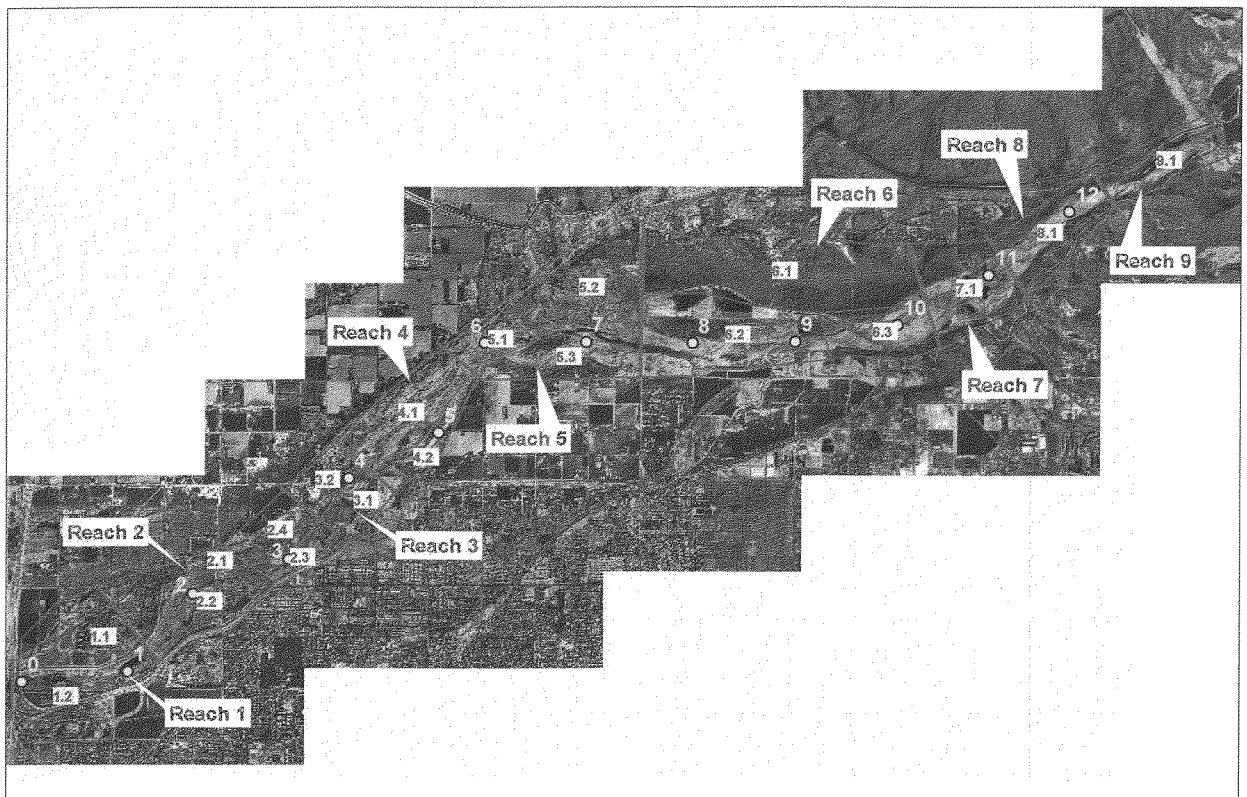
5.6.1 Features Common to the Alternative Plans – Second Array

The study area was divided into nine distinct reaches, each of which was divided into sub-area locations that could undergo specific restoration efforts (Table 35). Figure 31 shows an aerial image of the study area identifying the nine distinct reaches and sub-area locations used in this report. The following features, which are discussed in more detail in the following sections, were applied to all of the alternatives, as they form the minimum structural support for any ecosystem restoration alternative and do not affect the design of the vegetation or irrigation systems.

Table 35. Reach Description

Reach	Description
1	*From the Pima (SR101) Highway to immediately downstream of Longmore Road* Portions of this reach are characterized by the existing high quality habitat.
2	*From immediately downstream of Longmore Road to the Beeline Highway river crossing* This reach is characterized by the disturbances of the Salt River Sand and Rock (SRS&R) Dobson Plant without interfering with the existing vegetation in Reach 1.
3	*From the Beeline Highway river crossing to the downstream edge of the Old Tri-City landfill* This reach is characterized by a landfill and a United Metro quarry. Because of the limitations of these two features, this reach was identified independently.
4	*From the downstream edge of the Old Tri-City landfill to the downstream edge of Lehi Cemetery* This reach is characterized by the landfill.
5	*From the downstream edge of Lehi Cemetery to Gilbert Road* This area encompasses the reach of river that contains the SRS&R Beeline One Plant and its downstream area of effect.
6	*From Gilbert Road to immediately upstream of the Hennessey Drain* This reach can be characterized by the water available through the Hennessey Drain, the channels flowing from the drain, and the GRUSP site. Any vegetation planned for Reach 6 can be supported by SRPMIC water transported through the Hennessey Drain, as feasible.
7	*From immediately upstream of the Hennessey Drain to the upstream edge of the SRS&R Higley Plant* This reach is characterized by the existing mining operations. Because of the disturbance associated with such activities and the assumed eventual failure of any vegetation planted in this area, no features were planned.
8	*From the upstream edge of the SRS&R Higley Plant to the end of the existing riparian vegetation* This reach has existing quality scrub shrub habitat. While scrub shrub habitat is of a lower wildlife value, it is still part of the southwestern greater river ecosystem. Given the proximity to the quarry plant, the disturbances associated with it, and the relative habitat health, it was determined that Reach 8 did not warrant additional planning.
9	*From the existing riparian vegetation to the Granite Reef Diversion Dam* Because ecosystem restoration is the purpose of this project, areas with no or declining riparian vegetation were given the highest priority. The area within Reach 9 has high quality existing riparian habitat; thus, activities are limited to invasive species control.

Figure 31. Va Shly'ay Akimel Location Map – Reaches and Project Sub-areas



5.6.1.1 Water Sources

The without-project condition in Chapter 4 investigated the quantity and reliability of all possible water sources. During plan formulation, the water sources determined usable include groundwater from existing and new wells, City of Mesa WWTP effluent water for limited use on non-SRPMIC lands, and surface water available for use by the SRPMIC via existing water source locations (Figure 32). According to the SRPMIC staff, 30,000 ac-ft/yr of water could be allocated to the project. The water requirements from the various sources for each of the alternatives are discussed in more detail in Section 5.7.1.

5.6.1.2 Water Distribution System

The water distribution system refers to the infrastructure needed to deliver water (i.e. surface water or groundwater) from the source (i.e. irrigation canal or well) to the newly-restored vegetated areas of a given alternative. The distribution system is not the same as the irrigation system required by a given alternative, which may also differ from alternative to alternative. Surface water from the SRPMIC would be the primary source of water. A new well, proposed near Gilbert Road, was also examined as a water source option. The system was designed to utilize stormwater and irrigation tailwater whenever it is available.

Surface water would enter the study area by way of irrigation canals controlled by the SRPMIC. SRPMIC would then distribute the water to satisfy water demands within the project area. A flow diversion structure would be required to store and divert surface water from the irrigation channels to the water distribution drain, a 12-inch buried pipe (Figure 33). The diversion structures would divert both project water and excess water to the project area. In general, the location of the distribution pipes varies for each alternative. In addition, Alternatives B, C, E, G, and H require an additional distribution channel, which is 40 feet wide with a maximum depth of 3 feet. The distribution channel would be lined and would convey excess irrigation water to the vegetated areas within the 10-year area of inundation. After significant flow events, segments of the channel would require maintenance.

Figure 32. Water Source Location Map

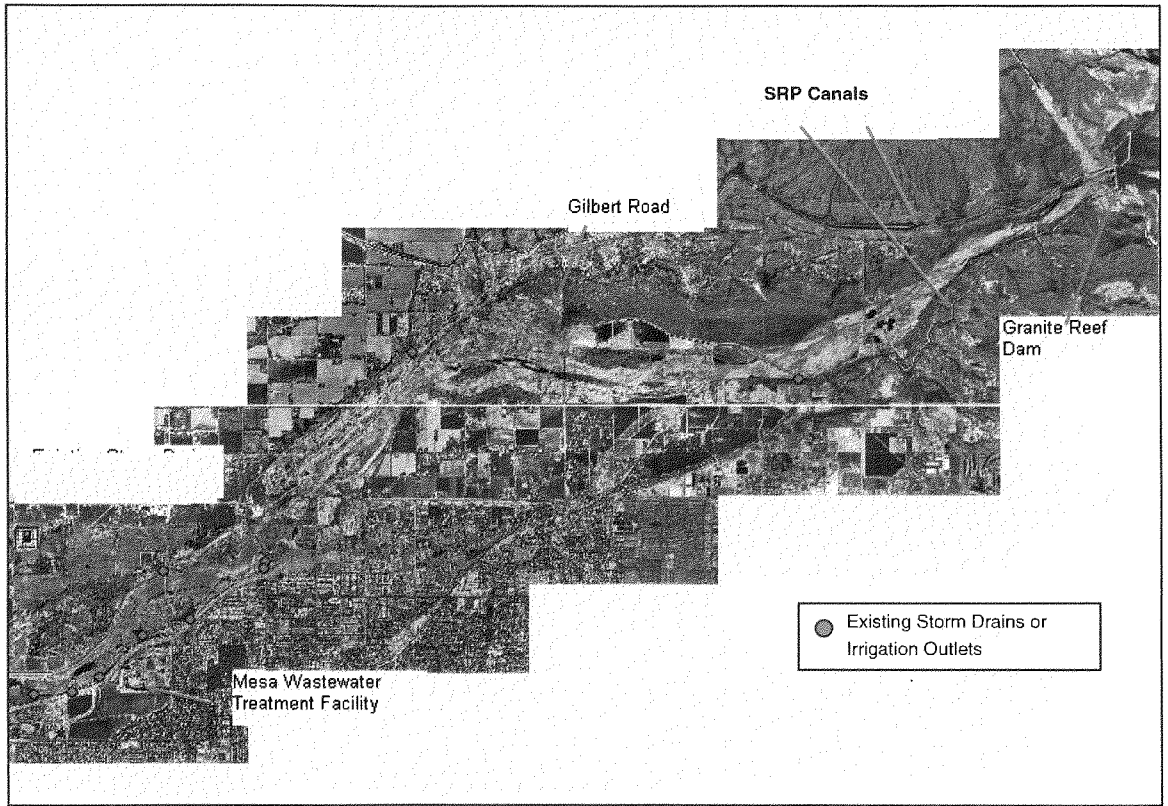
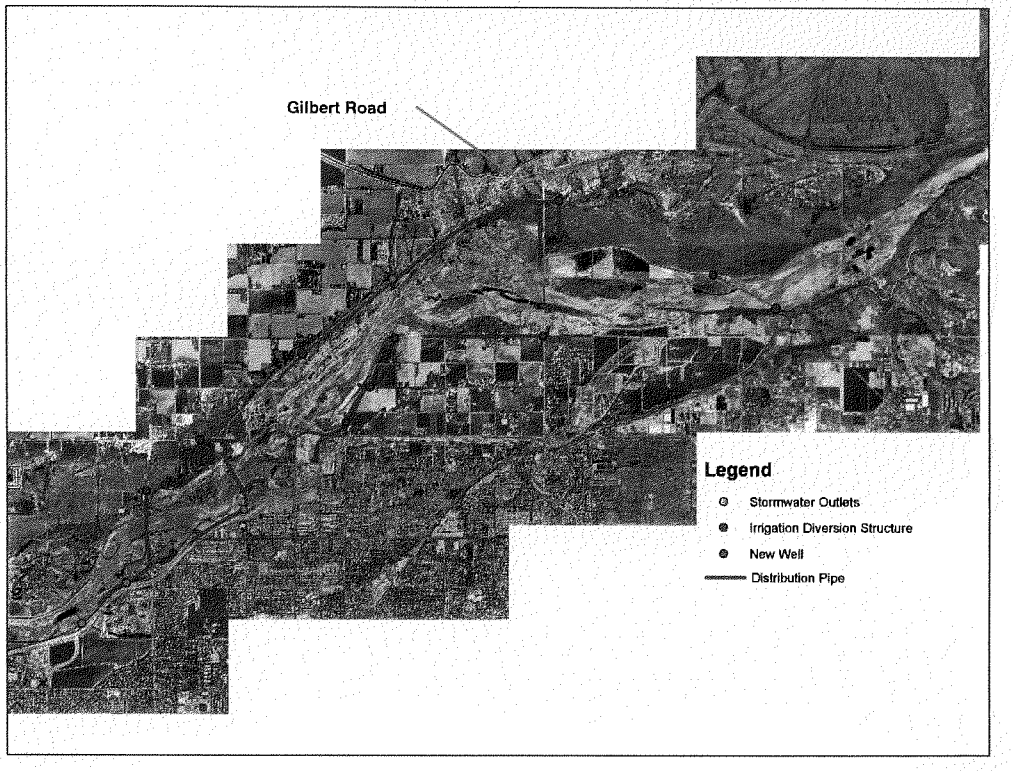


Figure 33. Location of Water Surface Sources, New Wells, and Distribution Pipes



Note: Not all alternatives require all the surface water sources, wells, and distribution pipes shown. In general, the location of the distribution pipes varies for each alternative.

5.6.1.3 Irrigation Techniques

Surface water from stormwater sources, irrigation canals and ditches, would be diverted to the proposed newly-vegetated areas by a network of lined irrigation channels and buried pipes. The size of the channel and pipe would depend on site-specific conditions such as flow requirements and terrain. Pumps are needed in some cases to distribute water. To irrigate certain vegetated areas, a Surface Braided Irrigation Network (SBIN), flood irrigation, or drip irrigation could be used. Figure 34 depicts the layout of the SBIN irrigation method. Additional information about these irrigation systems, and their associated water usage, are discussed in Section 5.7.1 and the Water Budget Analysis Appendix.

The SBIN distributes water through a network of shallow ditches, 6 inches deep and 2 to 3 feet wide. Maintenance of these lined channels may be necessary after larger flow events. Water distribution would need to be manually controlled for the life of the project.

The flood irrigation method consists of inundating an area by overland flow. This method has a low irrigation efficiency, defined as vegetation water demand divided by total water demand (vegetation water demand plus water losses), but has low constructions costs and operations and maintenance requirements. Water distribution would need to be manually controlled for the life of the project.

Drip irrigation is a common system for irrigation; however, it is not an advantageous method for promoting recruitment of desirable vegetation types and irrigation of large areas. It is recognized that some drip irrigation may be needed in the beginning for establishing plants.

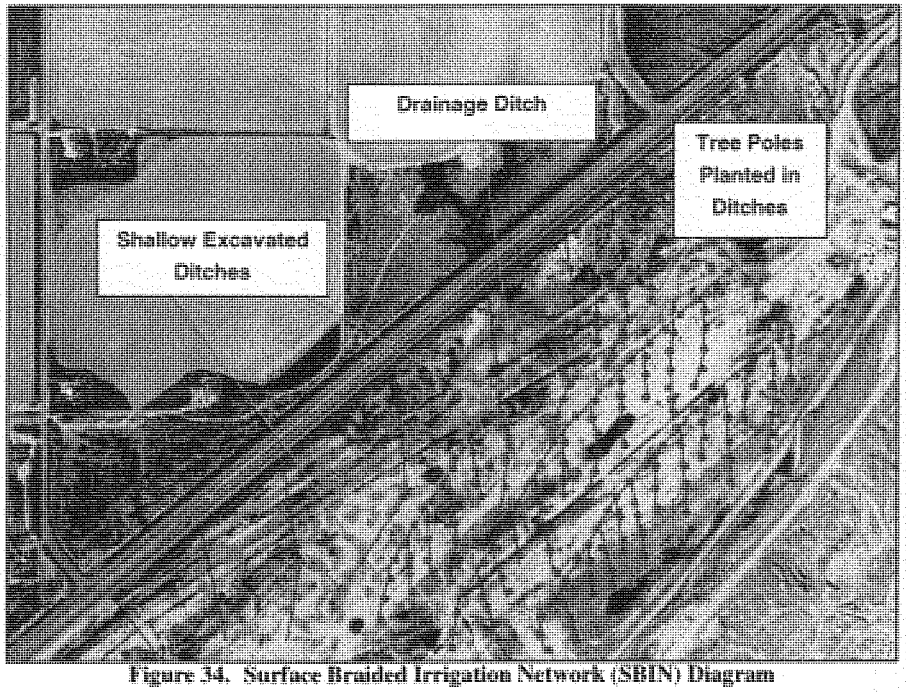


Figure 34. Surface Braided Irrigation Network (SBIN) Diagram

5.6.1.4 Reshaping

Many of the alternatives would require surface reshaping. The four types of reshaping categories incorporated in this project are discussed below.

- *Channelization* refers to the material moved in the process of constructing the 200-foot-wide, low-flow channel.
- *Surface Reshaping* refers to the material moved to alter significant features such as large mounds, filling quarry pits, and reducing the side slopes of the quarry walls.
- *Vegetation Reshaping* refers to the minor soil reshaping required for planting purposes and to ensure that gravity irrigation systems would be feasible. It is assumed that 2 feet of surface soil material would be moved per acre of vegetated area. This assumption was based on the relatively flat terrain for most of the project feature areas.

- *Irrigation Reshaping* refers to the construction of irrigation ditches needed in the flood irrigation, the SBIN irrigation methods (2 to 3 feet wide and 6 inches deep), and the construction of the drainage ditches (15 feet wide and 3 feet deep). Flood irrigation would require only a leveling of surface soil to ensure even water distribution while a SBIN would require minor surface soil reshaping to form shallow trenches for the water to flow through. A minimal amount of reshaping for a drip irrigation system is expected.

5.6.1.5 Vegetation

Five vegetation types were evaluated: Cottonwood/Willow, Mesquite, Wetlands, Sonoran Desert, and River Bottom. The requirements for implementing each vegetation type are as follow:

(a) Cottonwood/Willow (CW)

CW stands are restricted to the near overbank area of streams and rivers or other areas with saturated soil conditions. They require a water table or saturated soil conditions 1 to 10 feet (Anderson, 1995) below the ground surface and have an average annual water demand range from 4 to 8.5 feet. It was assumed that the average annual water demand is 6.3 feet. Soils range from finer sediments to sandy soils. In areas where grading may be required, uneven grading is most beneficial, allowing for depressions where sediment can collect and shelter seeds for establishment. Due to the relatively high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands would rely on flood irrigation or a SBIN for their water needs.

(b) Mesquite (MS)

MS are commonly found 5 to 20 feet above the river channel where water is adequate, and generally occur in soils approximately 10 to 45 feet above the water table (Arizona Department of Water Resources, 1994). However, occasional saturated soil conditions are necessary 1 to 3 feet below the surface as this is where 90 percent of the mesquite roots are found (www.desertmuseum.org). The average annual water demand range for MS is between 2 and 4 feet. It was assumed that the average annual water demand is 3.0 feet. Soils can be fine to gravelly with some rocky areas. A drip irrigation system may be necessary to establish the MS. However, once established, the MS would rely on flood irrigation or a SBIN for its water needs. Previous restoration efforts have shown that MS can survive on natural precipitation alone, even when groundwater is not

available. However, this cannot be assumed true for all locations. Therefore, a site-specific evaluation should be performed before determining if or how much supplemental water is required.

(c) Wetland (WT)

WT areas can consist of open water, submerged vegetation, or shorelines, all requiring a high water table level at or near the surface. The average annual water demand range for WT is between 9 and 16 feet. It was assumed that the average annual water demand is 9 feet.

Due to the porous soils found in this project area, lining the WT would be required to maintain surface water. Excavation and layering of a silt clay soil substrate overlain by coarser material is also recommended. This soil structure would reduce disturbance of the soil-clay layer by reducing piping of fine material and reducing turbulent forces acting on the layer.

Storm drain outlets located near WT would require erosion control measures at the outlets to prevent scouring. To distribute water from the WT laterally, a series of drainage ditches would be constructed from the WT to divert water to other areas that require irrigation. The ditches would be semi-elliptical in shape with a top width of 4 feet and maximum depth of 2 feet. The drains would increase lateral dispersion of runoff to maximize the stormwater benefit.

The WT would also be designed with an outlet channel leading to the main channel. The preliminary design of the outlet channel calls for a 20-foot bottom width, 3-foot maximum depth, 2:1 side slopes, 300-foot length, and large cobble bottom. The design discharge (Q) is 400 cfs. Not all proposed WT would require an outlet channel.

(d) Sonoran Desert (SD)

The specific vegetation species can vary depending upon the site's soil type. However, proposed vegetation types would not require saturated soil conditions and would have an average annual water demand between 0.5 to 2.5 feet. It was assumed that the average annual water demand is 2.0 feet. The SD may need to be periodically irrigated with a supplemental water source the first 5 years to establish the vegetation. Once established, SD should be sustained by annual precipitation or with periodic inundation, via flood irrigation, during extreme drought periods.

(e) River Bottom (RB)

RB would require only surface reshaping including partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. River bottom areas may also require hydro-seeding with a variety of native xeric river bottom shrub species to help establish vegetation. While RB areas are frequently dry, they are capable of sustaining xeric vegetation types, as seen in areas along the Salt River within or near the project site. These plants would be sustained with natural precipitation and any tailwater that may enter the river from other feature irrigation systems; thus, irrigation would not be required.

In addition to the planting of the vegetation, some reshaping may be necessary to provide the proper landscape to maintain and encourage the future propagation of the vegetation.

5.6.1.6 River Channelization

Some alternatives would require segments of the Salt River to be enlarged or better channelized, to offset a reduction in potential water conveyance created by the presence of additional vegetation within the main channel. The river bottom would be excavated to form a low-flow channel with a bottom width of approximately 200 feet, 1V:3H side slopes, and a depth of 4 to 8 feet. The channel would be free to migrate. The excavated material would be used to create benches along the channel to fill quarry pits and vary the local topography to encourage vegetation growth and reduce flood and consequent erosion damage to proposed newly-revegetated areas. Maintenance of the channel may be necessary after flow events. A 200-foot buffer on both sides of the low-flow channel would be incorporated to allow for the migration of the low-flow channel.

Portions of the low-flow channel would be designed with a semi-impervious soil substrate to support wetland areas. Sonoran desert vegetation would be planted along the low-flow channel to increase stability of the overbank area.

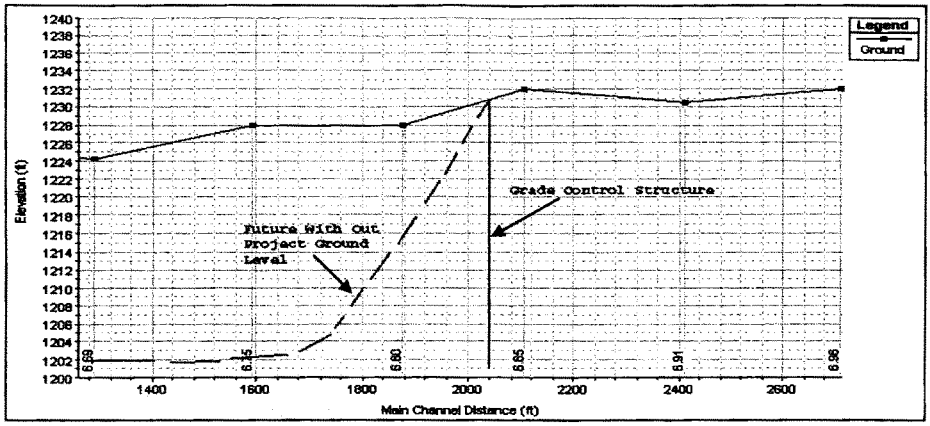
Buried guide dikes would need to be constructed in the overbank area perpendicular to the thalweg (center line) of the channel. Groins would act as a lateral control to prevent excess migration of the low-flow channel.

5.6.1.7 Grade Control Structures

A grade control structure would be needed to protect newly-restored areas of the channel subject to erosion as a result of extensive in-channel mining activities that occurred in the past downstream of the bridge. The SRPMIC is required only to comply with Federal law, and they are in Federal Regulatory compliance. While reclamation plans are currently required of the sand and gravel operations by the SRPMIC, they were not historically, as there was no applicable Tribal law and therefore no legal obligation. These sand and gravel mining activities created a "nickpoint," an area where an abrupt change in elevation and slope occurred. Over time, water flowing over this nickpoint resulted in upstream migration of a "headcut," causing degradation and incision of the channel bed upstream. Results from the hydraulic and sediment analyses indicate that the headcut would eventually damage restoration features located upstream of the former mining site, and could also potentially undermine the bridge at Gilbert Road. While the grade control structure would help reduce the degree of upstream channel migration and, by stabilizing the river system minimize impacts to newly-restored habitat, its likely degree of increased protection to Gilbert Road bridge was deemed minimal, and its benefits monetarily were judged to be only incidental.

The grade control structure would span the entire width of the riverbed and have sufficient toe-down to survive the anticipated scour resulting from a full range and magnitude of flood events expected during the period of analysis. It would be approximately 10 feet tall with a 20-foot toe depth (for a total height of 30 feet). The width and length of the structure would be 8 feet and 1,100 feet, respectively. Riprap would be placed on the downstream end to prevent erosion. Figure 35 shows the longitudinal profile of the Salt River with the structure.

Figure 35. Longitudinal Profile of Salt River Main Channel with Grade Control Structure

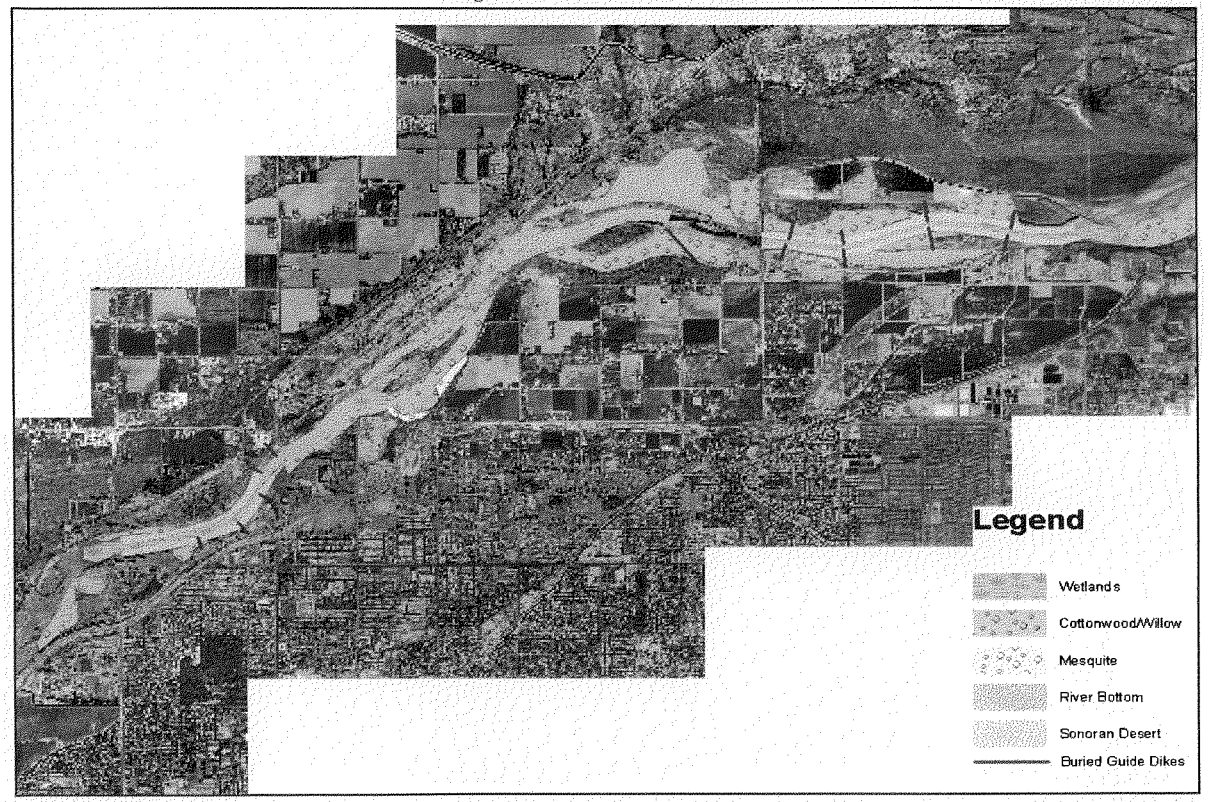


Concerns initially raised over the long-term stability of the Alma School drop structure required additional hydraulic modeling. More than 20 feet of scour occurred between River Stations 2.10 and 2.29, where the headcut from previous sand and gravel mining activities migrated upstream to this grade control structure. In the hydraulic analysis (WEST; 2002), the grade control structure was determined to remain intact throughout the entire period of analysis, although the toedown depth of the grade control structure is less than the computed scour depth at this location. While this analysis indicates that the grade control structure could fail under certain conditions, current designs submitted to modify the existing structure by the Maricopa County Department of Transportation indicate that solution of this problem is part of the future "without-project" condition, and this feature was therefore not included in any of the alternatives.

5.6.1.8 Buried Guide Dikes

Buried guide dikes would be used to control lateral migration of the low-flow channel under each alternative. Guide dikes are trapezoidal soil cement structures that would be constructed perpendicular to the low-flow channel, and below the grade of the existing channel invert. The guide dikes would have a top width of 5 feet, bottom width of 20 feet, and have an average length of 700 feet. The length of the guide dikes would depend on the position of the guide dikes with respect to the second terrace. The locations of the guide dikes are shown in Figure 36.

Figure 36. Guide Dikes Locations



5.6.1.9 Bank Stabilization

Several areas require bank stabilization to stabilize the river, reduce erosion, and provide protection for newly-established vegetation. Four general bank stabilization measures are included in the alternatives: riprap, buried groins, bendway weirs (wingdams, groins), and soil cement. The bank stabilization locations are shown in Figure 37. Application of each stabilization measure depends upon the local hydraulic, scour, and deposition conditions and proximity to newly-restored areas.

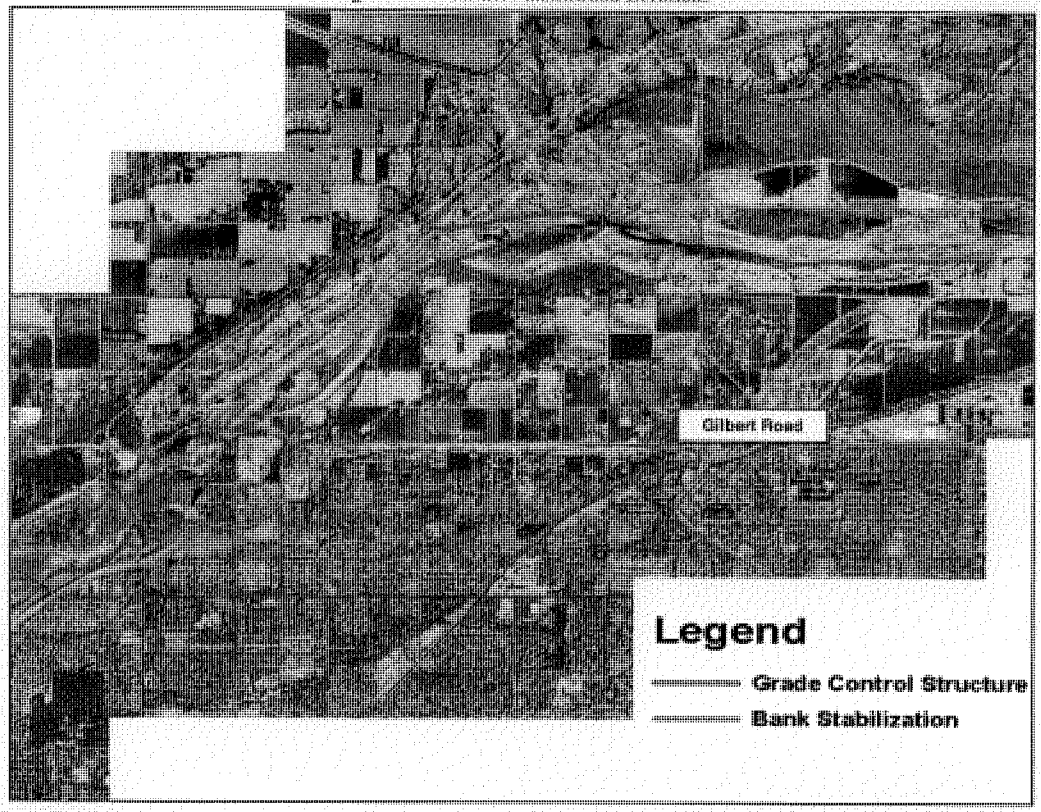
Locations 22, 51, 52, 53, and 62 include measures directed at channel stabilization.

- Location 22 would require channel stabilization measures along the south bank. This is necessitated by the geometry of the Salt River, which exhibits a 45-degree change in direction at this location. To prevent further southerly migration of the river, resulting in damage to proposed restoration features, protection of the south bank with soil cement, as shown on Figure 37, is recommended. The soil cement protection would be 3,000 feet long, 40 feet tall, and 6 feet deep.

- Location 51 would require riprap and soil cement to stabilize this reach of channel. Because of the elevation difference between the main channel and the quarry pit invert, river migration is anticipated to move north into the quarry pit. As mentioned above, this lack of stabilization measures would result in headcut migration, extending upstream through an area of newly-restored habitat. Implementation of this measure would provide incidental benefit to the Gilbert Road Bridge (WEST, 2002)

  On-going headcutting would affect project features downstream. To ensure that this does not occur, the quarry would be reshaped. Guide channels/spillways would be constructed to control water flow into and out of the quarry area. The reconnection of surface water sources to the quarry would increase river bottom habitat, and provide more suitable conditions to establish CW, SD, and MS. It may also provide incidental benefits from groundwater recharge. The soil cement structure would be 6,500 feet long, 30 feet tall, and 6 feet deep.

Figure 37. Channel Stabilization Locations



- Location 52 would require channel stabilization measures due to on-going migration of the channel into important restoration areas. Location 52 is sited along the south bank of Reach 5 extending from just downstream of Gilbert Road to Lehi Cemetery. Although Lehi Cemetery is a culturally sensitive area currently threatened by river migration, it is also the site of several project features in certain alternatives. To prevent impacts to newly-established vegetated areas, buried guide dikes and cottonwood and other dense riparian vegetation would be established to potentially reduce shear stresses along the south bank. The structure would be 5,000 feet long, 30 feet tall, and 6 feet deep.

- Location 53 would be necessary to stabilize the channel at this location. The soil cement structure would be 5,500 feet long, 30 feet tall, and 6 feet deep.

- Location 62 would require channel stabilization measures along the south bank in Reach 6. An abandoned quarry on the south bank, with a maximum depth below riverbed of 50 feet, is oriented so that the quarry pit could encourage the river to be redirected south into the pit, causing bank erosion along the south bank and a headcut migration upstream and downstream of the quarry (WEST, 2002). The headcut would adversely affect any attempts at vegetation establishment within Reach 6 and may incidentally affect the Gilbert Road Bridge. This feature would require two measures to prevent this from occurring. First, the pit would be partially filled with material resulting from upstream channel enlargement activities. Second, the south bank of the river would be stabilized with soil cement north of the quarry.

Additional bank stabilization needed to stabilize segments of the river outside of those required for reestablishment of the ecosystem was not pursued.

5.6.1.10 Levee

A levee measure was examined to potentially protect the Lehi area near Gilbert Road. The levee would need to be 15,000 feet long, extending from Reach 5 to Reach 6, and would be 6 feet high. However, a levee could not be economically justified due to the minimal damage resulting from a 100-year event, and only slightly more from a 500-year flood event.

5.6.1.11 Cultural Center

A cultural center, intended to provide SRPMIC members and visitors with information regarding the historic way of Pima-Maricopa Indian Community life, was examined as a potential component of a larger river restoration project. The exact location of a center has yet to be determined; however, it would be placed relatively close to the river, so that the river and its associated vegetation can be visually highlighted in the area surrounding the center. Materials historically and culturally important to the SRPMIC may be planted in the area surrounding the center, as well as highlighting the native river vegetation. It is understood that a cultural center may be implemented with no Federal cost-sharing.

5.6.2 Second Array of Alternatives

Table 36 presents a comparison of restoration features proposed in each alternative. The alternatives are described in detail in the sections following Table 36.

Table 36. Comparison of Second Array of Alternatives

Alternative	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reaches 8 & 9	Increase in AAFCUs	Water Sources	Water Demand
A	No activity	No activity	No activity	No activity	SD	SD	No activity	Invasive species removal	373	3 new irrigation diversion structures	992 ac-ft/yr
B	No activity	MS and SD	No activity	SD	MS and SD; spillway at the SRS&R Beeline One Plant	MS and SD	No activity	Same as Alt. A	594	4 new irrigation diversion structures; 1 new well	2,172 ac-ft/yr
C	No activity	CW, MS, and SD; wetland; bank stabilization	No activity	SD	SD, CW, and 2 small pockets of MS; SRS&R Beeline One Plant reshaped and converted to new river bottom	Two water distribution channels created; CW, MS, and SD	No activity	Same as Alt. A	771	4 new irrigation diversion structures	3,696 ac-ft/yr
D	No activity	No activity	No activity	CW, MS and SD; main channel reshaped and converted to new river bottom	SRS&R Beeline One Plant and main channel reshaped and converted to new river bottom; grade control structure; CW, MS, and a wetland feature	No activity	No activity	Same as Alt. A	598	6 new irrigation diversion structures; 1 new well	3,629 ac-ft/yr
E	CW; invasive species control	SD and CW; old quarry at Alma School Road converted to new river bottom; bank stabilization	No activity	MS	CW, MS, and SD; wetland created at the Evergreen Ditch outlet; main channel reshaped to allow for river bottom establishment and increase channel conveyance capacity	CW, MS, and SD	No activity	Same as Alt. A	926	4 new irrigation diversion structures; 1 new well	4,540 ac-ft/yr
F	No activity	CW, MS, CW; bank stabilization for south bank between Country Club Road and Alma School Road	CW; channelization	MS, SD, CW	SRS&R Beeline One Plant reshaped and converted to river bottom; two spillways constructed; bank stabilization; CW, MS, and SD; grade control structure	CW and MS; wetland	No activity	Same as Alt. A	1,035	9 new irrigation diversion structures; 1 new well	8,304 ac-ft/yr
G	CW; invasive species control	Distribution channel; MS and SD; bank stabilization between Country Club Road and Alma School Road	Wetland, CW, and MS	CW, SD, and MS; main channel reshaped and seeded to reestablish river bottom	CW, MS, and SD; SRS&R Beeline One Plant reshaped and converted to new river bottom; spillway and low-flow channel	CW, MS, and SD; wetland	No activity	Same as Alt. A	943	7 new irrigation diversion structures; 1 new well	5,690 ac-ft/yr
H	No activity	Wetland; MS and SD; channel reshaped and seeded to create new river bottom; bank stabilization between Country Club Road and Alma School Road	Wetland, MS, and SD	MS and SD; main channel reshaped and reseeded to reestablish new river bottom	SRS&R Beeline One Plant and main channel reshaped and converted to new river bottom; MS, SD, and CW	MS and SD; wetland	No activity	Same as Alt. A	850	8 new irrigation diversion structures; 1 new well	4,032 ac-ft/yr

Alternative	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reaches 8 & 9	Increase in AAFCUs	Water Sources	Water Demand
I	No activity	SW and two wetland features; bank stabilization between Country Club Road and Alma School Road; buried dikes	Wetland	Wetland, CW, and MS	SRS&R Beeline One Plant reshaped and converted to new river bottom; CW and two wetlands; bank stabilization; grade control structure	Low-flow channel; CW and wetland; buried guide dikes	No activity	Same as Alt. A	675	6 new irrigation diversion structures	4,920 ac-ft/yr
J	No activity	Wetland, CW, and MS; bank stabilization between Country Club Road and Alma School Road	CW; abandoned quarry reshaped to establish new river bottom	MS, SD, CW, and wetland	SRS&R Beeline One Plant reshaped and converted to new river bottom; CW, MS, and SD; wetland; bank stabilization; main channel reshaped for river bottom establishment and increase channel conveyance capacity	CW, MS, and wetland	No activity	Same as Alt. A	872	9 new irrigation diversion structures; 1 new well	6,087 ac-ft/yr
K	No activity	Wetland, MS, and CW; bank stabilization between Country Club Road and Alma School Road	Wetland, CW, SD, and MS	MS, SD, and CW	CW, MS, SD, and wetlands	DW, MS, and wetland	No activity	Same as Alt. A	627	9 new irrigation diversion structures; 1 new well	6,304 ac-ft/yr
L	No activity	Wetland, CW, and MS; bank stabilization between Country Club Road and Alma School Road	No activity	CW, MS, and wetland	SRS&R Beeline One Plant reshaped and converted to new river bottom; CW, MS, and wetlands; grade control structure	CW, MS, and wetlands	No activity	Same as Alt. A	758	4 new irrigation diversion structures; 1 new well	5,602 ac-ft/yr
M	No activity	Wetlands, CW, and MS	No activity	MS, CW, SD, and wetlands	SRS&R Beeline One Plant reshaped and converted to new river bottom; wetlands, CW, and MS; grade control structure; bank stabilization	CW and wetlands	No activity	Same as Alt. A	829	8 new irrigation diversion structures; 1 new well	6,488 ac-ft/yr
N	CW	Wetlands, CW, and MS	No activity	CW, MS, and wetland	SRS&R Beeline One Plant reshaped and converted to new river bottom; CW, MS, SD, and wetland; grade control structure	CW and MS	No activity	Same as Alt. A	913	9 new irrigation diversion structures; 1 new well	7,736 ac-ft/yr
O	Wetlands and CW	Wetlands, CW, MS; drainage channel constructed	CW and MS	CW, MS, and wetland	SRS&R Beeline One Plant reshaped and converted to new river bottom; CW, MS, and SD; grade control, WT structure	CW and MS	No activity	Same as Alt. A	963	9 new irrigation diversion structures; 1 new well	8,550 ac-ft/yr
P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5.6.2.1 Alternative A

Alternative A provides a vegetation plan that obligates the least amount of water; 992 acre-feet/year (Table 37). Sonoran desert scrub shrub, which is adapted to survive on relatively little rainfall, is the sole vegetation type planned. Scrub shrub establishment is limited to the areas between the Hennessey Drain and the eastern end of the Tri-City landfill. Limiting the size of vegetation establishment allows for a lower project cost. This also limits the potential net habitat value to 373 FCUs (Table 57). Mechanical features include reshaping of the SRS&R Beeline One Plant to increase the stability of the area to create new river bottom acreage. No structural features are proposed. The proposed restoration features in each reach are described below and are shown in Figure 38.

Reach 1

- No activity is planned for this reach. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- No activity is planned in this area.

Reach 3

- No activity is planned in this area.

Reach 4

- No activity is planned in this area.

Reach 5

- A new well drilled in Reach 6 would provide water to Sub-areas 5.1 and 5.2 for the SD in and around the new river bottom created by reshaping the SRS&R Beeline One Plant. The SD would be irrigated by a SBIN. It can also be supplemented by overland flow from water diverted from the Evergreen Drain during storm event.

- In Sub-area 5.3, on the western end of the south bank, a small area of SD would be established along the upland area. The SD would be irrigated with a SBIN using diverted surface water.

Reach 6

- Within Sub-area 6.1, SD would be planted on both the north and south side of the GRUSP site. The SD would be irrigated using a SBIN and water diverted from the Hennessey Drain. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. A more detailed analysis is needed.

- In Sub-area 6.3, SD would be established at the Hennessey Drain, where the north and south GRUSP channels diverge. This area would be irrigated using a SBIN and/or flood irrigation. SRPMIC surface water from the Hennessey Drain would be used as a water source.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Three new irrigation diversion structures, no new WWTP diversion structure, and no new wells are proposed for this alternative.

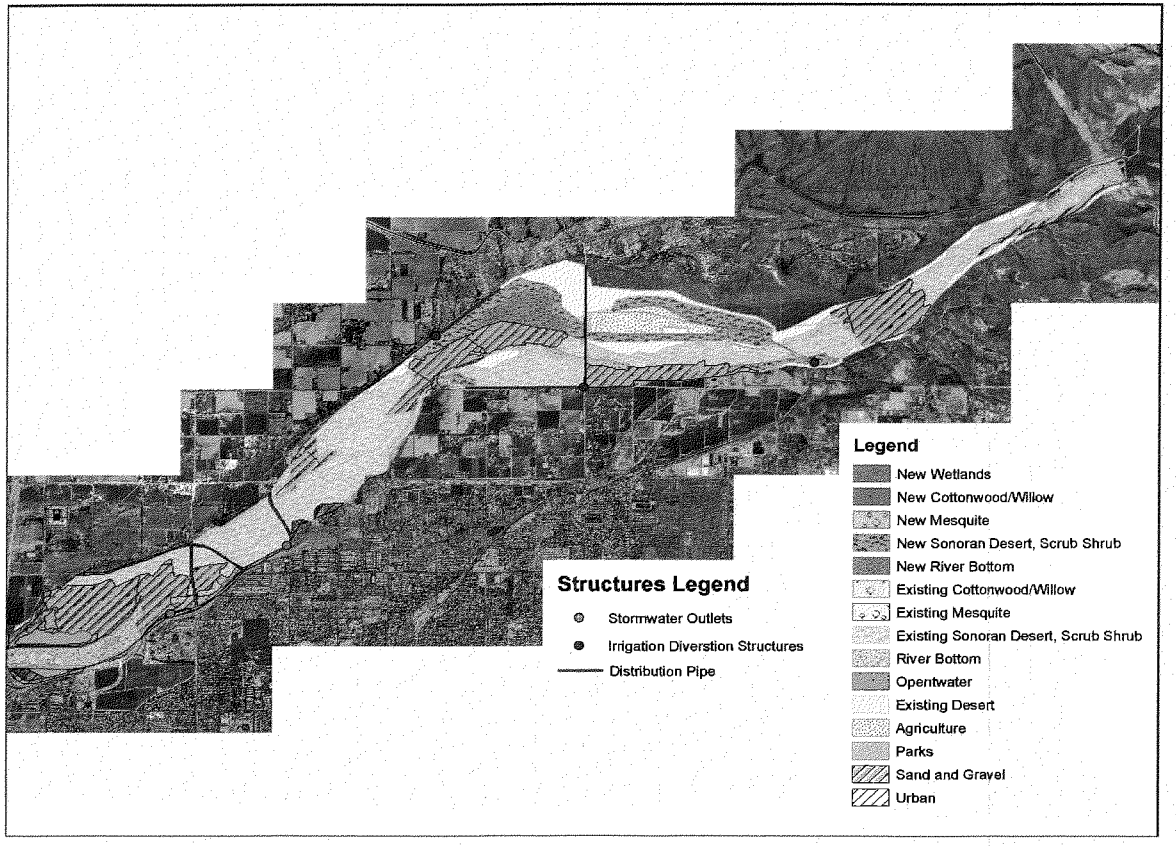
Water Demand

As presented in Table 37, the total annual evapotranspiration demand for Alternative A is 992 acre-feet.

Table 37. Vegetated Area and Evapotranspiration Rate – Alternative A

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	0	0
3	0	0
4	0	0
5	198	396
6	298	595
Total	**496**	**992**

Figure 38. Alternative A



5.6.2.2 Alternative B

Alternative B provided slightly more vegetation than Alternative A with an increase in the Sonoran desert scrub shrub including areas of mesquite. The water demand is still considerably lower relative to other alternatives at 2,172 acre-feet/year (Table 38). This alternative provides a net habitat value of 594 FCUs (Table 57). Vegetation establishment would be concentrated around SRS&R Beeline One Plant and the existing GRUSP site. However, the area around Hennessey Drain and a portion of the Tri-City landfill are also planned for vegetation establishment. Alternative B also proposes a single area of bank stabilization with a spillway at the SRS&R Beeline One Plant site. The area within the quarry would be reshaped and converted to new river bottom. The proposed restoration features in each reach are described below and are shown in Figure 39.

Reach 1

No activity is planned for this reach.

Reach 2

- Along the south bank in Sub-area 2.3, a small MS bosque and SD area would be constructed near the Country Club Storm Drain on the existing river bottom. The area would be located in a high-velocity area and would suffer damages during flow events every 3 years on average. However, these flow events would allow the transport of seeds further downstream, aiding establishment of new areas.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- No activity is planned in this area.

Reach 4

- Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, SD can be established. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace via a SBIN.

Reach 5

- In Sub-areas 5.1 and 5.2, water diverted from the new groundwater well would irrigate the SD surrounding the new river bottom created by reshaping the SRS&R Beeline One Plant, as well as the small pocket of MS just west of Gilbert Road. Both the MS and SD would be irrigated by a SBIN. Some areas of vegetation can also be irrigated by overland flow from water diverted from the Evergreen Drain during storm events.

- To allow water into and out of the new river bottom within the SRS&R Beeline One Plant, a spillway would be constructed. The general shape of the spillway consists of a 200-foot bottom width trapezoidal structure, with a maximum depth of 10 feet, and 1:1 side slopes. A low-flow channel would be constructed in the spillway with a 40-foot bottom width, a maximum depth of 4 feet, and 1:3 side slopes. Riprap or soil cement would be placed on both sides of the structure to prevent scouring from occurring. The north bank would be armored using soil cement and/or riprap to increase conveyance in the north.

- In Sub-area 5.1, an MS bosque would be created on a terrace at the Evergreen Ditch outlet. The new groundwater well can be used for additional water, if necessary. The MS can be irrigated by a SBIN.

- In Sub-area 5.3, on the western end of the south bank, SD would be established along the upland area. The SD would be irrigated with a SBIN using diverted surface water.

Reach 6

- Within Sub-area 6.1, MS and SD would be planted both north and south of the GRUSP site, and MS and SD would be planted north of the GRUSP site. The vegetation planted to the north of the GRUSP site would be irrigated with groundwater extracted from a new well distributed with the SBIN. Surface water,

also distributed using a SBIN, would be diverted from a new outlet to supply water to the vegetation south of the GRUSP site. Because the vegetated areas are near the GRUSP site, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed. A section of the distribution channel would be installed to extend the Hennessey Drain East to supply water to Sub-area 5.2.

- In Sub-area 6.3, MS and SD would be established at the Hennessey Drain outlet. These areas would be irrigated using a SBIN and/or flood irrigation. SRPMIC surface water from the Hennessey Drain would be used.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Four new irrigation diversion structures, no new WWTP diversion structure, and one new well are proposed for Alternative B.

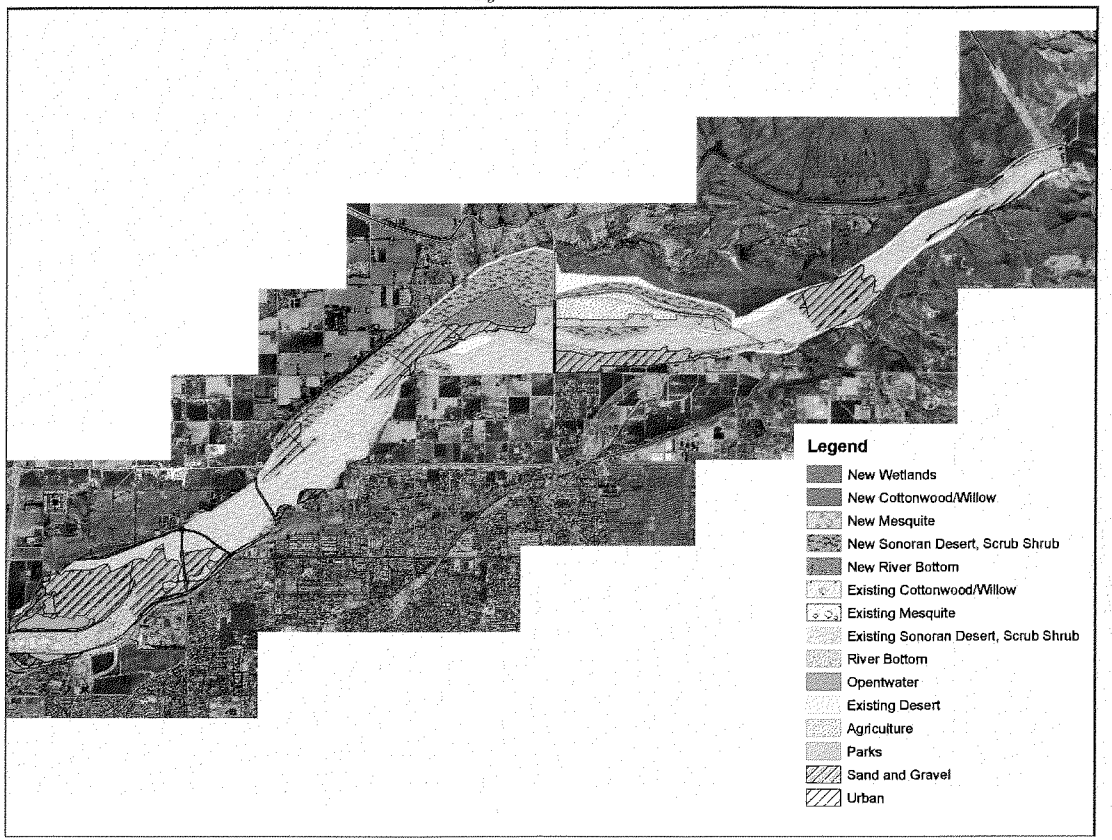
Water Demand

As shown in Table 38, the total annual evapotranspiration demand for Alternative B is 2,172 acre-feet.

Table 38. Vegetated Area and Evapotranspiration Rate – Alternative B

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	18	46
3	0	0
4	121	242
5	432	929
6	382	956
Total	**952**	**2,172**

Figure 39. Alternative B



5.6.2.3 Alternative C

Alternative C increases the vegetation establishment both in size and complexity. While Alternative C is dominated by Sonoran desert scrub shrub, areas of mesquite, cottonwood-willow, and wetlands are also created. While the inclusion of cottonwood-willow and wetland features increases the water demand to 3,696 acre-feet/year (Table 39), this alternative provides a net habitat value of 771 FCUs (Table 57). Vegetation planting extends from the Hennessey Drain to the western end of the Tri-City landfill, with two smaller areas of vegetation between County Club Road and Alma School Road. Alternative C also proposes two areas of bank stabilization. The SRS&R Beeline One Plant and portions of the main channel immediately downstream of the quarry would be reshaped and converted to new river bottom. The proposed restoration features are described below and are shown in Figure 40.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- A small wetland feature with CW, MS, and SD extending downstream would be created in Sub-area 2.3, near the Country Club Storm Drain. The wetland would be constructed near the drain on the existing river bottom and would need to withstand stormwater runoff. MWWTP water would be dispersed using the SBIN to the CW and MS. Stormwater would function as the secondary source of water.

- MWWTP water supports the small wetland feature created in Sub-area 2.2 at Alma School Road downstream of the old quarry. The wetland would support CW to the west and SD to the east, distributing water using a SBIN. The quarry would be reshaped to create new river bottom.

- Bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. Bank stabilization is necessary to prevent further erosion, which affects the newly established vegetation, and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the

structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

No activity is planned for this reach.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, SD could be established in this area. The area would be irrigated using surface and stormwater, distributed by a SBIN.

- No activity is planned for Sub-area 4.2.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to new river bottom in Sub-area 5.2. During high flow events, water would be allowed to spill into the area. No spillways or bank stabilization features are proposed. Sub-area 5.2 would support areas of SD, CW, and two small pockets of MS on the overbank area. All vegetation would be irrigated using surface water diverted from the north drainage channel, distributed using a SBIN.

- The main channel, extending into Sub-area 4.1, would also be reshaped to allow for the establishment of river bottom. Another alternative is to allow naturally occurring flow events to reshape the river bottom. The advantage of mechanical reshaping is to utilize material in the construction of proposed features.

- Sub-area 5.1 would support a wetland feature created at the Evergreen Ditch outlet with MS and CW, buffering it to the south, and SD, buffering it to the east and west. The wetland would need to be designed to handle storm flow and disperse storm water laterally. To disperse the storm water, side drains would be constructed to convey water during storm events. The vegetation would be irrigated using surface water and stormwater runoff using a SBIN.

- Sub-area 5.3, located along the south bank, would be vegetated with SD and a small pocket of MS found at the western edge that extends into Sub-area 6.2. The vegetation would be irrigated using surface water, distributed by a SBIN.

Reach 6

- Two water distribution channels would be created using SRP water originating from the Hennessey Drain. One would follow the north bank; the second would follow the south bank. These, supplemented by stormwater, would supply water to Sub-areas 6.1, 6.2, and 6.3.

- The north distribution channel flows through Sub-area 6.1, located on the north bank outside the 10-year floodplain. It would be flanked by CW, MS, and SD, irrigated with a SBIN, and constructed to expand the width of the vegetation areas. Because the vegetated areas are near the GRUSP, water that has infiltrated can also be used to support vegetation. A more detailed analysis is needed. The south distribution channel, in Sub-area 6.2, would be flanked with CW, MS, and a small pocket of SD, just east of Gilbert Road. These vegetation stands would also be irrigated using surface water distributed using a SBIN. In order to vegetate the south bank, the quarry would need to be filled and reshaped. The southern bank at the quarry would then be stabilized. Soil cement is recommended.

- Sub-area 6.3 would have a wetland feature and would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using a SBIN and/or flood irrigation. SRPMIC surface water from the Hennessey Drain would serve as the source of water.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This

could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Four new irrigation diversion structures, no new WWTP diversion structure, and no new wells are proposed for Alternative C.

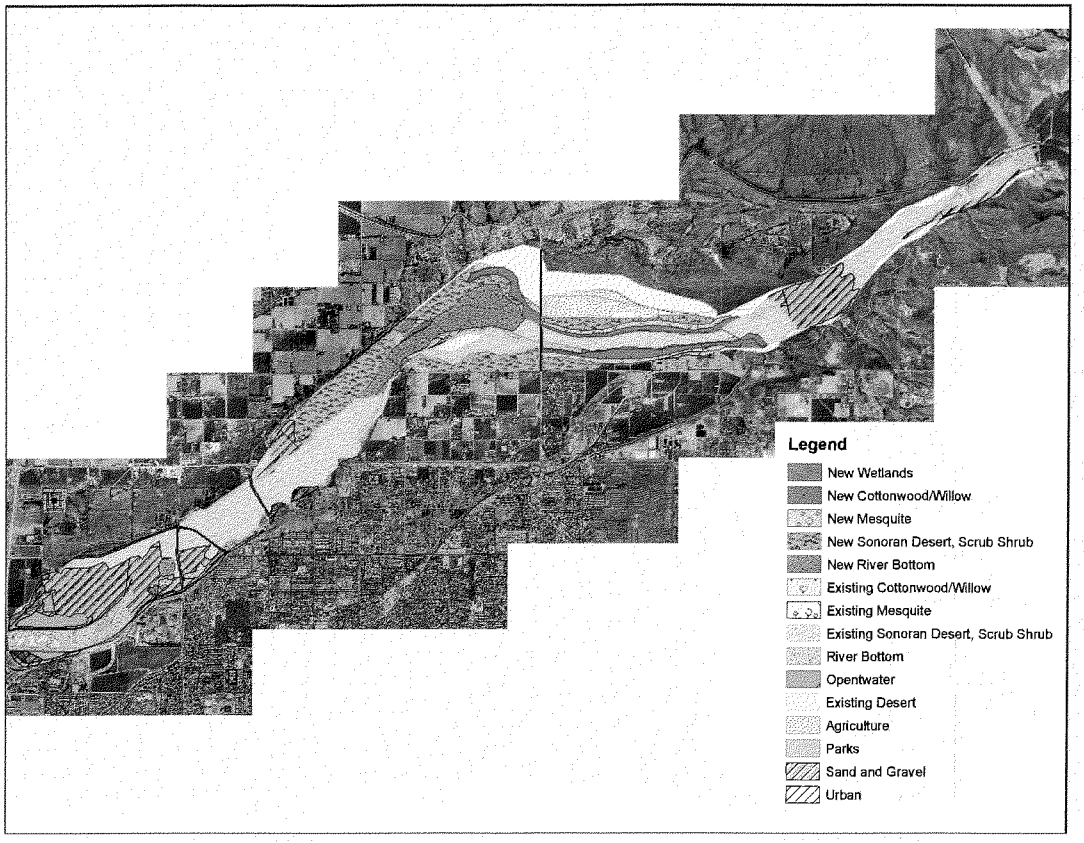
Water Demand

As presented in Table 39, the total annual evapotranspiration demand for Alternative C is 3,696 acre-feet.

Table 39. Vegetated Area and Evapotranspiration Rate – Alternative C

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	36	136
3	0	0
4	243	486
5	435	1,290
6	439	1,785
Total	**1,152**	**3,696**

Figure 40. Alternative C



5.6.2.4 Alternative D

Alternative D reduces the affected project area while still providing a complex vegetation plan. All project features fall between Gilbert Road and Country Club Road. A greater proportion of cottonwood-willow stands and wetlands are proposed, relative to the mesquite and Sonoran desert scrub shrub. Alternative D provides a net habitat value of 598 FCUs (Table 57). Although cottonwood-willow stands make up a larger proportion of the total vegetated areas, the water demand does not vary significantly from Alternative C due to the reduced project area. The water demand for this alternative is 3,629 acre-feet/year (Table 40). To create new river bottom acreage, the SRS&R Beeline One Plant would be reshaped along with portions of the main channel south and downstream of the quarry. Structural features would include two areas of bank stabilization. Both structures would help stabilize the area near the quarry. A grade control structure is also proposed near the quarry. The proposed restoration features in each reach are described below and are shown in Figure 41.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- No activity is planned for Reach 2.

Reach 3

- No activity is planned for Reach 3.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. MS and SD could be established in this area depending on water quality issues including potential leachate and methane production. The main channel would be reshaped and converted to new river bottom, with a wetland feature in the main channel and a small strip of CW on the northern edge of the main channel. The area would be irrigated using surface and storm water, distributed by a SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and an elongated wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant Pit would be reshaped and converted to river bottom in Sub-area 5.2. The north bank would be stabilized. Soil cement is recommended. CW and MS would be established to the north of the pit, on the overbank area. Both vegetation types would be irrigated using groundwater extracted from a new well. The water would be distributed using a SBIN.

- The main channel would be reshaped and converted to new river bottom. A grade control structure would also be placed in Sub-area 5.2, in the main channel at the center point of the SRS&R Beeline One Plant. This structure would help protect the channel and newly-restored riparian areas upstream from headcutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed and be designed to the estimated scour depth.

- Immediately downstream from the grade control structure, an area of soil cement bank stabilization would begin and continue for approximately 5,500 feet. The structure would be 30 feet high and 6 feet deep, and would be used to offset erosion concerns due to mining that is occurring within the main channel, along the island located immediately south of the SRS&R Beeline One Plant.

- Sub-area 5.3, located along the south bank, would be vegetated with CW, MS, and a wetland feature. The wetland feature would be immediately west of Gilbert Road. The CW would buffer the wetland feature to the west, with MS buffering it to the south. Surface water and stormwater would be used to irrigate these areas, distributed by SBIN.

Reach 6

- No activity is planned for Reach 6.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Six new irrigation diversion structures, no new WWTP diversion structure, and one new well are proposed for Alternative D.

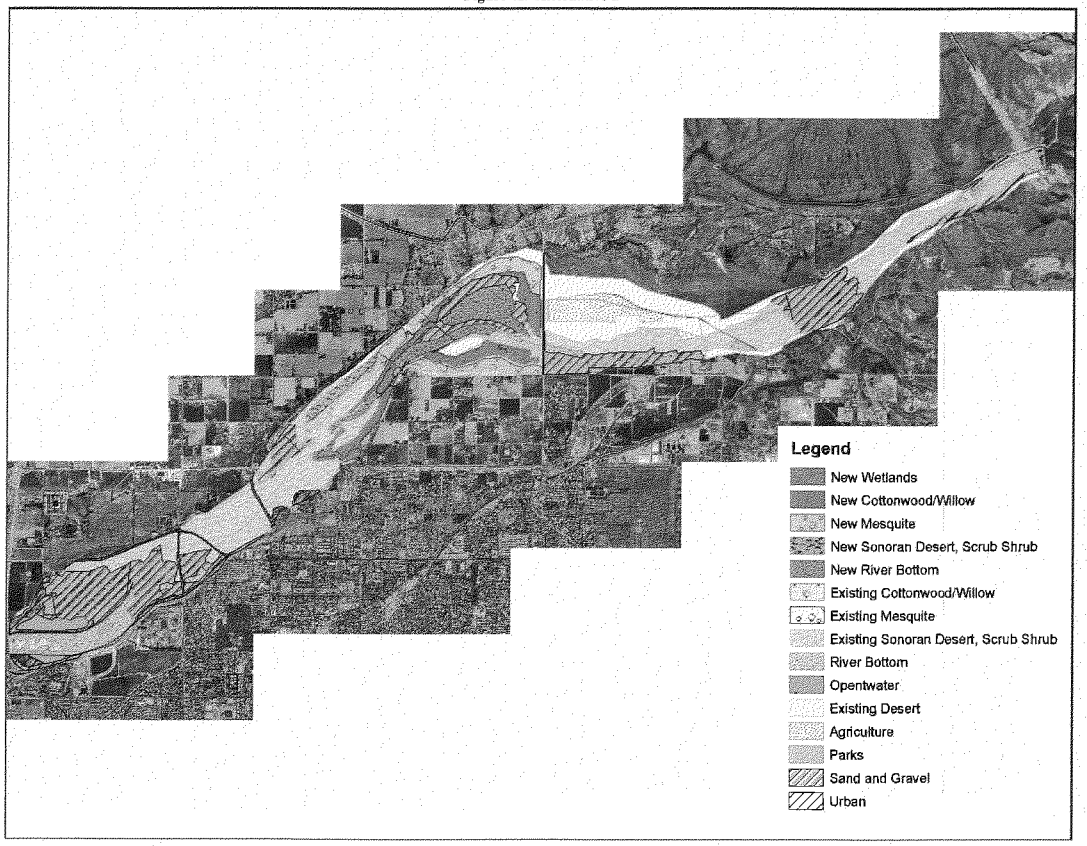
Water Demand

As presented in Table 40, the total annual evapotranspiration demand for Alternative D is 3,629 acre-feet.

Table 40. Vegetated Area and Evapotranspiration Rate – Alternative D

Reach	Area (acres)	Evapotranspiration(ac-ft)
1	0	0
2	0	0
3	0	0
4	272	1,361
5	467	2,268
6	0	0
Total	**739**	**3,629**

Figure 41. Alternative D



5.6.2.5 Alternative E

Alternative E includes all four vegetation types: Sonoran desert scrub shrub, mesquite, cottonwood-willow, and wetlands. Most of the proposed vegetation would be located upstream and downstream of Gilbert Road. Sonoran desert scrub shrub dominates downstream of Gilbert Road while cottonwood-willow dominates upstream of Gilbert Road. The wetlands are limited to two drain outlets while mesquite dominates the Tri-City landfill. Because of the large and contiguous stand of cottonwood-willow planned, the water demand for this alternative increases to 4,540 acre-feet/year (Table 41). This alternative provides a net habitat value of 926 FCUs (Table 57). Three areas of bank stabilization are proposed. Reshaping in the SRS&R Beeline One Plant and portions of the main channel to create new river bottom is also proposed in Alternative D. The proposed restoration features are described below and are shown in Figure 42.

Reach 1

- Sub-area 1.2 is a recharge area on the south side of the river and would be converted to a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area would be MWWTP water.

- The only measure applied in the main channel of the river is the eradication of invasive vegetation species, if no threatened or endangered species are associated with them, followed by possible enhancement plantings to avoid reoccurrence of invasive plants. It is also important to ensure existing or a sufficient percentage of existing water currently discharging into the river along Reach 1 be maintained.

Reach 2

- In Sub-areas 2.1 and 2.2, between Country Club Road and Longmore Road along the north bank and within the channel, SD would be established and irrigated using surface water via a SBIN. A wetland and small CW stand would also be established and irrigated using runoff from the golf course.

- Along the south bank, Sub-area 2.3, a wetland feature would be constructed near the Country Club Storm Drain on the existing river bottom. The wetland feature would need to withstand stormwater runoff. CW would be planted immediately adjacent to the wetland near a drainage channel. The area would be located in a high-velocity

area and would suffer damages during flow events at an average of every three years. However, these flow events would allow the transport of seeds and vegetative propagules further downstream, aiding establishment of new areas.

- The old quarry at Alma School Road would be converted to new river bottom.

- Bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. Bank stabilization is necessary to prevent further erosion, which affects the newly established vegetation, and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- No activity is planned in this area.

Reach 4

- Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, MS can be established. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace via a SBIN. Local sponsors have expressed their interest in potentially creating a nursery in this area.

Reach 5

- The distribution from Reach 6 would continue downstream to Reach 5 Sub-area 5.2. The north distribution channel would provide water to CW plants, MS, and SD in and around the new river bottom created by reshaping the SRS&R Beeline One Plant. The MS and SD would be irrigated using a SBIN with groundwater from a new well as a source.

- Sub-area 5.1, which is predominantly wetland, would be created at the Evergreen Ditch outlet on a terrace. Groundwater from a new well can be used for additional water, if necessary. The wetland would need to be designed to handle storm flow and disperse storm water laterally. To disperse the storm water, side drains would be created and allowed to convey water during storm events. Irrigation of the CW and MS surrounding the wetland could be done by a SBIN.

- In Sub-area 5.3, on the south bank from Gilbert Road to Lehi Cemetery, SD would be established along the upland area. The SD would be irrigated with a SBIN using diverted surface water. Bank stabilization along this south bank is recommended to prevent erosion and the loss of newly established vegetation. Soil cement is recommended.

- The main channel would be reshaped to allow for the establishment of river bottom and to increase channel conveyance capacity. Another alternative is to allow naturally occurring flow events to reshape the river bottom. The advantage of mechanical reshaping is to utilize material in the construction of proposed features.

Reach 6

- SRP water currently flows from the Hennessey Drain to the GRUSP site via an existing drainage channel. The channel flows along the north side of the GRUSP site. The drainage channel would be extended past Gilbert Road to supply water to Sub-area 5.2.

- Within Sub-area 6.1, CW would be planted south of the GRUSP site, and MS and SD would be planted north of the GRUSP site. The CW would be irrigated using a SBIN. Water from the drainage channel would be diverted to the SBIN for CW use. MS and SD would be planted north of the drainage channel and irrigated using a SBIN and/or a drip system. Groundwater from a new well would be the source of water. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. A more detailed analysis is needed. A section of distribution channel would be installed to extend the Hennessey Drain East to supply water to Sub-area 5.2.

- Sub-area 6.2, located on the south bank, would require reshaping of an old quarry and seeding to establish SD. MS would be planted upstream of the quarry outside of the 20-year floodplain. The area would be irrigated using a SBIN with water diverted from the Hennessey Drain. The south bank would be hard-banked with soil cement or coarse rock to prevent headcutting that could compromise the establishment of the vegetation.

- In Sub-area 6.3, at the GRUSP diversion, a wetland and CW area would be established. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using a SBIN and/or flood irrigation. SRPMIC surface water from the Hennessey Drain would be used to irrigate this area.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp*), would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Four new irrigation diversion structures, no new WWTP diversion structure, and one new well are proposed for Alternative E.

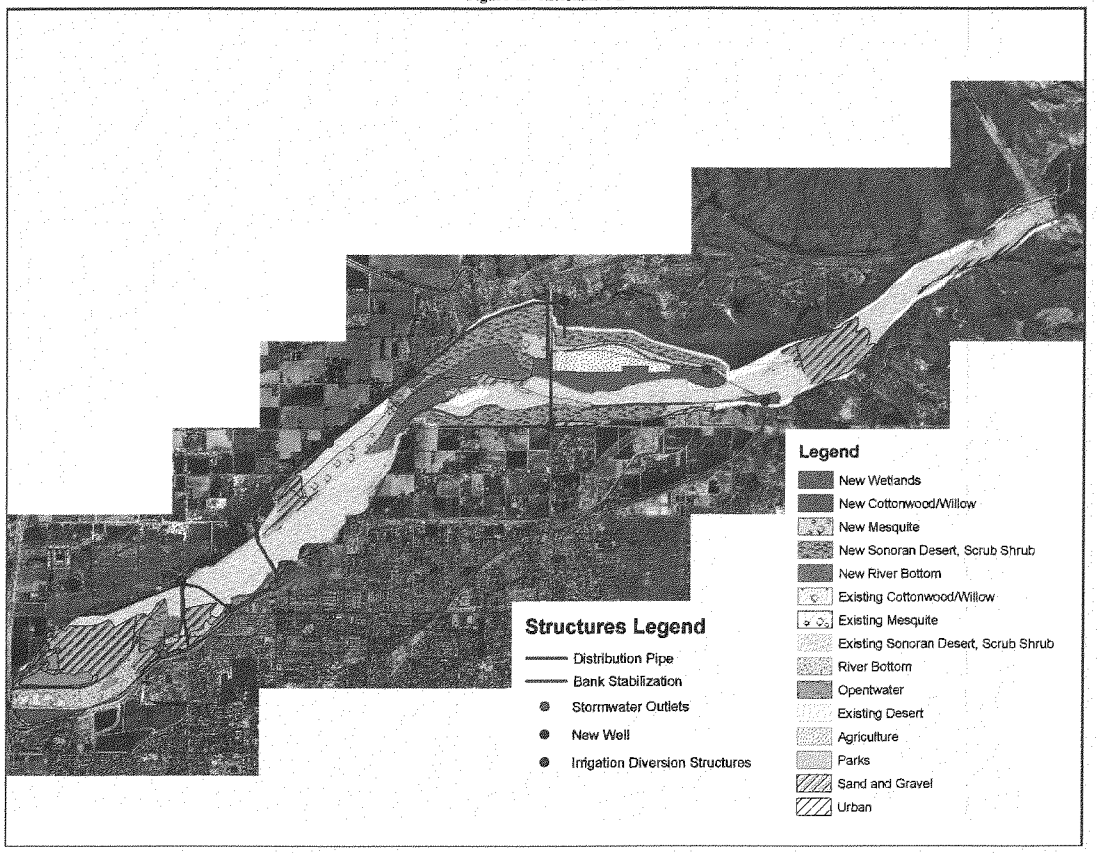
Water Demand

As presented in Table 41, the annual evapotranspiration demand for Alternative E is 4,540 acre-feet.

Table 41. Vegetated Area and Evapotranspiration Rate – Alternative E

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	38	242
2	98	261
3	0	0
4	128	384
5	577	1,461
6	575	2,191
Total	**1,416**	**4,540**

Figure 42. Alternative E



5.6.2.6 Alternative F

Alternative F is the most expansive alternative. A low-flow channel would be created from Hennessey Drain down to Gilbert Road and from Country Club Road downstream to Alma School Road. The low-flow channel would support Sonoran desert scrub shrub and wetlands. However, cottonwood-willow would be the dominant vegetation type with sufficient acreage of mesquite. The water demand of this alternative is highest at 8,304 acre-feet/year (Table 42). However, Alternative F also produces the most net habitat value at 1,035 FCUs (Table 57). Four areas of bank stabilization are proposed. A grade control structure would also be placed near the SRS&R Beeline One Plant. Extensive reshaping of the quarry and portions of the main channel from Gilbert Road to Country Club Road would provide new river bottom. The proposed restoration features are described below and are shown in Figure 43.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by CW on the south side and MS on the north side. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by runoff from a golf course located north of the Salt River, if it is of sufficient quality. The channelized river would support an in-channel wetland in this area that would terminate with a larger wetland immediately downstream of Alma School Road.

- Along the south bank, Sub-area 2.3 would support a wetland feature, MS, and two small pockets of CW. A stand of CW would surround the wetland. A second stand begins in the eastern edge of Sub-area 2.3 and extends slightly into Sub-area 2.2. Surface water via a SBIN would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff. The wetland would be surrounded by CW and irrigated using a SBIN.

- Similar to Alternatives C and E, bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- A channel would be constructed to drain Reach 4.2 to supply water to the in-channel wetland and CW vegetation of Sub-area 3.1. Water would be dispersed to the CW using the SBIN.

- The river would also be channelized throughout Reach 3, connecting the low-flow channel in Reach 4 to one in Reach 2.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, MS, SD, and a small stand of CW could be established in this area. The area would be irrigated using surface water and stormwater by way of the SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and a wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently. The western wetland feature would also serve as an upstream starting point for a second reach of channelized river bottom supporting two wetland features within the channel and SD on the benches.

Reach 5

- The SRS&R Beeline One Plant Pit would be reshaped and converted to river bottom in Sub-area 5.2. Two spillways would be constructed to allow water flow into and out of the pit from the river. CW, MS, and SD would be located on the overbank area. The SD and MS would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from the North Drainage Channel. The water would be distributed using SBIN. The north bank would also be stabilized in this area. Soil cement is recommended.

- The channel in Sub-area 5.1 and the western half of Sub-area 5.3 would be reshaped and converted to river bottom. A wetland feature and MS would be established at Evergreen Drain. The MS would be irrigated using groundwater from the new well. The wetland would be supported by runoff from Evergreen Drain.

- Sub-area 5.3, located along the south bank, would be vegetated with CW and MS. Surface water and stormwater would be used to irrigate these areas. The south bank CW and MS would continue eastward, ending at Gilbert Road. The CW and MS would be irrigated with a SBIN.

- A grade control structure would be placed in Sub-area 5.2 in the main channel at the center point of the SRS&R Beeline One Plant. This structure would help protect the channel and newly-restored riparian area upstream from headcutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed and be designed to the estimated scour depth.

Reach 6

- CW and MS would be established in Sub-area 6.1. The MS would be irrigated using surface water from the North Canal. The CW would be irrigated using surface water from the Hennessey Drain. For both areas, the water would be distributed using a SBIN or flood irrigation method. The MS is located on the north bank, immediately outside of the active channel, outside of the 10-year floodplain. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. A more detailed analysis is needed.

- In Sub-area 6.2, located on the south bank of the river, CW would be planted in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain, between a larger quarry and the channel. The area would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation. The larger quarry located further upstream along the south bank would be reconnected to the Salt River with two spillways. No reshaping is recommended due to the volume of material required to fill the quarry back to channel invert level. It is recommended that the south bank be armored to ensure that the quarry does not affect the current channel layout.

- Sub-area 6.3 would have a wetland feature, which would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW to the east, taking advantage of the saturated soil conditions, and would be irrigated using surface water from the Hennessey Drain and a SBIN or flood irrigation. The wetland would also serve as the upstream starting point of the low-flow channel. The larger wetland feature would narrow down to fit within the channelized portion of the river. The river channelization would continue downstream to approximately Gilbert Road, with two wetland features within the channel and SD on the benches – one at the eastern end and the other at the western end. Surface water from the Hennessey Drain would be used to irrigate the features.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Nine new irrigation diversion structures, no new WWTP diversion structure, and one new well are proposed for Alternative F.

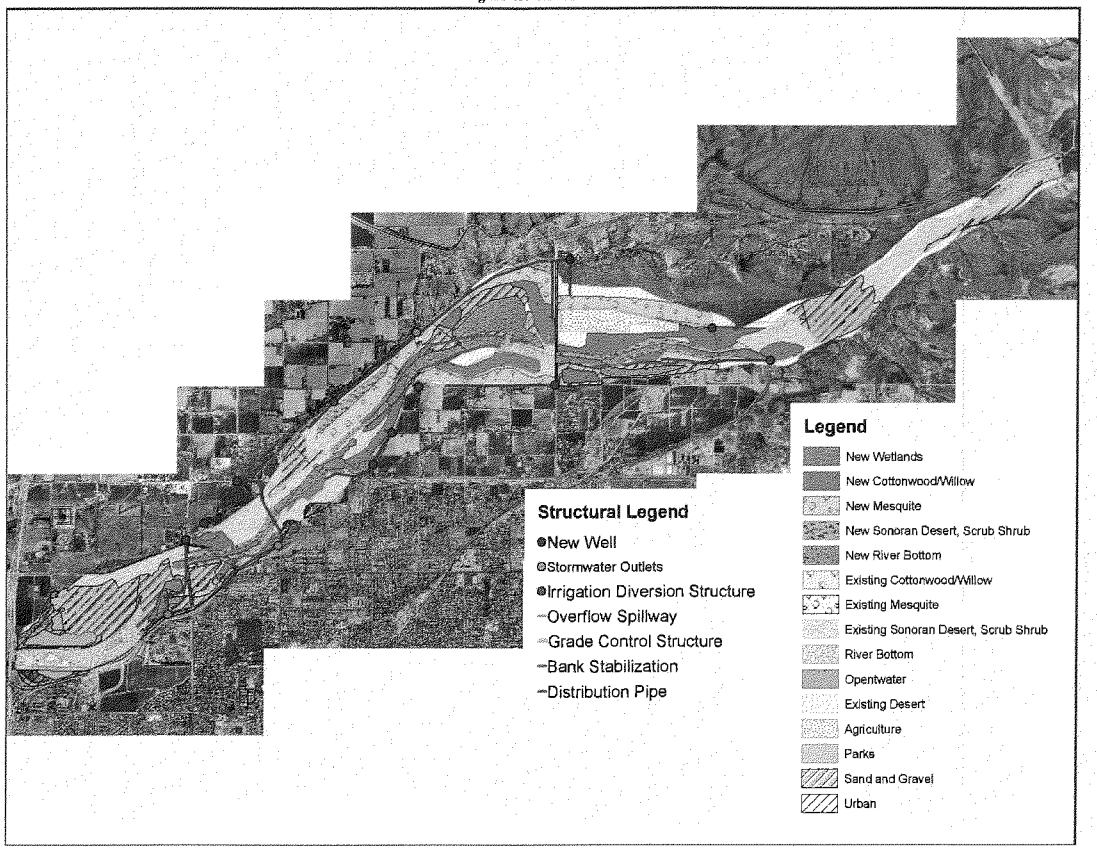
Water Demand

As presented in Table 42, the annual evapotranspiration demand for Alternative F is 8,304 acre-feet.

Table 42. Vegetated Area and Evapotranspiration Rate – Alternative F

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	233	1,298
3	29	181
4	344	1,668
5	495	2,204
6	610	2,952
Total	**1,711**	**8,304**

Figure 43. Alternative F



5.6.2.7 Alternative G

Alternative G is similar to Alternative F. However, it does not have a low-flow channel, and some stands of cottonwood-willow are replaced with more xeric vegetation, decreasing the water demand to 5,690 acre-feet/year (Table 43). The vegetation plan, which is dominated by mesquite and cottonwood-willow, results in a net habitat value of 943 FCUs (Table 57). The SRS&R Beeline One Plant and portion of the main channel near Horne Street and Alma School Road would be reshaped to create new river bottom. Four areas of bank stabilization are planned for Alternative G. The proposed restoration features are described below and are shown in Figure 44.

Reach 1

- Sub-area 1.2 is a recharge area on the south side of the river, which would be converted to a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area would be MWWTP water.

- Similar to Alternative E, the only measure applied in the main channel of the river is the eradication of invasive vegetation species, followed by possible enhancement plantings to avoid reoccurrence of invasive plants. It would also be important to ensure existing water or a sufficient percentage of the existing water currently discharging into the river along Reach 1 be maintained.

Reach 2

- Sub-area 2.3 would be restored like Alternative E.

- A distribution channel would be constructed from the Country Club wetland and would extend downstream along the south bank. To supply water to the diversion channel, MWWTP water can be diverted from an existing line going north along Highway 202 at Country Club Road. A wetland feature would be created from Alma School Road downstream past the old quarry. The quarry would be converted into a dry lake. Water from the diversion channel would flow into these features and act as the water supply.

- On the south terrace, outside the 10-year floodplain, MS and SD would be established and irrigated using stormwater. The irrigation system would be a combination of flood irrigation and SBIN or drip system.

- The channel would be reshaped and seeded to create a new river bottom.

- Bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- Diversion channels from Reach 4 would converge and discharge remaining water into Sub-area 3.1, supporting a wetland feature and CW and MS vegetation. Water would be dispersed to the CW and MS using the SBIN. Additional water can come from groundwater wells, if necessary. Because no wells are in the vicinity, a new one may need to be constructed. Sub-area 3.1 is confined by a landfill (Old Tri City).

Reach 4

- The north diversion channel would continue downstream merging with the Evergreen Drain into Reach 4, Sub-area 4.1. The channel would now be located within the 10-year floodplain. To maintain the channel configuration, periodic rechannelization of the diversion channel would be required, on average, every three years. CW would be planted along both channels. To increase the CW width, a SBIN would be created. Water sources for the channel are the Evergreen Ditch and water from Reach 5. The CW would be susceptible to damage because the stands would be located in or near the main channel and would experience high velocities and shear stresses during flow events. However, these flood events would transport seed and vegetative propagules downstream, allowing for natural recruitment of new areas.

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, SD and MS can be established. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace.

- The north diversion channel would split at the upstream boundary of Reach 4 and distribute water to Sub-area 4.2, the south bank outside of the main channel. The south channel would supply water to CW and a small mesquite stand. Again, a SBIN would be constructed to expand the CW stand along the drainage channel. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

- An upstream portion of the main channel would be reshaped and seeded to reestablish river bottom. Another alternative is to allow naturally occurring flow events to reshape the river bottom. The advantage of mechanical reshaping is to utilize material in the construction of proposed features.

Reach 5

- The north diversion channel from Reach 6 would continue downstream to Reach 5. The channel would provide water to CW and MS in and around a dry lake that would be created out of the SRS&R Beeline One Plant. Fill material would be required to raise portions of the quarry bottom to support MS plants. The MS and SD would be irrigated using surface water diverted from the North Drainage Channel, distributed using SBIN.

- The SRS&R Beeline One Plant would be reshaped and converted to river bottom. To allow water to flow into and out of the dry lake during high flow, four spillways would be constructed. The general shape of the spillway consists of a 100-foot bottom width trapezoidal structure, with a maximum depth of 8 feet and 1:1 side slopes. A low-flow channel would be constructed in the spillway with a 40-foot bottom width, a maximum depth of 4 feet, and 1:3 side slopes. Riprap or soil cement would be placed on both sides of the structure to prevent scouring from occurring. The north bank would be set back and armored using soil cement and/or riprap to increase conveyance in the north.

- Sub-area 5.1, predominantly wetland, would be created at the Evergreen Ditch outlet on a terrace. The wetland outlet would connect with the north diversion channel. Groundwater wells can be used for additional water, if necessary. The wetland would need to be designed to handle storm flow and disperse stormwater laterally. To disperse the stormwater, side drains would be constructed to convey water during storm events.

- Irrigation of the CW and MS surrounding the wetland could be done by a SBIN. The north diversion channel would continue downstream reconnecting to the Evergreen Ditch drain. Groundwater wells can be used for additional water, if necessary.

- The south diversion channel would extend downstream from Reach 6 to Sub-area 5.3. CW would be planted along the channel. MS would be planted along the south bank. Surface water would be used to irrigate the MS and SD, distributed with a SBIN.

- The main channel would be reshaped to allow for the establishment of river bottom and to increase channel conveyance capacity. Another alternative is to allow naturally occurring flow events to reshape the river bottom.

Reach 6

- SRPMIC surface water coming from the Hennessey Drain would be diverted to two diversion channels along the north and south banks. This, supplemented by stormwater and well water, would supply water to Sub-areas 6.1, 6.2, and 6.3.

- The north distribution channel flows through Sub-area 6.1, which is located on the north bank outside the 10-year floodplain. The CW would be irrigated using a SBIN supplied by the north diversion channel. The MS and some of the CW could be maintained using the saturated soil conditions located around the south side of the GRUSP site. Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed.

- Sub-area 6.2, located on the south bank, would have the south diversion channel flowing on a terrace. The channel invert elevation would be above the existing channel bed, outside the 10-year floodplain. CW would be planted along the channel, with SBIN constructed to expand the width of the CW and MS. SD would buffer the CW. In order to vegetate the south bank, the quarry needs to be filled and reshaped.

- In Sub-area 6.3, wetland features would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using SBIN and/or flood irrigation. SRPMIC surface water from the Hennessey Drain would be used to irrigate this area.

Reach 7

- The proposed restoration effort for this alternative is identical to Alternative A.

Reaches 8 and 9

- The proposed restoration effort for this alternative is identical to Alternative A.

Water Sources

Seven new irrigation diversion structures, no new WWTP diversion structures, and one new well are proposed for Alternative G.

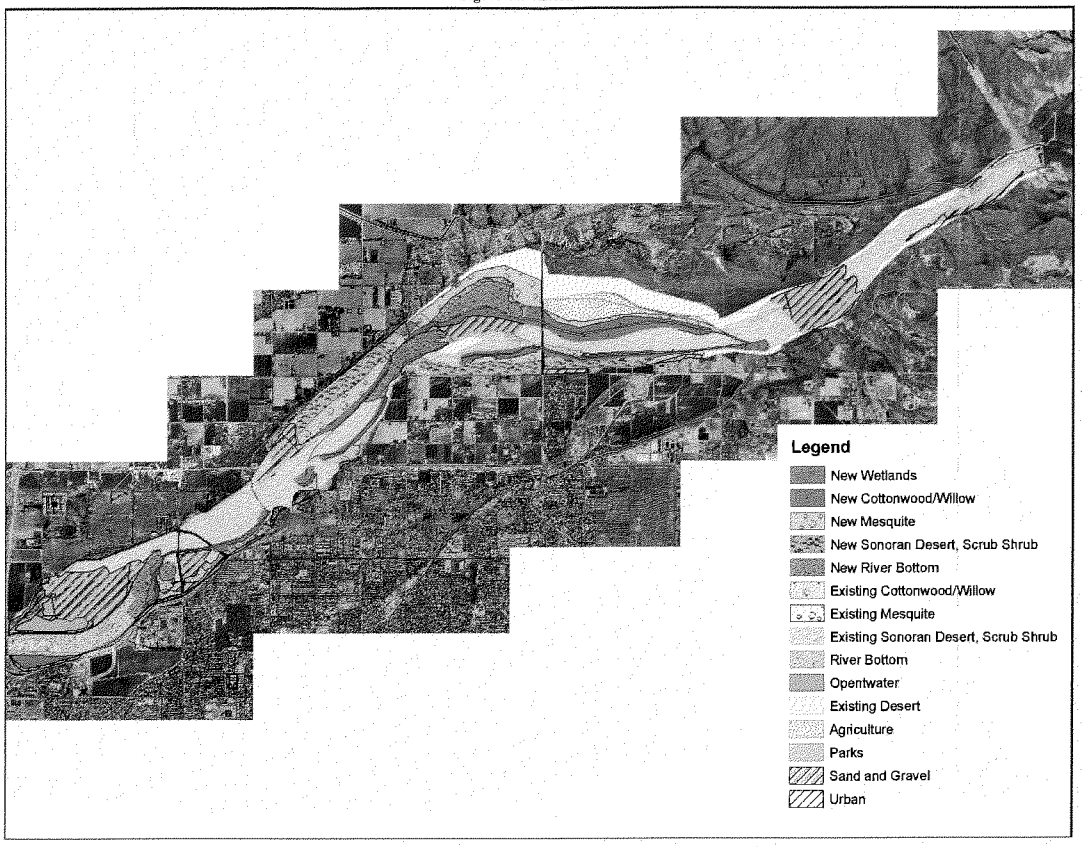
Water Demand

As presented in Table 43, the annual evapotranspiration demand for Alternative G is 5,690 acre-feet.

Table 43. Vegetated Area and Evapotranspiration Rate – Alternative G

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	37	234
2	101	554
3	31	207
4	327	1,083
5	519	1,840
6	368	1,773
Total	**1,383**	**5,690**

Figure 44. Alternative G



5.6.2.8 Alternative H

Alternative H keeps the amount of vegetated areas high but replaces all of the cottonwood-willow stands with mesquite. The other acreages are dominated by Sonoran desert scrub shrub with small areas of wetlands. Because of the drier vegetation, the water demand is 4,032 acre-feet/year (Table 44), which is relatively low given the amount of vegetated area. This alternative provides a net habitat value of 850 FCUs (Table 57), reflecting the high habitat value of mesquite. Alternative H has four areas of bank stabilization with one spillway at the SRS&R Beeline One Plant stabilization site. The SRS&R Beeline One Plant and two relatively large sections of the main channel would also be reshaped to create new river bottom. The proposed restoration features are described below and are shown in Figure 45.

Reach 1

- No activity is planned is this reach. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Along the south bank, Sub-area 2.3, a wetland feature would be constructed near the Country Club Storm Drain on the existing river bottom. The wetland feature would need to be able to withstand stormwater runoff. It appears that the wetland area is protected from main channel flow. MS would be planted on the south bank along a drainage channel and would be buffered to the south by SD. The area would be located in a high-velocity area and would suffer damages during flow events, on average, every three years. However, these flow events would allow the transport of seeds and vegetative propagules further downstream, aiding establishment of new areas.

- Similar to Alternative G, a distribution channel would be constructed from the Country Club wetland and would extend downstream along the south bank. To supply water to the drainage channel, MWWTP water can be diverted from an existing line going north along Highway 202 at Country Club Road. A wetland feature would be created from Alma School Road downstream past the old quarry. The quarry would be converted into a dry lake. Water from the diversion channel would flow into these features and act as the water supply.

- On the south terrace, outside the 10-year floodplain, MS would be established and irrigated using stormwater and MWWTP water. The irrigation system would be a combination of flood irrigation and SBIN or drip system.

- The channel would be reshaped and seeded to create a new river bottom.

- Bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- Distribution channels from Reach 4 would converge and discharge the remaining water into Sub-area 3.1, supporting a wetland feature and a small area of MS and SD vegetation. Water would be dispersed using the SBIN to both.

- Sub-area 3.1 is confined by a landfill (Old Tri-City) and would not be planted.

Reach 4

- The north distribution channel would continue downstream merging with the Evergreen Drain into Reach 4, Sub-area 4.1. The channel would now be located within the 10-year floodplain. To maintain the channel configuration, periodic rechannelization of the diversion channel would be required, on average, every three years. MS would be planted along the channels. To increase the MS width, a SBIN would be created. Water sources for the channel are the Evergreen Ditch and water from Reach 5. The MS would be susceptible to damage because the stands would be located in or near the main channel and would experience high velocities and shear stresses during flow events.

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, SD and MS can be established. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace.

- The north distribution channel would split at the upstream boundary of Reach 4 and distribute water to Sub-area 4.2, the south bank outside of the main channel. The south channel would supply water to MS. Again, SBIN would be constructed to expand the MS stand along the diversion channel. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

- An upstream portion of the main channel would be reshaped and seeded to reestablish river bottom. Another alternative is to allow naturally occurring flow events to reshape the river bottom.

Reach 5

- In Sub-area 5.2, the SRS&R Beeline One Plant would be reshaped and converted to river bottom. To allow water to flow into and out of the dry lake during high flow, four spillways would be constructed. The general shape of the spillway consists of a 100-foot bottom width trapezoidal structure, with a maximum depth of 8 feet and 1:1 side slopes. A low-flow channel would be constructed in the spillway with a 40-foot bottom width, a maximum depth of 4 feet, and 1:3 side slopes. Riprap or soil cement would be placed on both sides of the structure to prevent scouring from occurring. The north bank would be set back and armored using soil cement and/or riprap to increase conveyance in the north.

- The north distribution channel from Reach 6 would continue downstream to Reach 5. The channel would provide water to MS on the southern side of the abandoned SRS&R Beeline One Plant pit. Groundwater from a new well would provide water to MS around the north side of the SRS&R Beeline One Plant. Fill material would be required to raise portions of the quarry bottom to support MS plants. In Sub-Area 5.2, MS can also be irrigated by overland flow from water diverted from Evergreen Drain during storm events, as a supplemental source.

- Sub-area 5.1, which is predominantly wetland, would be created at the Evergreen Drain outlet on a terrace. The wetland outlet would connect with the north distribution channel. Groundwater from the new well can be used as a supplemental source of water, if necessary. The wetland would need to be designed to handle storm flow and disperse stormwater laterally. To disperse the stormwater, side drains would be constructed to convey water during storm events. MS and a small area of CW would be established around the wetland. These areas would be irrigated by a SBIN. The north distribution channel would continue downstream reconnecting to Evergreen Drain.

- The south distribution channel would extend downstream from Reach 6 to Sub-area 5.3. MS would be planted along the channel. Surface water would be used to irrigate the MS, distributed with a SBIN. SD would be established along the upland area; the SD would also be irrigated by a SBIN. Bank stabilization along this southern bank is recommended to prevent erosion and the loss of newly-established vegetation. Soil cement is recommended.

- The main channel would be reshaped to allow for establishment of river bottom and to increase channel conveyance capacity. Another alternative is to allow naturally occurring flow events to reshape the river bottom.

Reach 6

- SRPMIC surface water coming from Hennessey Drain would be diverted to two channels along the north and south banks. This, supplemented by stormwater, would supply water to Sub-areas 6.1, 6.2, and 6.3.

- The north distribution channel flows through Sub-area 6.1, located on the north bank outside the 10-year floodplain. MS would be established and would be irrigated using a SBIN. The MS areas could also be maintained using the saturated soil conditions located around the south side of the GRUSP site. Because the vegetated area is near the GRUSP, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed.

- Sub-area 6.2, located on the south bank, would have the south diversion channel flowing on a terrace. The channel invert elevation would be above the existing channel bed, outside the 10-year floodplain. MS would be planted along the channel, with a SBIN constructed to expand the width of the MS. SD would buffer the MS. In

order to vegetate the south bank, the quarry would need to be filled and reshaped. The southern bank at the quarry would be stabilized. Soil cement is recommended.

- In Sub-area 6.3, a wetland feature would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland, which would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. Water from Hennessey Drain would be diverted to this area. MS would surround the wetland taking advantage of the saturated soil conditions. It would be irrigated using a SBIN and/or flood irrigation using SRPMIC surface water from Hennessey Drain as source.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Eight new irrigation diversion structures, no new WWTP diversion structures, and one new well are proposed for Alternative H.

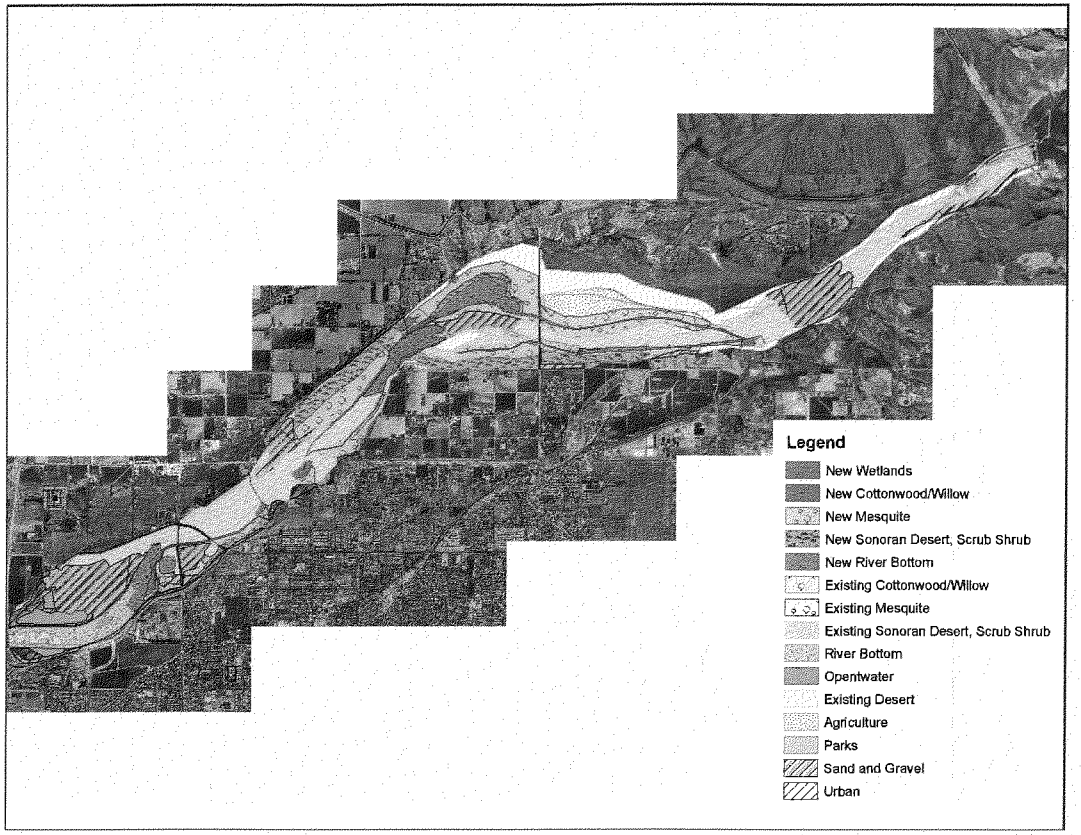
Water Demand

As presented in Table 44, the annual evapotranspiration demand for Alternative H is 4,032 acre-feet.

Table 44. Vegetated Area and Evapotranspiration Rate – Alternative H

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	101	463
3	32	190
4	328	865
5	520	1.471
6	358	1.043
Total	**1,338**	**4.032**

Figure 45. Alternative H



5.6.2.9 Alternative I

Alternative I places all vegetation within the main channel and is dominated by cottonwood-willow, with some areas of wetlands and Sonoran desert scrub shrub. A low-flow channel would be constructed from Hennessey Drain downstream to Gilbert Road and from approximately Country Club Road downstream to Alma School Road. Sonoran scrub shrub sits on the benches of the low-flow channel and wetlands are housed within it. This alternative provides a net habitat value of 675 FCUs (Table 57), and the water demand is 4,920 acre-feet/year (Table 45). There are several structures within this alternative: four areas of bank stabilization, guide dikes to control water flow and protect areas of the river channel, and a grade control structure for ensuring minimization of incision and provision of stability to the channel and riparian area upstream. The proposed restoration features are described below and are shown in Figure 46.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a small strip of CW buffering the low-flow channel on the north side of the riverbank. An in-channel wetland feature in Sub-area 2.1 would serve as the termination point of the low-flow channel. Sub-area 2.3 would support a small CW stand on the south side of the riverbank. MWWTP effluent would be used to support the vegetation.

- MWWTP effluent would support two wetland features created in Sub-area 2.2 at Alma School Road downstream of and within the old quarry. The downstream wetland would be surrounded by CW and irrigated using a SBIN.

- Like the other alternatives, bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Buried guide dikes may need to be constructed in the overbank area throughout Sub-area 2.2 and Sub-area 2.4 perpendicular to the thalweg. The groins would act as a

lateral control to prevent excess migration of the low-flow channel. Exact locations of the guide walls have yet to be determined.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- Sub-area 3.1 would support a wetland feature that would mark the upstream segment of the low-flow channel that would be constructed from Sub-area 3 to Alma School Road in Sub-area 2.2. A strip of CW would buffer the channel on the south side of the riverbank.

Reach 4

- Sub-area 4.1 would support an in-channel wetland with a strip of CW to the north and west. The wetland would be within the low-flow channel and constructed to maintain the surface water level. The CW would be irrigated with surface water redirected from a surface water outlet, distributed using flood irrigation or a SBIN.

- Sub-area 4.2 would support CW, MS, and a wetland feature. Two surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and irrigation system would occur less frequently.

Reach 5

- In Sub-area 5.2, the SRS&R Beeline One Plant Pit would be reshaped and converted to river bottom. The north bank would be set back and armored using soil cement and/or riprap to increase conveyance to the north. A stand of CW and two small wetlands would also be established on the overbank area at Gilbert Road. These would be irrigated using groundwater diverted from the new well in Sub-area 6.1. The water would be distributed using a SBIN.

- The main channel would be reshaped and converted to new river bottom, beginning at the midpoint of SRS&R Beeline One Plant and ending at the downstream end of Sub-area 4.1. An area of soil cement bank stabilization would also begin at the mid-point of the SRS&R Beeline One Plant, on the south side of the channel, and continue for approximately 5,500 feet downstream. The structure would be 30 feet high and 6 feet deep and would be used to offset erosion concerns due to mining occurring within the main channel along the island located immediately south of the quarry.

- A grade control structure would help reduce the upstream headcut migration and stabilize the river system improving the likelihood of success of vegetation established upstream and downstream. The grade control structure would need to span the entire width of the riverbed and be designed to the estimated scour depth. The structure would be 8 feet deep, 10 feet high with a 20-foot toe depth (total height of 30 feet), and 1,100 feet long. Riprap would be placed on the downstream end to prevent erosion.

- Sub-area 5.3, located along the south bank, would be vegetated with CW. Surface water and stormwater would be used to irrigate this area, distributed using flood irrigation or a SBIN.

Reach 6

- A low-flow channel would be constructed beginning just downstream of Hennessey Drain and ending at Gilbert Road through Sub-areas 6.1, 6.2, and 6.3. The low-flow channel would have a bottom width of approximately 200 feet, 1V:3H side slopes, and a depth of 4 to 8 feet. This would increase conveyance to offset the decrease in conveyance due to the establishment of vegetation in the riverbed. The low-flow channel would contain two wetland features: one in Sub-area 6.3 where the low-flow channel begins, the other at the western edge of Sub-area 6.2, at Gilbert Road, where the low-flow channel ends. The low-flow channel would be buffered on both sides by SD, which would be planted on the benches created just outside of the low-flow channel.

- Two pockets of CW would be established in Sub-area 6.1: one at the eastern edge and the other at the western edge. Both CW pockets would fall immediately outside of the 5-year floodplain. The CW would be irrigated using surface water from Hennessey Drain. The water would be distributed using a flood irrigation method or the SBIN. In the center of Sub-area 6.2, located on the south bank of the river, a

small pocket of CW would be established. This would be irrigated using surface water and stormwater when available, distributed by flood irrigation or a SBIN. Just south of the CW stand, the quarry pit would be reshaped and converted to new river bottom. To protect the new vegetation, the south bank would be stabilized using soil cement.

- Sub-area 6.3 would have a wetland feature bordered by CW to the east. The wetland would be constructed on the riverbed, near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. This wetland would also serve as the furthest upstream point of the low-flow channel. The CW would be irrigated by SRPMIC surface water from Hennessey Drain.

- Buried guide dikes may need to be constructed in the overbank area throughout Sub-areas 6.2 and 6.3, perpendicular to the thalweg. The groins would act as lateral control to prevent excess migration of the low-flow channel. Exact locations of the guide walls have yet to be determined.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in

its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Six new irrigation diversion structures, no new WWTP diversion structures, and no new wells are proposed for this alternative.

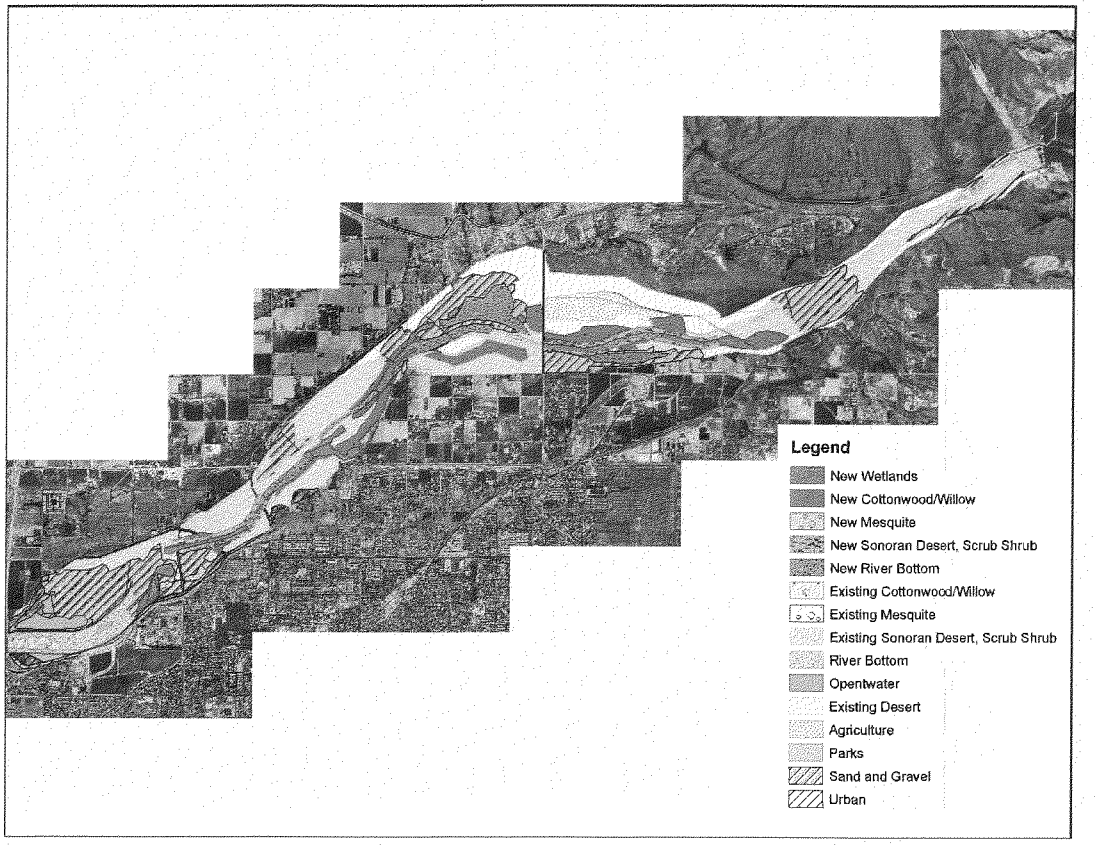
Water Demand

As presented in Table 45, the total annual evapotranspiration rate for Alternative I is 4,920 acre-feet.

Table 45. Vegetated Area and Evapotranspiration Rate – Alternative I

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	156	853
3	17	105
4	168	1,204
5	164	1,103
6	314	1,656
Total	**819**	**4,920**

Figure 46. Alternative I



5.6.2.10 Alternative J

Alternative J has several large stands of cottonwood-willow and mesquite, with smaller areas of Sonoran desert scrub shrub and wetlands. The high proportion of cottonwood-willow increases the water demand to 6,087 acre-feet/year (Table 46). Alternative J provides a net habitat value of 872 FCUs (Table 57). There are three areas of bank stabilization with a single spillway in the stabilization area at SRS&R Beeline One Plant. Five areas (three quarries and two areas within the main channel) would be reshaped to create new river bottom. The proposed restoration features are described below and are shown in Figure 47.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by CW on the south side and MS on the north side. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by runoff from a golf course located north of the Salt River, if it is of sufficient quality.

- Along the south bank, Sub-area 2.3 would support a wetland feature, MS, and two small pockets of CW. A stand of CW would surround the wetland. Another stand would start in the eastern edge of Sub-area 2.3 and extend slightly into Sub-area 2.2. MWWTP effluent would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- MWWTP effluent would also support the wetland feature created in Sub-area 2.2 at Alma School Road downstream of the old quarry. The wetland would be surrounded by CW and irrigated using a SBIN. The quarry would be reshaped to create new river bottom.

- Like the other alternatives, bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the EST (2002) report presents a conservative estimate of future conditions.

Reach 3

- A drainage channel would be constructed to drain Reach 4.2 to supply water into the wetland and CW vegetation of Sub-area 3.1. Water would be dispersed to the CW using the SBIN. The abandoned quarry would be reshaped in the main channel to establish new river bottom.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, which is the site of an old landfill. Depending on water quality issues including potential leachate and methane production, MS and SD could be established in this area. The area would be irrigated using surface water and stormwater, distributed by a SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and a wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to it and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to new river bottom in Sub-area 5.2 The quarry pit would have CW, MS, and SD established to the north and east, located on the overbank area. All three vegetation types would be irrigated using groundwater diverted from the new well in Sub-area 6.1. The water would be distributed using a SBIN.

- Sub-area 5.3, located along the south bank, would be vegetated with CW, MS, and a wetland feature at Gilbert Road. Surface water and stormwater would be used to irrigate these areas. A SBIN would irrigate the CW and MS in this area.

- An area of soil cement bank stabilization would begin at the midpoint of the SRS&R Beeline One Plant, on the south side of the channel, and continue for approximately 5,500 feet downstream. The structure would be 30 feet high and 6 feet deep and would be used to offset erosion concerns due to mining that is occurring within the main channel, along the island located immediately south of SRS&R Beeline One Plant.

- The main channel would be reshaped to allow for the establishment of river bottom and to increase channel conveyance capacity. Another alternative is to allow naturally occurring flow events to reshape the river bottom. The advantage of mechanical reshaping is to utilize excavated material in the construction of proposed features.

Reach 6

- CW and MS would be established in Sub-area 6.1. The MS would be located on the north bank, immediately outside of the active channel, outside of the 10-year floodplain. It would be irrigated using groundwater from a new well located in Sub-area 6.1. The CW, located closer to the main channel, would be irrigated using surface water from Hennessey Drain. In both areas, the water would be distributed using a flood irrigation method or the SBIN. Because the vegetated areas are near the GRUSP site, water that has infiltrated the soil can be used to support vegetation. A more detailed analysis is needed.

- Area 6.2 is located on the south bank of the river. CW would be planted in an abandoned quarry depression directly east of Gilbert Road. The area would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation. The abandoned quarry immediately upstream of the newly established CW would be reshaped and converted to new river bottom.

- In Sub-area 6.2, located on the south bank of the river, CW would be planted in an abandoned quarry depression directly east of Gilbert Road. The area would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation. The abandoned quarry immediately upstream of the newly established CW would be reshaped and converted to new river bottom. The southern bank would be stabilized to prevent erosion, and soil cement is recommended.

- Sub-area 6.3 would have a wetland feature, which would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using a SBIN and/or flood irrigation. SRPMIC surface water from Hennessey Drain would be used to irrigate this area.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Nine new irrigation diversion structures, no new WWTP diversion structures, and one new well are proposed for this alternative.

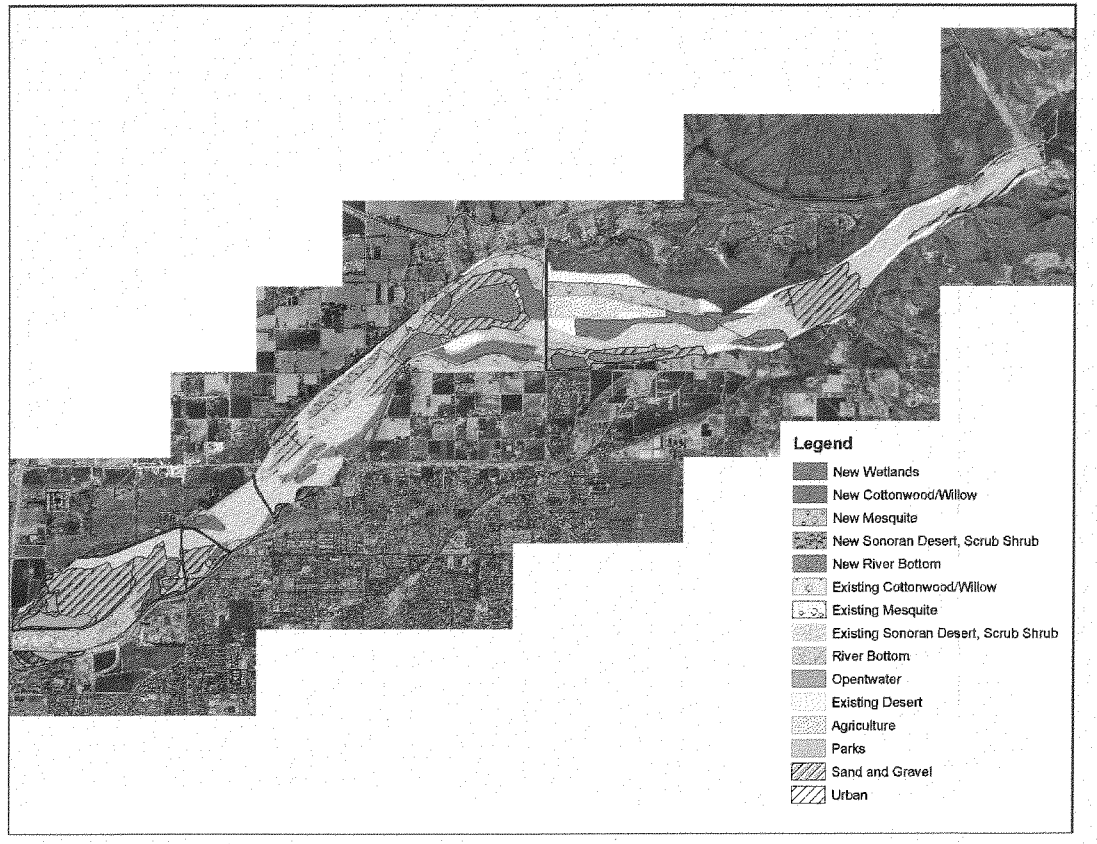
Water Demand

As presented in Table 46, the total annual evapotranspiration rate for Alternative J is 6,087 acre-feet.

Table 46. Vegetated Area and Evapotranspiration Rate – Alternative J

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	112	693
3	20	124
4	270	1,113
5	475	2,117
6	409	2,040
Total	**1,285**	**6,087**

Figure 47. Alternative J



5.6.2.11 Alternative K

Alternative K is dominated by cottonwood-willow and mesquite with fewer Sonoran desert scrub shrub acreage. Because of the prevalence of water-dominate vegetation, the water demand is higher at 6,304 acre-feet/year (Table 47). This alternative provides a net habitat value of 627 FCUs (Table 57). This alternative is structurally simple with no reshaping or bank stabilization features. The proposed restoration features are described below and are shown in Figure 48.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by MS and CW on the north and south sides, respectively. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by runoff from a golf course, located north of the Salt River, if it is of sufficient quality.

- Similar to Alternative J, Sub-area Area 2.3 would support a wetland feature, MS, and two small pockets of CW along the south bank. One stand of CW would surround the wetland; a second stand would start in the eastern edge of Sub-area 2.3 and extend slightly into Sub-area 2.2. MWWTP effluent or groundwater would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- MWWTP effluent would support the wetland feature created in Sub-area 2.2 at Alma School Road downstream of the old quarry. The wetland would be surrounded by CW and irrigated using a SBIN.

- Similar to the other alternatives, bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- A drainage channel would be constructed to drain Reach 4.2 to supply water to the wetland, CW, and SD vegetation of Sub-area 3.1. Water would be dispersed to the features using a SBIN.

- Sub-area 3.2 would support small stands of CW, MS, and SD. They would be supported by SBIN, using redirected surface water outlets as a source.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, MS and SD could be established in this area. The area would be irrigated using surface water and stormwater by SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and a wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- CW, MS, and SD would be established in the overbank of Sub-area 5.2, with the MS extending into Sub-area 5.1. The CW acreage would be restricted to a single stand on the north side of the river immediately outside of the 5-year floodplain at Gilbert Road. A wetland would be constructed at the Evergreen Drain outlet, within the 5-year floodplain. All three vegetation types would be irrigated using surface water diverted from the North Drainage Channel distributed using SBIN. The vegetation planted in Sub-area 5.2 can also be irrigated by overland flow from water diverted

from Evergreen Drain during storm events or supplemented by groundwater extracted from a new well, if necessary.

- Sub-area 5.3, located along the south bank, would be vegetated with CW, MS, and two wetland features. A wetland would be established just west of Gilbert Road, and another on the western edge of Sub-area 5.3. CW would buffer the two wetlands to the west and east, respectively. MS would buffer the CW to the south. Surface water and stormwater, distributed by a SBIN, would be used to irrigate these areas.

Reach 6

- CW, MS, and a wetland feature would be established in Sub-area 6.1. The MS is located on the north bank immediately outside the active channel, outside the 10-year floodplain, and would be irrigated using groundwater extracted from a new well. The CW and wetland feature would be established on the north bank, immediately outside of the 5-year floodplain and partially within the 5-year floodplain, and would be irrigated using SRPMIC surface water from Hennessey Drain. In both areas, the water would be distributed using a flood irrigation method or a SBIN. Because vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed.

- Sub-area 6.3 would have a wetland feature, which would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The CW would take advantage of the saturated soil conditions and would be irrigated using a SBIN or flood irrigation supplied by SRPMIC surface water from Hennessey Drain.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be

encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Nine new irrigation diversion structures, no new WWTP diversion structures, and a new well are proposed for this alternative.

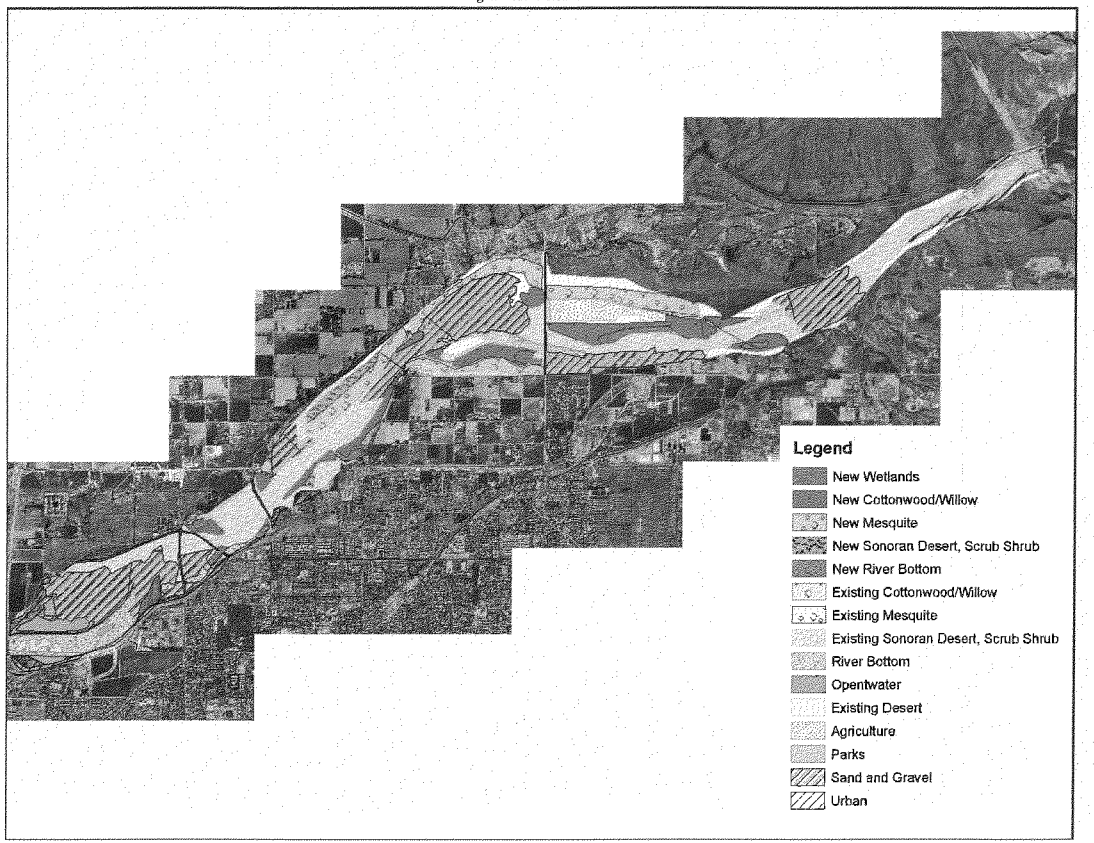
Water Demand

As presented in Table 47, the total annual evapotranspiration rate for Alternative K is 6,304 acre-feet.

Table 47. Vegetated Area and Evapotranspiration Rate – Alternative K

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	108	652
3	68	306
4	270	1,113
5	416	1,852
6	445	2,381
Total	**1,301**	**6,304**

Figure 48. Alternative K



5.6.2.12 Alternative L

Alternative L places vegetation in less contiguous, distinct pockets. However, the vegetation is dominated by cottonwood-willow with several areas of wetlands, which are both valuable habitat types. Alternative L provides a net habitat value of 758 FCUs (Table 57). The water demand is 5,602 acre-feet/year (Table 48), relatively high due to the cottonwood and wetlands. Two bank stabilization areas, with a single grade control structure, are planned. SRS&R Beeline One Plant would also be reshaped to create new river bottom. The proposed restoration features are described below and are shown in Figure 49.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by a large CW stand on the south side and a smaller MS stand on the north side. The CW would follow the river upstream for most of Sub-area 2.4. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by golf course runoff if it is of sufficient quality.

- Along the south bank, Sub-area 2.3 would support a wetland feature, MS, and two small pockets of CW. One stand of CW would surround the wetland; a second stand would start at the eastern edge of Sub-area 2.3 extending slightly into Sub-area 2.2. MWWTP effluent would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- MWWTP effluent would support the two wetland features created in Sub-area 2.2, at Alma School Road downstream of the old quarry. The downstream-most wetland would be surrounded by CW and irrigated using a SBIN, while the upstream wetland would be a stand-alone feature.

- Similar to the other alternatives, bank stabilization is recommended for the south bank between Country Club Road and Alma School Road. Soil cement is the

recommended method. The bank stabilization is necessary to prevent further erosion and possible damage to Highway 202.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and Sedimentation Analysis* (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- No vegetation establishment is planned for Reach 3 in this alternative.

Reach 4

- A small CW stand would be established in Sub-area 4.1, immediately downstream of the wetland located in Sub-area 5.1. No other vegetation would be planted in this area.

- Sub-area 4.2, along the downstream portion of the south bank, would support CW, MS, and a wetland feature. The wetland would be located entirely in the 5-year floodplain. A south bank surface water outlet would supply water to the SBIN used to irrigate the vegetation. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to river bottom in Sub-area 5.2. The north bank would be set back and armored using soil cement and/or riprap to increase conveyance to the north.

- Sub-area 5.2 would also have CW, MS, and two wetland features. One wetland would be located at Gilbert Road within the 5-year floodplain. It would be buffered to the north by CW, which would be buffered by MS. The second wetland would be located immediately upstream of the Evergreen Drain outlet, with a portion of it falling within Sub-area 5.1. This would also be buffered by CW and MS to the north. All three vegetation types would be irrigated using surface water diverted from the

North Drainage Channel, with groundwater extracted from a new well as a secondary source. The water would be distributed using a SBIN.

- A drop structure would be placed in Sub-area 5.2 in the main channel at the center point of SRS&R Beeline One Plant. This would help protect the newly-restored channel and riparian area upstream from headcutting due to the extensive mining that has occurred downstream. The structures would span the entire width of the riverbed and be designed to the estimated scour depth.

- Sub-area 5.3, located along the south bank, would be vegetated with CW, MS, and a large wetland feature at Gilbert Road. Surface water and stormwater would be used to irrigate these areas. The water would be distributed by a SBIN.

Reach 6

- Large areas of CW and MS and two small wetlands would be established in Sub-area 6.1. The MS would be irrigated using surface water from the North Canal. The CW and wetlands would be irrigated using surface water from the Hennessey Drain. For all areas, the water would be distributed using a flood irrigation method or the SBIN. The MS is located on the north bank, outside the 10-year floodplain. The CW and wetlands are located immediately south of the MS, just outside of the 5-year floodplain. Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Four new irrigation diversion structures, no new WWTP diversion structures, and a new well are proposed for this alternative.

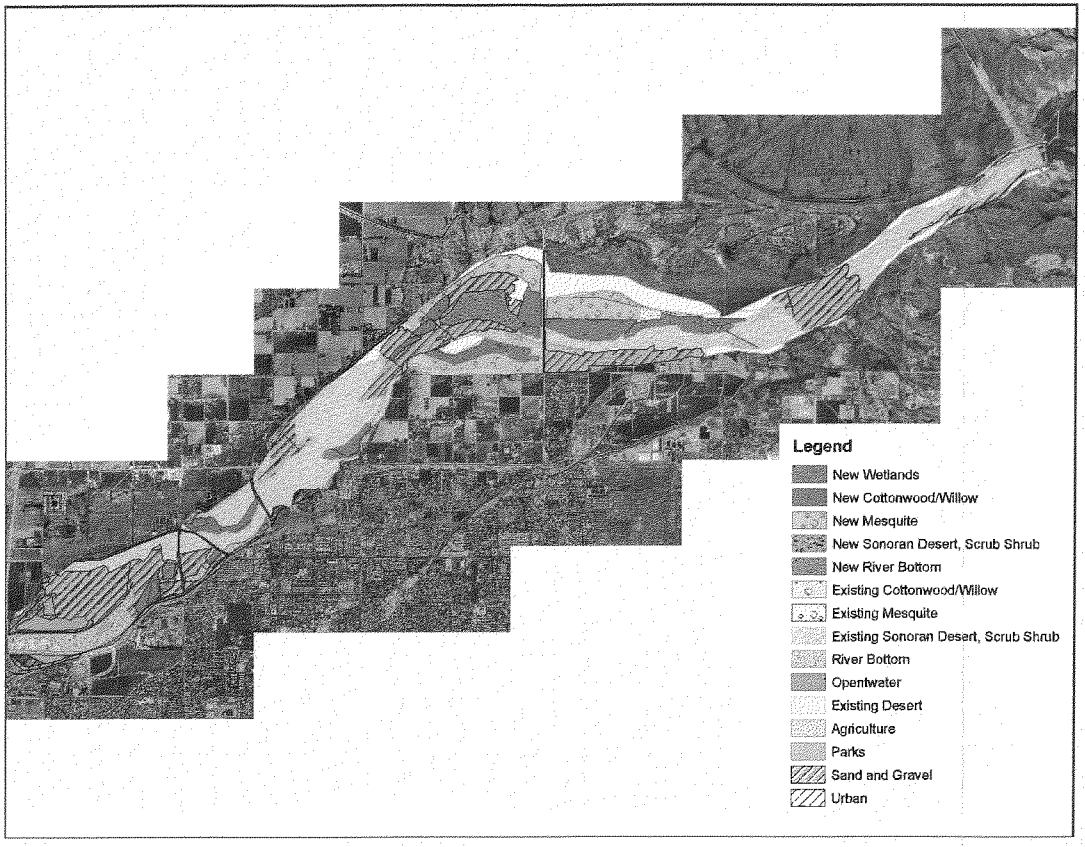
Water Demand

As presented in Table 48, the total annual evapotranspiration rate for Alternative L is 5,602 acre-feet.

Table 48. Vegetated Area and Evapotranspiration Rate – Alternative L

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	157	1,001
3	0	0
4	56	389
5	446	2,294
6	379	1,918
Total	**1,037**	**5,602**

Figure 49. Alternative L



5.6.2.13 Alternative M

Alternative M is dominated by wetlands and plans for 12 separate features. Cottonwood/willow surrounds each wetland, allowing for significant acreage. Mesquite is also prevalent with smaller areas of Sonoran desert scrub shrub. Because wetlands and cottonwood-willow dominate this alternative, the water demand is relatively high at 6,488 acre-feet/year (Table 49). However, this alternative provides a high net habitat value of 829 FCUs (Table 57). Three areas of bank stabilization and a single grade control structure are proposed. Two quarries would be reshaped creating new river bottom. The proposed restoration features are described below and are shown in Figure 50.

Reach 1

- No activity is planned for Reach 1. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by CW on the south side and MS on the north side. These features would be supported by surface water outlets, and maintained using a SBIN. Additional water may be supplied by runoff from a golf course located north of the Salt River, if it is of sufficient quality.

- Along the south bank, Sub-area 2.3 would support a wetland feature, MS, and two small pockets of CW. One stand of CW would surround the wetland; a second stand would start at the eastern edge of Sub-area 2.3 and extend slightly into Sub-area 2.2. MWWTP effluent or groundwater would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- In Sub-area 2.2, MWWTP effluent would support the wetland feature created at Alma School Road, downstream of the old quarry. The wetland would be buffered on the south side by CW and irrigated using a SBIN.

- Some concern has been raised regarding the Alma School drop structure. Currently, there has been a design to modify the existing structure. The possible loss of the structure due to scouring and eventual undermining of the structure is documented in the *Final Without-Project Analysis Report, Va Shly'ay Akimel Hydraulic and*

Sedimentation Analysis (WEST, 2002). Additionally, the WEST (2002) report presents a conservative estimate of future conditions.

Reach 3

- No activity is planned for Reach 3.

Reach 4

- A large portion of Sub-area 4.1 is located on a terrace north of the channel, the site of an old landfill. Depending on water quality issues including potential leachate and methane production, MS and SD could be established in this area. The area would be irrigated using surface and stormwater via a SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and a series of four wetlands. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. There would be four total wetland features, the first three in succession heading downstream and surrounded by CW and the final and largest wetland at the downstream end of Sub-area 4.2 and into Sub-area 3.1. A small stand of MS would buffer the downstream CW and a portion of the adjacent wetland. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to river bottom. The north bank would also be set back and armored using soil cement and/or riprap to increase conveyance to the north.

- Sub-area 5.2 would have a small wetland feature within the 5-year floodplain at Gilbert Road, buffered by CW and MS to the north. The MS would extend around the perimeter of SRS&R Beeline One Plant, downstream into Sub-area 5.1 past the Evergreen Drain. There would also be a small wetland feature at the Evergreen Drain outlet. The MS would be irrigated using groundwater extracted from a new well and distributed with either a flood irrigation method or a SBIN. The CW and wetland feature would be irrigated using surface water diverted from the North Drainage Channel. The water would be distributed using a SBIN. The vegetation planted in Sub-area 5.2 can also be irrigated by overland flow from water diverted from Evergreen Drain during storm events.

- The grade control structure would be placed in Sub-area 5.2 in the main channel at the center point of the SRS&R Beeline One Plant. This structure would help protect the newly-restored channel and riparian area upstream from headcutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed and be designed to the estimated scour depth.

- Immediately downstream from the grade control structure, an area of soil cement bank stabilization would begin and continue for approximately 5,500 feet. The structure would be 30 feet high and 6 feet deep and would be used to offset erosion concerns due to mining that is occurring within the main channel, along the island located immediately south of SRS&R Beeline One Plant.

- Sub-area 5.3, located along the south bank, would support three wetland features and would be surrounded by CW and buffered to the south with MS. Surface water and stormwater, distributed by a SBIN, would be used to irrigate these areas.

Reach 6

- Sub-area 6.1 would be planted with CW and two wetland features. Both would be irrigated using surface water from Hennessey Drain and distributed using a flood irrigation method or a SBIN. The MS would be irrigated using groundwater extracted from a new well. The water would be distributed using flood irrigation or a SBIN. The eastern wetland would be placed within the 5-year floodplain, while the western wetland would be placed immediately outside of the 5-year floodplain. The CW stands would buffer and connect both wetland features. Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. A more detailed analysis is needed.

- In Sub-area 6.2, located on the south bank of the river, CW would be planted in an abandoned quarry depression directly east of Gilbert Road. The area would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation. A larger quarry located further upstream along the south bank would be reshaped and converted to new river bottom. It is recommended that the south bank be armored to ensure that the quarry does not affect the current channel layout.

- Similar to Alternative C, Sub-area 6.3 would have a wetland feature, which would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using a SBIN. SRPMIC surface water from Hennessey Drain would be used to irrigate this area.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Eight new irrigation diversion structures, no new WWTP diversion structures, and a new well are proposed for this alternative.

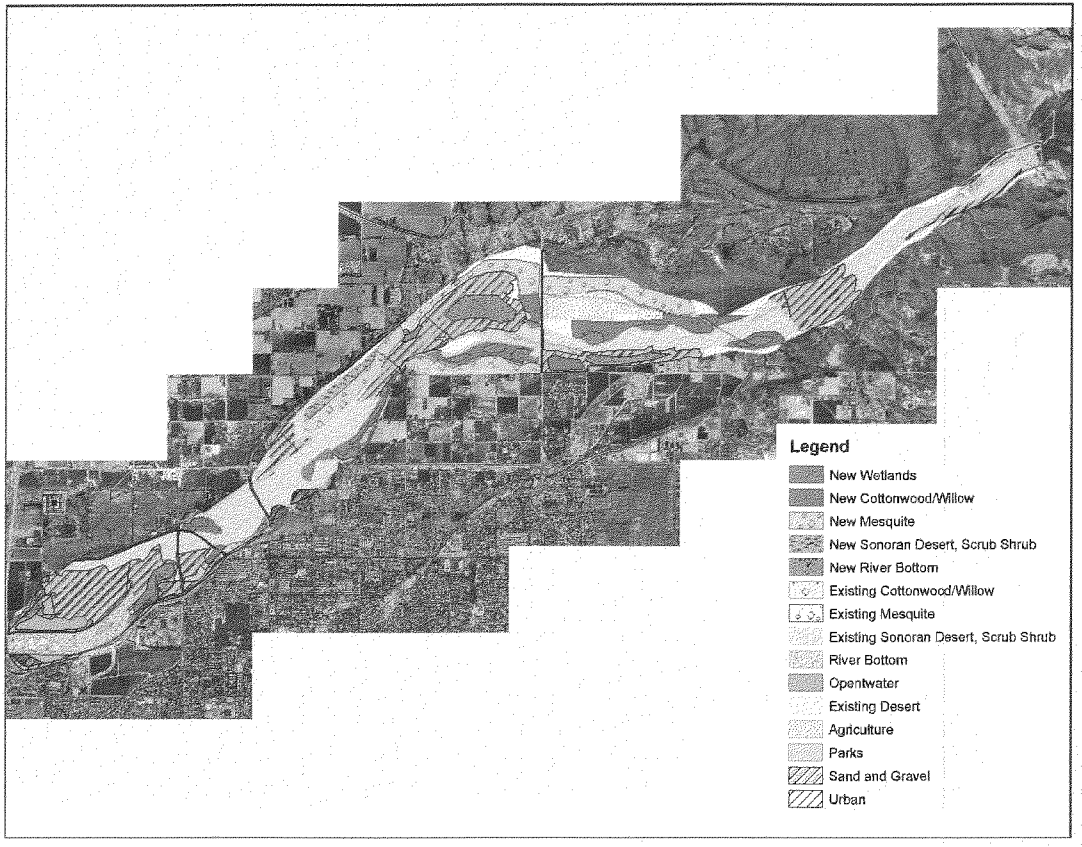
Water Demand

As presented in Table 49, the total annual evapotranspiration rate for Alternative M is 6,488 acre-feet.

Table 49. Vegetated Area and Evapotranspiration Rate – Alternative M

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	0	0
2	139	948
3	16	147
4	271	1,157
5	407	1,900
6	453	2,336
Total	**1,285**	**6,488**

Figure 50. Alternative M



5.6.2.14 Alternative N

Alternative N is similar to Alternative F. However, it does not have any structural features. Furthermore, this alternative proposes additional vegetation. The water demand is 7,736 acre-feet/year (Table 50). Alternative N provides a net habitat value of 913 FCUs (Table 57). The proposed restoration features are described below and are shown in Figure 51.

Reach 1

- The CW stand adjacent to the wetlands of Sub-area 2.2 would continue westward into Sub-area 1.1 within the main channel. The percolation ponds found immediately outside of the southern bank in Sub-area 1.2 would be planted with CW. This area would be supported using the existing irrigation infrastructure and MWWTP effluent. No activity is planned for the northern side of Reach 1 within the Indian Community. The SRPMIC has expressed an interest in commercially developing this area.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by CW to the west, south, and east, and MS to the north. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by runoff from a golf course located north of the Salt River, if it is of sufficient quality.

- Along the south bank, Sub-area 2.3 would support a small wetland feature and small areas of CW and MS. One stand of CW would surround the wetland; a second stand would start at the eastern edge of Sub-area 2.3 and extend slightly into Sub-area 2.2. Surface water via a SBIN would be used to support the vegetation. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- MWWTP effluent would support the two wetland features created in Sub-area 2.2 at Alma School Road downstream of the old quarry. The western-most wetland would be flanked by CW to the west that would continue into Sub-area 1.1. The CW would be irrigated using a SBIN. A small area south of the wetlands would be reshaped and converted to new river bottom.

Reach 3

- Irrigation water from Sub-area 4.2 would supply water to the CW vegetation in Sub-area 3.1. Water would be distributed using the SBIN.

Reach 4

- The majority of Sub-area 4.1 would be left unvegetated due to the existence of the Tri-City Landfill. However, a narrow strip of CW would be established along the north bank at the edge of the main channel. The area would be irrigated using surface water and stormwater using a SBIN.

- Sub-area 4.2, along the south bank, would support CW, MS, and a large wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel, so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to new river bottom in Sub-area 5.2. CW, MS, and a small pocket of SD would be located on the overbank area. The MS and SD would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from an irrigation canal. The water would be distributed using a SBIN.

- The channel in Sub-area 5.1 and the western half of 5.3 would be reshaped and converted to new river bottom. A wetland feature and CW would be established at Evergreen Drain. The CW would be irrigated using groundwater from the new well. The wetland would be supported by runoff from Evergreen Drain.

- Sub-area 5.3, located along the south bank, would be vegetated with CW and a small stand of MS. Surface water and stormwater would be used to irrigate these areas. Irrigation of the CW and MS would be done by SBIN.

- A grade control structure would be placed in the main channel at the center point of SRS&R Beeline One Plant in Sub-area 5.2. This structure would help protect the newly-restored channel and riparian area upstream from headcutting due to the

extensive mining that has occurred downstream. The structure, approximately 1,500 feet long, would span the entire width of the riverbed and be designed to the estimated scour depth.

Reach 6

- Large areas of CW and MS would be established in Sub-area 6.1. The CW is located south of the GRUSP site and would be irrigated using SRPMIC surface water from Hennessey Drain. The MS is located on the north bank, immediately outside of the active channel, outside the 10-year floodplain, and would be irrigated using ground water from the new well. In both areas, the water would be distributed using a flood irrigation method or the SBIN. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. A more detailed analysis is needed.

- In Area 6.2, located on the south bank of the river, two areas of CW would be planted: one in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain and a second narrow strip along the southern edge of the main channel. Both areas would be irrigated using surface water and stormwater when available.

- Sub-area 6.3 would have a wetland feature, which would be constructed on the riverbed near the existing Hennessey Drain outlet. A berm of coarse rock would be constructed on the upstream side of the wetland. This would provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland would consist of a low permeability liner system to maintain the surface water level and allow for vegetation growth. The wetland would be flanked by a relatively large CW stand to the east, taking advantage of the saturated soil conditions, and would be irrigated using surface water from Hennessey Drain and a SBIN or flood irrigation.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the SRS&R Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This

could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Nine new irrigation diversion structures, no new WWTP diversion structures, and a new well are proposed for this alternative.

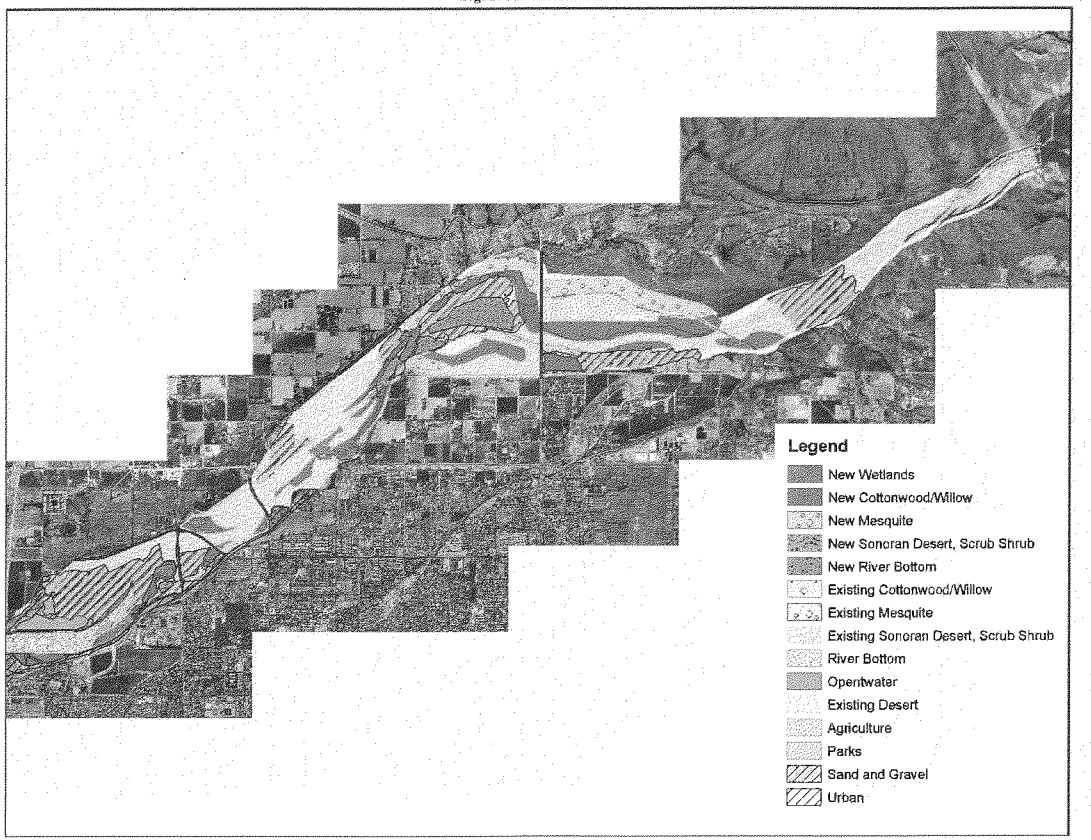
Water Demand

As presented in Table 50, the total annual evapotranspiration rate for Alternative N is 7,736 acre-feet.

Table 50. Vegetated Area and Evapotranspiration Rate – Alternative N

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	51	320
2	141	905
3	29	181
4	152	1,057
5	434	2,224
6	580	3,048
Total	**1,387**	**7,736**

Figure 51. Alternative N



5.6.2.15 Alternative O

Alternative O is similar to Alternative N. However, this alternative proposes additional vegetation in Sub-areas 1 and 2. The water demand is 8,550 acre-feet/year. Alternative O provides a net habitat value of 963 FCUs. The proposed restoration features are described below and are shown in Figure 52.

Reach 1

- Sub-area 1.1 would support one wetland feature and two CW stands. The wetland would be located in the main channel. A CW stand would be established within the main channel along the north bank and at the far southeast end of Sub-area 1.1. The percolation ponds found immediately outside of the southern bank in Sub-area 1.2 would be planted with CW. This area would be supported with water from the WWTP.

Reach 2

- Sub-area 2.4 would support a wetland feature surrounded by CW to the west, south, and east. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River, if it is of sufficient quality.

- Along the south bank, Sub-area 2.3 would support two wetland features and small areas of CW and MS. One small stand of CW would surround the wetland; a second stand would be established in the western edge of Sub-area 2.3 and extend into Sub-area 2.2. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand stormwater runoff.

- In Sub-area 2.2, one wetland feature would be created in the old quarry located near Alma School Road. The small wetland to the north and the larger wetland to the east would be surrounded by a CW stand. The CW would be irrigated using a SBIN. A small area, south of the wetlands, would be reshaped and converted to new river bottom.

Reach 3

- CW and MS stands would be established on the north and south banks.

Reach 4

- Sub-area 4.1 would be left unvegetated due to the existence of the Tri-City Landfill.
- Sub-area 4.2, along the south bank, would support CW, MS, and a large wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding CW and MS. Sub-area 4.2 is relatively protected from the main channel so damages to the channel and the irrigation system would occur less frequently.

Reach 5

- The SRS&R Beeline One Plant pit would be reshaped and converted to new river bottom in Sub-area 5.2. CW, MS, and a small pocket of SD would be located on the overbank area. The CW, MS, and SD would be irrigated using groundwater from a new well. The water would be distributed using a SBIN.
- The channel in Sub-area 5.1 would be reshaped and converted into new river bottom. A wetland feature as well as CW would be established at the Evergreen Drain. The CW and WT would be irrigated using groundwater from the new well.
- Sub-area 5.3, located along the south bank, would be vegetated with CW, a small stand of MS, and a small wetland feature. Surface water and stormwater would be used to irrigate these areas. Irrigation of the CW and MS would be done by a SBIN.
- A grade control structure would be placed in Sub-area 5.2, in the main channel at the center point of the SRS&R Beeline One Plant. This structure would help protect the newly-restored channel and riparian area upstream from headcutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed, approximately 2,000 feet, and would be designed to the estimated scour depth.

Reach 6

- Large areas of CW and MS would be established in Sub-area 6.1. The CW is located south of the GRUSP site and would be irrigated using SRPMIC surface water from the Hennessey Drain. The MS is located north of the GRUSP site would be irrigated using groundwater from the new well. In both areas, the water would be distributed using a SBIN. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. A more detailed analysis is needed.

- In Sub-area 6.2, located on the south bank of the river, one area of CW would be planted in an abandoned quarry depression directly east of Gilbert Road and would be within the 5-year floodplain. The area would be irrigated using surface water, and stormwater, when available.

- Sub-area 6.3 would have a CW stand on the north bank near Hennessey Drain, just outside the 10-year area of inundation.

Reach 7

- No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed there is a high probability that any vegetation planted would be damaged due to in-channel mining operation. The ongoing quarrying of the SRS&R Higley Plant may potentially cause scouring to occur along the main channel downstream, particularly in Reach 6. Based on the technical studies to date, the preservation of the corridor within Reach 7 is not required. However, if the detailed analysis during the design phase indicates that a narrow corridor is required to secure the benefits in Reach 6, then the appropriate control would need to be secured by way of the SRPMIC regulating the sand and gravel operation by preserving the corridor or reclaiming it to a grade required for an effective project.

Reaches 8 and 9

- Invasive plant species, primarily saltcedar (*Tamarisk sp),* would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in

its place. Because of the relative good habitat health in this reach, no other changes to the current conditions were proposed.

Water Sources

Eight new irrigation diversion structures, no new WTTP diversion structure, and one new well are proposed for Alternative O.

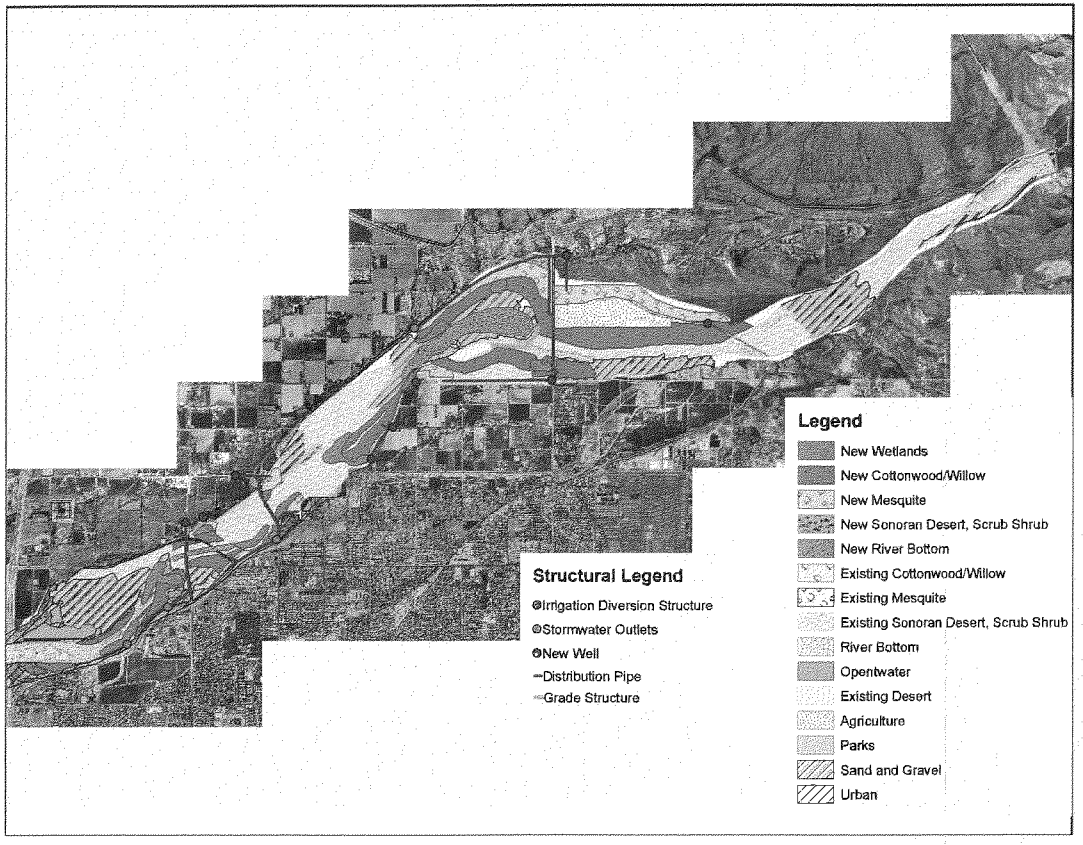
Water Demand

As presented in Table 51, the total annual evapotranspiration demand for Alternative O is 8,550 acre-feet.

Table 51. Vegetated Area and Evapotranspiration Rate – Alternative O

Reach	Area (acres)	Evapotranspiration (ac-ft)
1	66	475
2	226	1,565
3	29	181
4	152	1,057
5	434	2,224
6	580	3,048
Total	**1,486**	**8,550**

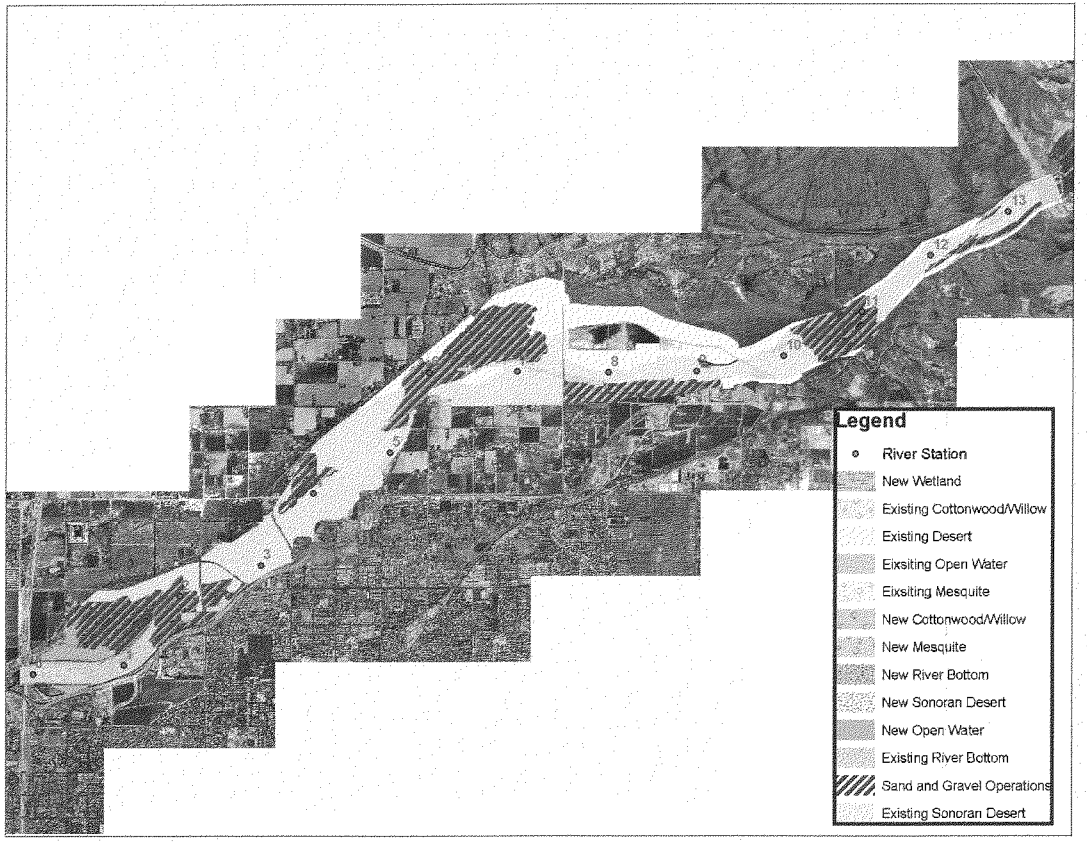
Figure 52. Alternative O



5.6.2.16 Alternative P: No Action Alternative

The No Action Alternative is carried forward and analyzed to provide a basis from which to assess the advantages and disadvantages of the other study alternatives. Under this alternative, the Federal government would take no action to provide ecosystem restoration within the study area and would not develop plans with potential incidental benefits associated with flood damage reduction, recreation, or water quality and supply. As previously discussed, habitat diversity and quality are expected to decline if no restoration efforts are conducted at the study area. A continued decline in the quantity and quality of most areas of cottonwood-willow stands, mesquite, scrub shrub, and wetlands is expected due to a continued decrease in available surface water and groundwater and continued surface disturbance caused by the sand and gravel operations (Figure 53). Habitat values in the study area are projected to decline (by about 13 percent) from 812 FCUs to 705 FCUs in the next 50 years. All of the restoration alternatives were evaluated against the No Action Alternative to determine the benefits and risks associated with each of the proposed alternatives.

Figure 53. Alternative P



5.7 Comparison and Evaluation of the Second Array of Alternatives

Each plan was independently evaluated and compared to the No Action Alternative. In this evaluation, factors such as short- and long-term environmental impacts, short- and long-term environmental benefits, costs, and implementability are taken into consideration. Using a cost-effectiveness and incremental cost analysis, the National Ecosystem Restoration (NER) Plan was identified.

5.7.1 Water Budget

Water budget for the alternatives was determined based on the evapotranspiration rate for each of the vegetation types including irrigation system inefficiency. Infiltration losses for the wetlands were taken into account. The water budget assumed that precipitation, agriculture tailwater, and stormwater runoff did not contribute to irrigation of the vegetated areas, as these areas require a continual and predictable supply of water.

5.7.1.1 Vegetation Water Demand

Table 52 presents the annual water demand for each of the vegetation types proposed for each alternative. As shown, the total water demand ranged from 992 ac-ft/yr for Alternative A to as high as 8,550 ac-ft/yr for Alternative O.

Table 52. Annual Vegetation Water Demand (ac-ft/yr)

Alt	WT		CW		MS		SD		TOTAL	
	Area (ac)	Water Demand	Area (ac)	Water Demand	Area (ac)	Water Demand	Area (ac)	Water Demand	Area (ac)	Water Demand
A	0	0	0	0	0	0	496	992	496	992
B	0	0	0	0	267	802	685	1,370	952	2,172
C	29	260	238	1,500	166	497	720	1,440	1,152	3,696
D	103	930	259	1,635	313	939	63	126	739	3,629
E	52	229	287	1,808	296	888	808	1,615	1,416	4,540
F	187	1,682	701	4,418	558	1,673	266	531	1,711	8,304
G	64	578	470	2,959	454	1,363	395	790	1,383	5,690
H	64	578	9	55	870	2,609	395	790	1,338	4,032
I	196	1,765	443	2,788	6	18	174	348	819	4,920
J	82	735	556	3,501	556	1,668	92	183	1,285	6,087
K	146	1,318	493	3,103	558	1,675	104	208	1,301	6,304
L	143	1,286	495	3,117	400	1,199	0	0	1,037	5,602
M	222	2,002	412	2,598	587	1,762	126	126	1,285	6,488
N	131	1,178	853	5,371	380	1,139	47	47	1,387	7,736
O	200	1,798	883	5,566	380	1,139	47	47	1,486	8,550
P	-	-	-	-	-	-	-	-	-	-

5.7.1.2 Water Sources

The water requirements (Table 53) from the various sources were based on water source location, proximity to vegetated areas, and water availability. The largest source of water is the SPRMIC surface water. Groundwater is designed to support large areas of vegetation in Sub-areas 5.2 and 6.1. Effluent would only be used to support vegetation located in Sub-area 1.2, well outside the SPRMIC. As previously discussed, precipitation, stormwater runoff, and agriculture tailwater were not accounted for in the water demand estimates.

Table 53. Water Source Requirement (ac-ft/yr)

Alternative	Effluent	SRPMIC Groundwater	SRPMIC Surface Water	TOTAL
A	0	0	992	992
B	0	787	1,385	2,172
C	0	676	3,021	3,696
D	0	887	2,742	3,629
E	242	1,419	2,879	4,540
F	0	1,331	6,973	8,304
G	234	943	4,513	5,690
H	0	782	3,250	4,032
I	0	0	4,920	4,920
J	0	1,249	4,838	6,087
K	0	1,350	4,954	6,304
L	0	1,072	4,530	5,602
M	0	1,228	5,259	6,488
N	174	1,804	5,757	7,736
O	174	1,804	6,571	8,550
P	-	-	-	-

5.7.1.3 Irrigation System Inefficiency

Inefficiencies in the drip irrigation and surface braided irrigation network systems were taken into account in the analysis by assuming that the former was 80 percent efficient and the latter was 50 percent efficient. This takes into account infiltration losses and conveyance losses from the sources (irrigation diversion structures) to vegetation location. To improve efficiency, liners could be used; these were not analyzed in the current design. Table 54 presents the increase in water demand for each alternative with the irrigation inefficiencies.

Table 54. Water Demand with Irrigation Inefficiencies (ac-ft/yr)

Alternative	Water Demand without Inefficiencies	Drip Irrigation	SBIN
A	992	1,240	1,983
B	2,172	2,715	4,345
C	3,696	4,620	7,393
D	3,629	4,537	7,259
E	4,540	5,675	9,080
F	8,304	10,380	16,607
G	5,690	7,113	11,381
H	4,032	5,040	8,064
I	4,920	6,150	9,840
J	6,087	7,609	12,174
K	6,304	7,880	12,608
L	5,602	7,002	11,204
M	6,488	8,110	12,976
N	7,736	9,669	15,471
O	8,550	10,668	17,100
P	-	-	-

5.7.2 Cultural Resources

Activities involved in constructing features to accomplish ecosystem restoration under Alternatives A though O would involve ground disturbances to varying degrees depending on specific locations within the project area. Defined restoration activities include reshaping and grading for irrigation, planting of vegetation, river channelization, construction of grade control structures, and bank stabilization, all of which were determined may have an adverse effect on National Register of Historic Places (NRHP) sites.

The restoration activities described above would move artifacts, ecofactual materials, and features from their original provenance. This displacement would either destroy or significantly diminish the scientific value of any information potential and adversely affect NRHP eligibility. Additionally, the newly planted vegetation would create adverse effects as the plants grow and develop root systems. Roots are a common form of archeological site disturbance. Furthermore, increasing the levels of water in the soil

would change the soil chemistry and possibly increase the degradation of important perishable ecofactual remains.

The results of the SRI Class III Cultural Resources Survey and archaeological testing done within the project site resulted in a series of recommendations. SRI recommend that the information potential of SRPMIC-90, 105, 112, and 113 has been exhausted. The two thermal pits and surface artifacts at SRPMIC-90 are best interpreted as the remains of a small Colonial period farmstead. The residential locus of this site, however, has been destroyed as part of road construction. No buried features were encountered at SRPMIC-105. SRPMIC-112 and 113 were determined to be modern drainage ditches. As such, these sites cannot contribute significantly towards our understanding of past lifeways within the project area. SRI, therefore, recommended that SRPMIC-90, 105, 112, and 113 are ineligible for inclusion in the National Register of Historic Places (NRHP).

SRI evaluated SRPMIC-108 and 109 as eligible for listing on the National Register of Historic Places. A large subsurface deposit of ash-stained soil and fire-cracked rock was identified at SRPMIC-108. This deposit likely represents rake-out debris from a nearby roasting pit or horno. SRI recommended that this part of the site be mechanically stripped and that the feature(s) be excavated. The excavation of a small roasting pit during testing at this site indicates that organic preservation is excellent in this portion of the site. SRPMIC-108 could, therefore, contribute significantly towards our understanding of prehistoric subsistence in the project area.

SRPMIC-109 represents the remains of a small mid-to-late nineteenth century historic Piman farmstead in Parcel 3. SRI also recommended that this site be mechanically stripped in order to determine the subsurface limits, structure, and contents of this site. SRPMIC-109 can contribute significantly towards our understanding of historic period Piman pottery production, agricultural activities, and settlement in the project area.

In addition, archival research indicates that several prehistoric canals have been mapped in the project area. No evidence of these canals or associated field systems are evident on the surface or in subsurface excavations conducted by SRI. There possible existence, however, should be considered during construction, or an effort should be made to locate these features, if there is a data recovery phase.

Consultation to identify traditional cultural properties has yet to be conducted. The SRPMIC would identify these types of resources. Other tribes may also be consulted to obtain their views also. There are locations within the land area required for several alternatives that contain historic and prehistoric resources. Additional studies will be necessary to evaluate the NRHP eligibility (significance) of these sites. If any of these sites are found to be eligible, modifications to the design will be required. If design changes are not feasible, mitigation measures will be required.

5.7.3 Hazardous, Toxic, or Radioactive Waste

As additional information on specific properties was gathered, assessed, and compared to the potential sites for restoration, the results of the environmental assessment were used to better guide plan formulation, particularly in the modification of alternatives to avoid potential impacts. Re-siting or elimination of features was necessary to prevent or minimize the possibility of interactions between identified sites and the areas slated for potential ecosystem restoration. The results of the environmental assessment are presented below.

Talley Defense Systems site. Because of concerns with this site, plan formulation changed the footprints of all potential alternatives to avoid potential interactions. For instance, the initial planned constructed wetland near the Talley Defense site was deleted so as to reduce any chance of impact to restored resources by the Talley Defense site. Available data are highly inconclusive regarding whether or not any released contaminants from Talley Defense Systems operations have impacted the current environment, could impact the planned environmental restoration features of the Va Shly'ay Akimel study area, or any other parts of the study area that are downstream of Talley Defense Systems burn pits.

As a result, it must be assumed that there is risk for some perchlorate contamination in the study area, where excavation, construction, and groundwater level manipulation are planned. The two potential sources of contaminant release (based on available data) have to be assumed as the washwater pits at plant #3, and the burn pits. Due to the high mobility of perchlorate, no greater or lesser risk is assigned to one source or the other. The burn pits, while farther away from project features, probably saw more total release than did the washwater pits. To a lesser degree than assigned to perchlorate, a risk of contamination of the from heavy metals has to be considered as possible for the study area, foremost from cadmium, chromium, and lead from the washwater pits, and to a

lesser degree (due to greater distance) from copper, lead, and possibly cadmium from the burn pits. Until direct sampling of soil and groundwater for these contaminants is undertaken in a manner that will determine contaminant concentrations (or the absence of contaminant) in the study area and in and near planned features, the presence or absence of contaminants will remain an unknown. Precautionary sampling and testing of soil to be moved and groundwater to be dewatered, for perchlorate and these heavy metals, would be undertaken during the PED phase, with study specifically oriented around the recommended plan. A line of exploratory borings immediately upstream of the upstream-most wetlands and/or constructed features would be undertaken. Such work would serve to remove most all of this potential risk with regard to the study at hand, by proving that contaminant migration did not proceed far enough downstream to impact the study area. The fact that project features could be down-gradient of surface runoff from the plant and are downgradient from the two known release areas has to be considered as increasing the risk to the study area, as the contaminants likely would travel such a route. However, the presence of Talley Defense's runoff retention basin would be expected to provide some manner of barrier to contaminant migration, especially the metals. The risk from halogenated and non-halogenated solvents probably should be considered a very low potential risk at this point, not worthy of follow-up at this time, based on available data about past practice at the facility. This should be tempered with the fact that no testing was done in any of the past studies for these potential contaminants of concern.

Landfills The five landfills within the study area are near the area of conceptual environmental features. All landfill sites for which there is any information are unlined, so there is concern regarding what might be leached from them if they are inundated as part of the conceptual environmental restoration. Potential riverbank erosion and breach of landfill contents deserves consideration as an issue. Only the Tri-Cities landfill has bank protection. As with the assessment of the Talley site, additional study of existing landfill issues will be done in the PED phase of study, as these studies would be focused directly on potential interactions with the recommended plan.

Drum dump site. The dump location has received partial cleanup under RCRA5 with the work done by ADEQ6 in May 1990. SRPMIC Environmental Services staff reports they are counting on the future EPA Brownfield cleanup of the underlying Cypress landfill to address the drum dump.

VOCs in groundwater, including the Indian Bend Wash Superfund sites. The North Indian Bend Wash and South Indian Bend Wash Superfund sites were evaluated for potential interactions with study alternatives. Monitoring of clean-up activities and monitor well test data by SRPMIC Environmental Services has led them to conclude that this site has not impacted the study area and likely will not in the future; pollutants are contained by current efforts and have not crossed into the study area (Ramirez, 2004, p. 2).

Analysis of the South Indian Bend Wash site indicates that the VOC groundwater contaminant plume in the Salt River is 1,350 feet down river from the downstream-most edge of the study area. That position places the groundwater contaminant plume from this Superfund site outside of the study area and should remove any potential risk of it contaminating the study area, based on the logic that groundwater beneath the Salt River is not going to travel in the upstream direction under any imaginable circumstance. SRPMIC Environmental Services has concluded that this site has not impacted the study area and cannot, due to the down-gradient location of all known pollutants (Ramirez, 2004, p. 4).

Two other VOC-groundwater contamination sites in the general vicinity of the Va Shly'ay Akimel study area appear to be incapable of impacting the study area, nor do they pose any foreseeable risk of doing so in the future, primarily due to their distance and their position down-gradient of the study area, with regard to groundwater flow direction. The South Mesa WQARF[7] site is successfully contained for the time being, via in-place remediation activities, according to data in the WQARF section on the ADEQ website as of March 19, 2004. The groundwater contaminant plume remains generally in the position shown in 1986 data attributed to K.D. Schmidt and Associates. That data

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[5] "RCRA" is "Resource Conservation and Recovery Act".

[6] "ADEQ" is "Arizona Dept. of Environmental Quality".

[7] WQARF is "water quality assurance revolving fund", essentially a State "Superfund" site.

suggest the plume is no closer to the study area than 23,000 feet to the southeast of the study area (about 4.3 miles). A second VOC-in-groundwater site is much closer to the southeast of the study area: the "Motorola Mesa WQARF" site, again according to data excerpted from the K.D. Schmidt & and Associates report mentioned above, is about 8,000 feet (1.5 miles) from the study area boundary. It has not been ascertained whether this site may have been completely cleaned up, and possibly dropped from the WQARF listings. Regardless, its distance and location down-gradient of known groundwater flow removes this site from being a potential risk to the study area.

DBCP contamination in groundwater. DBCP[8] (which is "dibromochloropropane") has been detected in groundwater over a large area south of the Salt River, and this area is as close as 1,700 feet south of the study area boundary, directly south of the GRUSP. The location once was known as the "Mesa DBCP WQARF Site." According to data from a 1986 report by K.D. Schmidt and Associates, the DBCP-contaminated groundwater apparently remains south of the Salt River and the study area; data suggest that groundwater flow is southeastward, away from the study area.

LUSTs[9]. In the Phase I EA, eleven LUST properties are listed, including five clustered in a commercial business district along Country Club Drive at the 202 highway, and along McKellips Road near Country Club Drive; and two others along Alma School Road. All of those are outside of the study area or at the study area periphery. Four others are in or adjacent the Salt River bottom, associated with the sand and gravel quarry or batch plant operations, and those are considered probably more important, as they are inside the study area. As with the above sites, additional study of these properties is warranted and will be done in the PED phase of study, as these studies would be focused directly on potential interactions with the recommended plan.

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[8] DBCP is a soil fumigant, applied to control nematodes and applied to crops such as cotton, soybeans, fruits, nuts, vegetables (cucumbers, summer squash, cabbage, cauliflower, carrots, snap beans, okra), plus aster, shasta daisy, lawn grasses and ornamental shrubs. Formerly heavily used in the agriculture industry, its use was stopped in 1979 except for application to pineapple crops in Hawaii (stopped in 1985). EPA lists the following as the health effects related to exposure: when people are exposed to it at levels above the MCL for relatively short periods of time: kidney and liver damage and atrophy of the testes. Sources: http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html; http://www.safetyinfo.com/safetyinfo/html/osha/Standards/z/1910_1044_APP_A.html

[9] "LUST" is the acronym for "*l*eaking *u*nderground *s*torage *t*ank".

Table 55 provides an assessment of each of the alternatives and sites of potential impact to identified hazardous, toxic, and radioactive waste sites within the boundaries defined for each alternative. Numbered sites are shown in Figure 25.

Table 55. Sites of Potential Environmental Concerns

Alternative	Environmental Concerns
A	- Interaction between study-induced irrigation and the local GRUSP-supported water table must be determined. The GRUSP-supported water table must remain at least 25 feet below the bottom of the Tri-Cities landfill to avoid any leaching of landfill contents. - Planting on the Tri-Cities landfill is also a concern due to irrigation. Both leaching through the landfill and impacts of rising groundwater elevation from below in response to the irrigation need to be considered and documented. - The surface runoff from irrigation may impact the adjoining Chandler Ready Mix site. A detailed site map with the relative elevations of the river bottom and the Chandler operation needs to be obtained. - The same issues also apply to the Salt River Sand and Rock Beeline One operations. Details of the operation need to be determined and documented. - The downstream extent of the expected groundwater elevation change, if any, should be determined, to ensure that potential impacts stated above do not occur further downstream at other sites. - While more distant from the planned study actions than the sites discussed above, the nature of the substances used at the Talley Defense Systems needs to be further defined.
B	- Same as Alternative A. - Due to the increase area of irrigation, there is potential to impact an additional six sites. These sites include the United Metro operations and several landfills including the land fill under the drum site (Site 11*), the Cypress, North Center Street (Tri-Cities South), Old Mesa, and Vulcan demolition debris landfill. Additional research and evaluation of these sites would be needed.
C	- Same as Alternatives A and B. - Since more water would be added to the system, the potential to impact or be impacted by landfills, the GRUSP, and Tri-Cities landfill groundwater elevation limits, and quarry operations runoff, are enhanced.
D	- Same as Alternatives A and B. - The potential to impact or be impacted by the Chandler quarry drops out; the potential impact of the Talley Defense Systems site diminished sharply, both due to increased distance. - The potential impact to the Tri-Cities landfill and other landfills downstream is enhanced due to the additional water.
E	- Same as Alternative C. - Potential impacts of the Indian Bend Wash NPL site need to be evaluated.

Alternative	Environmental Concerns
F	- Same as Alternatives C and D. - The enhanced wetland areas increase the potential for interaction between study-elevated groundwater and the landfills beyond those of Alternatives A through E. - Potential groundwater interaction with the Mesa Water Treatment Plant recharge and recharge ponds needs to be evaluated. - Potential impacts of the Indian Bend Wash NPL site need to be evaluated.
G	- Same as Alternative F.
H	- Same as Alternative G with reduced need to close the data gap on the Indian Bend Wash NPL site.
I	- Same as Alternative F.
J	- Same as Alternative F but with less impact to the GRUSP site, from the Tri-Cities landfill, and from the group of five landfills on both banks of the river between Country Club Drive and the alignment of Extension Road.
K	- Same as Alternative J.
L	- Same as Alternative F with reduced emphasis on the Talley Defense Systems site and less impact to the Tri-Cities landfill.
M	- Same as Alternative F.
N	- Irrigation around the GRUSP site (Site 17). - The largest of all planned wetlands construction adjoins the north side of the North Center Street landfill (Site 30) raises potential conflicts with inundating the landfill contents with the groundwater. - The second largest of all planned wetlands construction nearly adjoins part of the Tri Cities landfill (Site 15), raising potential conflicts with inundating the landfill contents with the groundwater.
O	- Same as Alternative N.
	* Site numbers refer to Figure 25, Activities in and near the Study Area with Potential Environmental Concerns.

5.7.4 Biological Resources

5.7.4.1 Vegetative Cover Types

The existing cover types in the study area along with the proposed additional vegetation acreages for each alternative are presented in Table 56. As shown, the proposed restoration varies between approximately 680 acres for Alternative 2, to as much as 2,100 acres of riparian and scrub shrub habitat for the most extensive alternative, Alternative F.

5.7.4.2 Biological Risk and Uncertainty

The purpose of the Va Shly'ay Akimel Salt River Restoration Project is to reestablish a variety of habitat types that were once found along the Salt River system. The habitat types were chosen based on existing vegetation and historical evidence of what was previously found on site; they are expected to establish and flourish over time. However, because of the dynamic nature of natural systems, there is a certain level of risk and uncertainty associated with habitat restoration. As part of the plan formulation process, an array of alternatives was developed to show what environmental features were feasible within the study area. These alternatives were then compared and analyzed based on cost and expected environmental outputs. The environmental outputs are derived from a Hydrogeomorphic (HGM) model. While models are valuable tools, they are not foolproof, nor can they be considered an exact predictor. It is this risk and uncertainty that will be addressed.

Table 56. With-Project Cover Types and Acreages

	Existing						Proposed Additional Vegetation						With-Project Cover Types						
Alt	CW	MS	RB	SD	OW	Total	CW	MS	RB	SD	WT	Total	CW	MS	RB	SD	WT	OW	Total
A	69	4	320	2,039	101	2,532	-	-	156	496	-	652	79	4	480	2,552	-	101	3,216
B	69	4	320	2,039	101	2,532	-	267	166	685	-	1,118	69	271	477	2,535	-	101	3,452
C	69	4	320	2,039	101	2,532	238	166	399	720	29	1,552	306	170	706	2,245	29	100	3,555
D	68	4	320	2,039	101	2,532	259	313	287	63	103	1,025	326	317	585	1,631	103	100	3,064
E	69	4	320	2,039	101	2,532	287	296	317	808	25	1,733	355	300	628	2,494	25	85	3,888
F	68	4	320	2,039	101	2,532	701	558	419	266	187	2,131	768	624	675	1,287	187	100	3,641
G	69	4	320	2,039	101	2,532	470	454	429	395	64	1,812	538	458	724	1,770	64	85	3,639
H	69	4	320	2,039	101	2,532	9	870	440	395	64	1,778	77	874	734	1,769	64	100	3,618
I	68	4	320	2,039	101	2,532	443	6	375	174	196	1,194	509	10	642	1,546	196	101	3,005
J	68	4	320	2,039	101	2,532	556	556	302	92	82	1,588	623	560	589	1,492	82	100	3,446
K	68	4	320	2,039	101	2,532	493	558	2	104	146	1,303	559	562	297	1,513	146	100	3,179
L	67	4	320	2,039	101	2,532	495	400	155	-	143	1,193	561	404	462	1,630	143	100	3,299
M	68	4	320	2,039	101	2,532	412	587	160	63	222	1,444	479	591	447	1,487	222	100	3,328
N	67	4	320	2,039	101	2,532	853	380	201	24	131	1,589	919	384	460	1,551	131	85	3,530
O	67	4	320	2,039	101	2,532	883	380	225	24	200	1,712	949	384	473	1,524	200	84	3,616
P	67	4	320	2,039	101	2,352	-	-	-	-	-	-	-	-	-	-	-	-	-

*Acreages were determined from GIS maps of the various alternatives.

(a) Physical Factors

Natural systems are dynamic and change depending upon physical, chemical, and biological processes. While some of these factors can be controlled or compensated for, others cannot. Unpredictable physical changes may include changes in land use (e.g., sand and gravel operations), a dramatic alteration of the river course due to flood damages, or anthropogenic influences such as increases in trash and debris, structures, or human presence. These physical factors can affect established vegetation directly, through removal, or indirectly, via degradation. Sand and gravel operations have been present within the Salt River for many years. Discussions with the SRPMIC suggest they will remain a part of the river for at least the next 10 to 25 years, depending upon location. Therefore, any risk and uncertainty related to physical changes within the river channel that are associated with sand and gravel operations can be expected to remain in place, potentially for the life of the project. Because the land on which the mining operations function is owned by the SRMPIC, the onus will fall upon them to direct the mining companies in terms of the location of future operations. The commitment to protect the established vegetation in the future, regardless of mining operations, will be outlined in the Project Cooperation Agreement, should this project be authorized.

Chemical and biological factors are often intertwined. A groundwater contamination would likely affect vegetation; a change in vegetation would likely affect the soil chemistry. A large flooding event would affect both. Uncontrollable weather events such as extreme temperatures, drought, or even extended rain can also affect the success of vegetation, not only within the project area, but also within the region. Hydraulic and hydrologic assessments estimate that during the 100-year storm event, approximately 90 percent of the vegetation within the 10-year floodplain will be uprooted. Floods of this magnitude have occurred most recently in 1978, 1980, 1983, and 1993. But as with most weather events, historic conditions are not always reliable predictors of future conditions. Under natural and expected project conditions, however, the vegetation will regenerate naturally. An Operations and Maintenance Plan is developed for each authorized project and would address what can be expected to occur after a damaging flood event should high levels of damage occur or should the vegetation not regenerate as expected.

(b) Biological Factors

The Va Shly'ay Akimel Ecosystem Restoration Project is perhaps most vulnerable to risk and uncertainty due to the large number of acres of newly established vegetation proposed. This project would likely use container plantings, pole plantings, and seed mixes to establish vegetation. While these methods are understood to be the most effective and successful means of establishment, there is a risk of mortality due to poor stock, a disease or insect infestation, excessive herbivory damage, unforeseen incompatibilities with regard to soil conditions, water demand, irrigation methods, etc. Any of the above factors can lead to a reduction in vegetation establishment or future success and consequently, in the extent to which the project achieves maximum benefit, measured in Average Annual Functional Capacity Units (AAFCUs). Other factors that may affect the AAFCU values are unusual weather patterns such as unusually long hot dry periods, flaws in the irrigation design, miscalculation of water demand, or error in soil requirements, to name a few. Nonetheless, U.S. Army Corps of Engineers' planning and construction process allows for contingency plans that would address such issues should they arise. Monitoring programs set success criteria standards and require replacement of vegetation until those criteria are met. A Monitoring and Adaptive Management Plan would provide a 5-year window to monitor the success of a constructed project and would allow for refinement to improve any features that may require it. Such refinements could include an adjustment of irrigation, water source, or vegetation type.

5.7.5 Environmental Benefits

Based on the individual features proposed for each alternative, the acreage and functional capacity indices were projected to derive with-project estimates of AAFCUs. Benefits are defined as the increase in AAFCUs for each alternative relative to the without-project conditions. As applied to the without-project conditions, the FCUs for each function have been estimated for TY 1 (year of construction), TY 6 (year the planting efforts are completed), TY 26 (year to capture significant anticipated ecosystem changes, and TY 51 (end of project) for the with-project condition for each alternative. These projected values were then converted into AAFCUs. In general, alternatives requiring moderate or minimum levels of vegetation restoration resulted in the least number of net AAFCUs, while those requiring maximum or extensive levels resulted in the highest number. The results, which range from 373 AAFCUs for Alternative A to 1,035 AAFCUs for Alternative F, are shown in Table 57.

Table 57. With-Project Average Annual Function Capacity Units – Second Array of Alternatives

Function	Without-Project	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H	Alt I	Alt J	Alt K	Alt L	Alt M	Alt N	Alt O
1	689	1,088	1,250	1,317	1,114	1,452	1,368	1,371	1,362	1,108	1,280	1,175	1,204	1,235	1,288	1,316
2	955	1,362	1,578	1,772	1,589	1,942	2,084	1,975	1,860	1,771	1,902	1,710	1,839	1,899	1,977	2,038
3	72	383	636	863	683	954	1,227	1,051	1,011	803	973	833	816	934	963	1,023
4	131	203	371	431	514	527	825	683	666	720	771	750	823	908	783	788
5	805	1,129	1,227	1,397	1,326	1,495	1,658	1,555	1,398	1,407	1,522	1,377	1,476	1,472	1,617	1,656
6	726	1,001	1,095	1,192	1,080	1,293	1,313	1,280	1,187	1,135	1,234	1,130	1,202	1,202	1,291	1,316
7	701	1,086	1,322	1,513	1,323	1,655	1,804	1,692	1,659	1,365	1,602	1,417	1,453	1,531	1,613	1,677
8	1353	1,922	2,162	2,368	2,080	2,578	2,601	2,530	2,393	2,105	2,397	1,881	2,273	2,306	2,480	2,546
9	889	1,423	1,729	1,954	1,644	2,157	2,266	2,146	2,036	1,655	2,020	1,509	1,836	1,913	2,067	2,131
10	854	1,308	1,741	2,081	1,804	2,379	2,376	2,321	2,104	1,861	2,197	1,668	1,832	2,066	2,224	2,309
Average	**718**	**1,091**	**1,311**	**1,489**	**1,316**	**1,643**	**1,752**	**1,660**	**1,568**	**1,393**	**1,590**	**1,345**	**1,475**	**1,547**	**1,630**	**1,680**
Increase	--	*373*	*594*	*771*	*598*	*926*	*1,035*	*943*	*850*	*675*	*872*	*627*	*758*	*829*	*913*	*963*

294

5.7.5.1 Period of Analysis

In accordance with ER 1105-2-100 guidance, project benefits and costs will be compared at a common point in time. Since the alternatives have different implementation periods – in this case, ranging from ten months to three years – a common base year has to be established. Costs and benefits are then compounded or discounted to this established base year. In addition, the guidance states that those benefits that are accrued during project construction should be brought forward from the time the benefits start to the beginning of the period of analysis, which coincides with the end of construction.

FCU projections have been made from T1 through T51. Since T1 corresponds with the first year of construction, T1 through T3 correspond to the construction period of three years. Hence, T4 corresponds to the Base Year (PY 1). Data for T4 was interpolated from T1 and T6 values. Since FCU projections were made through T51, which corresponds to PY 48, data for PYs 49 and 50 were estimated to be approximately equivalent to PY 48 since very little change in FCUs occurs during this timeframe on an annual basis.

The results, which range from 389 AAFCUs for Alternative A to 1,084 AAFCUs for Alternative F, are shown in Table 58.

Table 58. With-Project Average Annual Function Capacity Units – Adjusted Results

	T0 – T50		PY1 – P50	
Alternative	**Average**	**Increase**	**Average**	**Increase**
Without-Project	718	-	711	-
A	1,091	373	1,100	389
B	1,311	594	1,330	619
C	1,489	771	1,518	807
D	1,316	598	1,339	628
E	1,643	926	1,677	966
F	1,752	1,035	1,795	1,084
G	1,660	943	1,697	986
H	1,568	850	1,602	891
I	1,393	675	1,418	707
J	1,590	872	1,625	914
K	1,345	627	1,369	658
L	1,475	758	1,503	792
M	1,547	829	1,578	867
N	1,630	913	1,666	955
O	1,680	963	1,717	1,006

5.7.6 Costs

The cost estimates were developed to a level of detail sufficient for economic evaluation in order to select a plan based on cost effectiveness and other criteria from among the alternatives evaluated. Cost estimates for Alternatives A through O were developed for both irrigation methods. Those alternatives developed with drip irrigation have been assigned as Group 1. For example, Alternative A with drip irrigation is analyzed as Alternative A1. Those alternatives developed with SBIN have been assigned as Group 2. Again, Alternative A with SBIN is now analyzed as Alternative A2. However, these irrigation methods do not affect or change the areas of land associated with the project features; thus, real estate costs remain the same for either method.

5.7.6.1 Real Estate

The proposed project features are generally located on areas of land best described as the river corridor and floodplain. On some portions of the project, terraces or banks that are situated above floodplains may be incorporated into the project and used for ecosystem restoration. The lands are all undeveloped with the principle economic or industrial use being sand and gravel extraction. Typically these operations occupy leased land of the SRPMIC. Should any such areas be incorporated into the project, it will be the responsibility of the SRPMIC to extinguish or otherwise terminate the mineral extraction rights or leases. Since the land is generally in a floodplain or if out of the actual floodplain is inside the river corridor, the land lies mostly vacant and unimproved. No residences or businesses will be relocated.

For project formulation purposes, three general categories of land with their respective estimated values were applied as follow:

- River Channel Land: $5,000 per acre
- Farmland outside and above river channel: $7,500 per acre
- Sand and Gravel Operations: $15,000 per acre (estimated residual value of extraction rights)

Table 59 summarizes the estimated real estate costs for each alternative.

Table 59. Real Estate Costs

Alternative	100-Year Mined Acreage	Associated Value ($)	100-Year Unmined Acreage	Associated Value ($)	Outside 100-Year Acreage	Associated Value ($)	Total Acreage	Total Land Value ($)
A1/A2	201	1,006,930	255	3,831,675	195	4,883,650	652	9,722,255
B1/B2	297	1,482,545	429	6,440,970	392	9,803,325	1,118	17,726,840
C1/C2	633	3,163,205	443	6,648,930	476	11,894,500	1,551	21,706,635
D1/D2	313	1,567,035	395	5,929,200	317	7,933,075	1,026	15,429,310
E1/E2	659	3,297,425	559	8,378,145	515	12,881,750	1,733	24,557,320
F1/F2	442	2,210,050	1,177	17,650,500	512	12,790,550	2,130	32,651,100
G1/G2	639	3,193,440	661	9,917,205	513	12,825,050	1,812	25,935,695
H1/H2	639	3,193,750	663	9,941,100	476	11,907,850	1,777	25,042,700
I1/I2	375	1,877,470	805	12,070,620	14	347,800	1,194.	14,295,890
J1/J2	340	1,697,805	740	11,102,115	507	12,672,300	1,586	25,472,220
K1/K2	56	278,590	729	10,933,230	519	12,965,700	1,303	24,177,520
L1/K2	258	1,289,690	717	10,752,210	217	5,434,600	1,192	17,476,500
M1/M2	250	1,250,455	701	10,509,045	495	12,371,200	1,445	24,130,700
N1/N2	374	1,867,850	901	13,508,460	314	7,849,200	1,588	23,225,510
O1/O2	406	2,031,435	972	14,579,340	334	8,338,650	1,712	24,949,425
P	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Real Estate Descriptions:
100-Year Mined: Land in the 100-year floodplain that has been mined.
100-Year Unmined: Land that is in the 100-year floodplain that could potentially be mined.
Outside 100-Year: Land that is outside of the 100-year floodplain (i.e., commercial, residential, parks and recreation, etc.)

5.7.6.2 Operation and Maintenance Considerations

The features of the Va Shly'ay Akimel Restoration Project are subject to damage by recurrent flood flows and periods of inundation. This would result in the need for periodic maintenance to ensure successful habitat restoration. Operation and maintenance costs include periodic sediment removal, control of invasive plant species, vector control, pump replacement, irrigation system maintenance, and monitoring of the landfill area. Operation and maintenance also includes periodic replanting of habitat areas damaged by flood flows.

In compliance with authorizing legislation and cost-sharing requirements, the non-Federal sponsors must assume responsibility for operation and maintenance of project features for as long as the project remains authorized. Table 60 presents the costs associated with the operation and maintenance of each alternative.

5.7.6.3 Associated Costs

For as long as the project remains authorized, the non-Federal sponsors must provide sufficient water for construction, operation, and maintenance of the project. The cost of providing such water is 100 percent associated non-Federal cost and not LERRDs as the water is required for continued operation and maintenance of the project. Based on current and future water demand and cost analysis, a unit cost of $75 per acre-foot of (SRP) water was used. These annual costs are shown in Table 61.

5.7.6.4 Project Costs

Table 62 and Table 63 show the estimated costs for two variations of each alternative: drip irrigation or braided irrigation, respectively. Based on USACE requirements, all construction cost estimates includes a 25-percent contingency. The planning, engineering, and design (PED) and engineering during construction (EDC) (11 percent of construction cost) was calculated based upon previous USACE experience over a wide range of designed projects that are of a scope and complexity consistent with the project under consideration. As required by the USACE regulations, a 6.5-percent supervision and administration (S&A) cost was taken on the construction cost. Monitoring (1 percent) and adaptive management (3 percent) were also included. The breakdown of costs for each alternative is presented in Table 64 and Table 65.

Table 60. Annual Operation and Maintenance Costs

	Alt A1/A2	Alt B1/B2	Alt C1/C2	Alt D1/D2	Alt E1/E2	Alt F1/F2	Alt G1/G2	Alt H1/H2	Alt I1/I2	Alt J1/J2	Alt K1/K2	Alt L1/L2	Alt M1/M2	Alt N1/N2	Alt O1/O2
Control Invasive Vegetation	2,950	2,950	8,850	5,900	8,850	8,850	8,850	8,850	8,850	8,850	8,850	8,850	8,850	8,850	8,850
Low-Flow Channel	0	0	0	0	0	50,000	0	0	50,000	0	0	0	0	0	12,100
Wetland	0	0	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728	11,728
Water Well	0	30,400	0	30,400	30,400	30,400	30,400	30,400	0	30,400	30,400	30,400	30,400	30,400	30,400
Irrigation System Maintenance	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360	9,360
Patrol and Biological Survey	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600
Refurbishment of Plants	22,678	37,566	44,000	18,037	52,877	46,417	42,896	40,747	21,492	34,030	32,720	24,680	30,624	35,784	36,691
Landfill Area	0	90,000	145,000	111,000	94,000	145,000	145,000	145,000	145,000	116,000	116,000	0	116,000	0	0
TOTAL	**56,588**	**191,876**	**240,538**	**208,025**	**228,815**	**323,355**	**269,834**	**267,685**	**268,030**	**231,968**	**230,658**	**106,618**	**228,562**	**117,722**	**130,729**

Table 61. Annual Associated Costs – Water

	Alt A1	Alt B1	Alt C1	Alt D1	Alt E1	Alt F1	Alt G1	Alt H1	Alt I1	Alt J1	Alt K1	Alt L1	Alt M1	Alt N1	Alt O1
Drip Irrigation System	93,000	203,700	346,575	340,275	425,625	778,425	533,400	377,925	461,250	570,600	591,075	525,225	608,175	725,175	800,850
	Alt A2	**Alt B2**	**Alt C2**	**Alt D2**	**Alt E2**	**Alt F2**	**Alt G2**	**Alt H2**	**Alt I2**	**Alt J2**	**Alt K2**	**Alt L2**	**Alt M2**	**Alt N2**	**Alt O2**
Braded Irrigation System	148,725	325,800	554,400	544,425	680,925	1,245,525	853,650	604,875	737,925	913,050	945,525	840,300	973,125	1,160,325	1,282,500

300

Table 62. Cost Summary – Second Array of Alternatives with Drip Irrigation

	With-Project Average Annual Costs by Alternative (in $1,000s)														
	Alt A1	Alt B1	Alt C1	Alt D1	Alt E1	Alt F1	Alt G1	Alt H1	Alt I1	Alt IJ1	Alt IK1	Alt L1	Alt M1	Alt N1	Alt O1
Construction	$25,106	$62,128	$96,590	$91,796	$90,579	$155,599	$141,758	$144,398	$139,815	$101,980	$91,673	$86,282	$137,022	$89,927	$94,607
Contingency (25%)	$6,277	$15,532	$24,147	$22,949	$22,645	$38,900	$35,440	$36,100	$34,954	$25,495	$22,918	$21,571	$34,255	$22,482	$23,652
PED/EDC (11%)	$2,762	$6,834	$10,625	$10,098	$9,964	$17,116	$15,593	$15,884	$15,380	$11,218	$10,084	$9,491	$15,072	$9,892	$10,407
S&A (6.5%)	$1,632	$4,038	$6,278	$5,967	$5,888	$10,114	$9,214	$9,386	$9,088	$6,629	$5,959	$5,608	$8,906	$5,845	$6,149
Monitoring/Adaptive Mgmt.	$1,431	$3,541	$5,506	$5,232	$5,163	$8,869	$8,080	$8,231	$7,969	$5,813	$5,225	$4,918	$7,810	$5,126	$5,393
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	**$46,930**	**$109,800**	**$164,853**	**$151,471**	**$158,795**	**$263,249**	**$236,021**	**$239,041**	**$221,502**	**$176,607**	**$160,037**	**$145,346**	**$227,197**	**$156,498**	**$165,157**
IDC	$1,049	$4,452	$8,963	$8,226	$8,642	$21,762	$19,500	$19,746	$18,268	$9,607	$8,708	$7,899	$18,769	$8,515	$8,987
Gross Investment	$47,979	$114,252	$173,816	$159,697	$167,437	$285,011	$255,522	$258,787	$239,770	$186,214	$168,745	$153,246	$245,965	$165,013	$174,144
Annualized Invest. Cost	$2,886	$6,872	$10,455	$9,606	$10,071	$17,143	$15,369	$15,566	$14,422	$11,200	$10,150	$9,217	$14,794	$9,925	$10,474
Associated Cost (Water)	$93	$204	$347	$340	$426	$778	$533	$378	$461	$571	$591	$525	$608	$725	$801
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$268	$232	$231	$107	$229	$118	$131
Total Annual Cost	$3,035	$7,268	$11,042	$10,154	$10,726	$18,245	$16,172	$16,211	$15,151	$12,003	$10,971	$9,849	$15,631	$10,768	$11,406

Table 63. Cost Summary – Second Array of Alternatives with Braided Irrigation

	With-Project Average Annual Costs by Alternative (in $1,000s)														
	Alt A2	Alt B2	Alt C2	Alt D2	Alt E2	Alt F2	Alt G2	Alt H2	Alt I2	Alt IJ2	Alt IK2	Alt L2	Alt M2	Alt N2	Alt O2
Construction	$18,857	$50,120	$81,382	$82,485	$72,737	$134,040	$124,332	$127,527	$129,496	$85,777	$75,280	$73,203	$120,818	$72,451	$75,871
Contingency (25%)	$4,714	$12,530	$20,345	$20,621	$18,184	$33,510	$31,083	$31,882	$32,374	$21,444	$18,820	$18,301	$30,204	$18,113	$18,968
PED/EDC (11%)	$2,074	$5,513	$8,952	$9,073	$8,001	$14,744	$13,677	$14,028	$14,245	$9,435	$8,281	$8,052	$13,290	$7,970	$8,346
S&A (6.5%)	$1,226	$3,258	$5,290	$5,361	$4,728	$8,713	$8,082	$8,289	$8,417	$5,575	$4,893	$4,758	$7,853	$4,709	$4,932
Monitoring/Adaptive Mgt.	$1,075	$2,857	$4,639	$4,702	$4,146	$7,640	$7,087	$7,269	$7,381	$4,889	$4,291	$4,173	$6,887	$4,130	$4,325
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	**$37,668**	**$92,004**	**$142,314**	**$137,671**	**$132,354**	**$231,299**	**$210,196**	**$214,037**	**$206,209**	**$152,593**	**$135,743**	**$125,964**	**$203,183**	**$130,598**	**$137,390**
IDC	$844	$3,735	$7,744	$7,480	$7,212	$19,134	$17,376	$17,689	$17,010	$8,308	$7,394	$6,851	$16,793	$7,114	$7,485
Gross Investment	$38,512	$95,739	$150,058	$145,151	$139,566	$250,433	$227,572	$231,726	$223,219	$160,901	$143,137	$132,814	$219,976	$137,712	$144,875
Annualized Invest. Cost	$2,316	$5,759	$9,026	$8,731	$8,395	$15,063	$13,688	$13,938	$13,426	$9,678	$8,609	$7,989	$13,231	$8,283	$8,714
Associated Cost (Water)	$149	$326	$554	$544	$681	$1,246	$854	$605	$738	$913	$946	$840	$973	$1,160	$1,283
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$268	$232	$231	$107	$229	$118	$131
Total Annual Cost	$2,522	$6,276	$9,821	$9,483	$9,304	$16,632	$14,812	$14,811	$14,432	$10,823	$9,786	$8,935	$14,433	$9,561	$10,127

302

5.7.7 Cost-Effectiveness and Incremental Cost Analysis

Cost-effectiveness (CE) and incremental cost analyses (ICA) were performed using the IWR-Plan software. CE/ICA identifies the least-costly solution for each level of output. The three criteria used for identifying non-cost-effective plans or combinations include (1) the same level of output could be produced by another plan at less cost; (2) a larger output level could be produced at the same cost; or (3) a larger output level could be produced at the least cost.

ICA compares the incremental costs for each additional unit of output. The first step in developing "best buy" plans is to determine the incremental cost per unit. The plan with the lowest incremental cost per unit over the No Action Alternative is the first incremental best buy plan. Plans that have a higher incremental cost per unit for a lower level of output are eliminated. The next step is to recalculate the incremental cost per unit for the remaining plans. This process is reiterated until the lowest incremental cost per unit for the next level of output is determined. The intent of the incremental analysis is to identify large increases in cost relative to output. Table 64 summarizes average annual output and cost as well as annual cost per AAFCU for each alternative as determined by the initial ICA run.

Table 64. Average Annual Cost per Average Annual FCU

Alternative	AAFCU	AA COST (1,000s)	AAC/AAFCU (1,000s)
A1	389	$ 3,035	$ 7.8
A2	389	$ 2,522	$ 6.5
B1	619	$ 7,268	$ 11.7
B2	619	$ 6,276	$ 10.1
C1	807	$ 11,042	$ 13.7
C2	807	$ 9,821	$ 12.2
D1	628	$ 10,154	$ 16.2
D2	628	$ 9,483	$ 15.1
E1	966	$ 10,726	$ 11.1
E2	966	$ 9,304	$ 9.6
F1	1084	$ 18,245	$ 16.8
F2	1084	$ 16,632	$ 15.3
G1	986	$ 16,172	$ 16.4

Alternative	AAFCU	AA COST (1,000s)	AAC/AAFCU (1,000s)
G2	986	$ 14,812	$ 15.0
H1	891	$ 16,211	$ 18.2
H2	891	$ 14,811	$ 16.6
I1	707	$ 15,151	$ 21.4
I2	707	$ 14,432	$ 20.4
J1	914	$ 12,003	$ 13.1
J2	914	$ 10,823	$ 11.8
K1	658	$ 10,971	$ 16.7
K2	658	$ 9,786	$ 14.9
L1	792	$ 9,849	$ 12.4
L2	792	$ 8,935	$ 11.3
M1	867	$ 15,631	$ 18.0
M2	867	$ 14,433	$ 16.6
N1	955	$ 10,768	$ 11.3
N2	955	$ 9,561	$ 10.0
O1	1,006	$ 11,406	$ 11.3
O2	1,006	$ 10,127	$ 10.1

As can be seen from this analysis, the alternatives that utilize the braided irrigation system (those designated with a "2" following the letter) are clearly more cost-effective than those utilizing drip irrigation (those designated with a "1" following the letter). However, it must also be pointed out that, although drip irrigation has a higher first cost, it also possesses greater cost efficiency in long-term water costs.

As previously discussed, alternatives are considered cost-effective if no other alternatives provide greater output for the same cost or provide the same output for a lesser cost. This step eliminates alternatives that are "non-cost effective" from further consideration. With the No Action Alternative comprising the first increment, seven alternatives were determined as cost-effective. These are presented in Table 65.

Table 65. Cost-Effective Alternatives

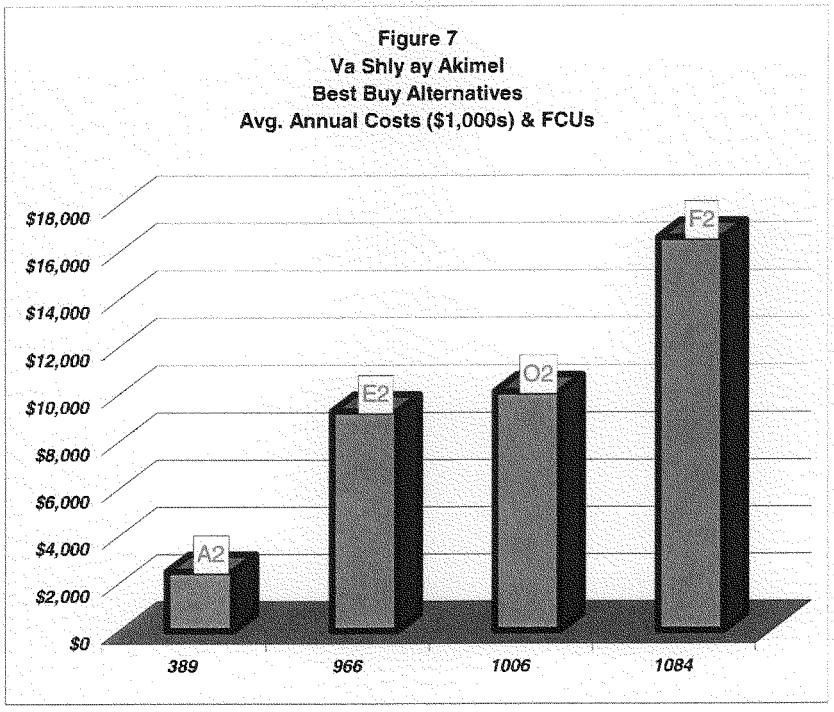
Alternative	AAFCU	AA COST ($1,000s)	AAC/AAFCU ($1,000s)
P	-	-	-
A2	389	2,522	6.5
B2	619	6,276	10.1
L2	792	8,935	11.3
E2	966	9,304	9.6
O2	1,006	10,127	10.1
F2	1,084	16,632	15.3

An incremental cost analysis was conducted on the set of cost-effective plans to identify the most efficient set of alternatives for providing the full range of restoration. These "best buy" combinations provided the greatest increase in FCUs for the least increase in cost. The analysis resulted in the identification of five best buy plans (including the No Action Alternative, "P"). Table 66 and Figure 54 present these alternatives, with the values for their average annual costs and outputs, ordered by increasing incremental cost per unit.

Table 66. Incremental Cost Analysis – Best Buy Alternatives

Alternative	AAFCU	Incremental AAFCU	AA Cost (1,000s)	Incremental AA Cost (1,000s)	Incremental AAC/AAFCU (1,000s)
P	-	-	-	-	-
A2	389	389	2,522	2,522	6.5
E2	966	577	9,304	6,783	11.8
O2	1,006	40	10,127	823	20.6
F2	1,084	78	16,632	6,505	83.4

Figure 54. Incremental Cost Analysis – Best Buy Alternatives Chart



With the No Action Alternative comprising the first increment, Alternative A2 has the lowest average annual cost per AAFCU and is therefore the first point on the ICA curve. ICA then determines which alternative has the lowest incremental average annual cost (relative to Alternative A2) per incremental increase in output (relative to Alternative A2). Based upon this methodology, Alternative E2 is identified as the next best buy plan. Alternative E2 provides an increase of 577 AAFCUs for an additional average annual cost of about $6.8 million. The next Best Buy plan is Alternative O2, which provides an additional 40 AAFCUs relative to Alternative E2, for an additional average annual cost of $823,000. As the largest of all plans in terms of output, Alternative F2 is also shown on the final list of alternatives under the ICA analysis. However, this can be somewhat misleading, since this alternative is included because it serves as an "end point" and not because it is necessarily a good buy. For example, Alternative F2 only provides an extra 78 AAFCUs relative to Alternative O2, but has a 64 percent higher cost. As a result, the incremental AAC/AAFCU for Alternative F2 is equal to $83,400, which is more than

four times higher than the incremental AAC/AAFCU for Alternative O2. Hence, from an ICA perspective, it would seem difficult to justify the additional costs for Alternative F2.

Although the above alternatives represent the best buys of the proposed alternatives, it should be pointed out that there are several alternatives that have similar output and cost to these alternatives. For example, Alternative N2 provides similar output and has similar costs relative to O2. However, Alternative N2 does not provide the same array of habitats, nor the extent per habitat, and was therefore, dropped from the array.

The information provided through incremental cost analysis allows decision-makers to decide when it is no longer worth the additional cost to increase the level of output. This may be easily seen when examining Alternative F2, which costs substantially more for a less dramatic gain in habitat value.

5.7.8 Recreation

The development of ecosystem restoration alternatives also provides a unique opportunity to provide resource-based recreation and environmental education that integrates the community and the restored environment along the Salt River. The restoration of the degraded ecosystem along the Salt River channel will bring a riparian open space features to the rapidly expanding planning area. Drawing on a population base of over three million in the metropolitan Phoenix area, it is estimated that visitation to the study area could be significant. Primary use times for this unique resource would coincide with the "visitor season" between October and May when temperatures are moderate.

The goal of the environmental education and recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of the Salt River on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the study area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle or horseback. Recognizing the diverse local society, an integrated project could employ design components ranging from areas adapted for special needs to multi-lingual signage.

5.7.8.1 Proposed Recreation Alternatives

Three recreational trail alternatives were developed. In addition to trailheads with small parking lots located approximately every four miles of trail length, all trail options include a larger parking lot and restroom facility, which would also feature utilities, lighting, a habitat interpretive center, picnic facilities, benches and signage. It should also be noted that the Local Sponsors have indicated a potential desire to locate a cultural center complex that may cost in excess of $10 million in the location designated for the parking and restroom facility. However, Federal cost sharing would be based upon the cost sharable options included in this analysis. More aggressive recreational components, such as lakes, sporting centers, parks, ball fields, etc. were rejected as out-of-harmony with the character of this project.

Details of the planned features associated with the trail improvements include:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar materials
- Trail lined with boulders or curbing to define the trail location
- Mileage markers
- Plaques or similar markers at significant project features to educate the public relative to cultural, biological or environmental aspects of the project
- Concrete benches located approximately every quarter mile
- Bike stop/ rest stations spaced approximately one per mile (perhaps overlooking significant project features and having the plaques or markers discussed above)
- Integral art that highlights the cultural, biological and/or environmental theme of the project (e.g., artwork incorporated into the design of such things as ramadas, bike racks, the trail surface, etc.)
- Signs at major mile cross streets

Trails in all the recreation alternatives would be available for use by pedestrians, bicyclists, and equestrians (i.e., "multi-use"). Motorized vehicles of all types would be

prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

(a) Recreation Alternative A

In Recreation Alternative A, a 7.77 mile trail (Trail #1) on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. In Alternative A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete.

Recreation Alternative A would also include trail head signage, three parking lots, mileage markers, educational plaques along the trail system, concrete benches, rest stops, guard posts, and street crossing signage. It would also incorporate a restroom, habitat interpretive outdoor demonstration area, a 12-foot-by-12-foot ramada, a small parking lot, four picnic tables, trash receptacles, benches and signs. These latter features are included as cost-shareable elements of a proposed Cultural Center, located within the footprint of the ecosystem restoration project. The proposed center, while not cost-shareable under the existing study authority, would be approximately 29,400 square feet in area, and would serve as the educational lynchpin of the project. Schools, environmental education, and other stakeholder groups would make use of the center to promote environmental awareness, and foster a greater sense of awareness of the importance of the environment to its community. The center's programs would foster campaigns that would create a sense of stewardship and "ownership" in the project's resources, to further enhance wise use of the area.

The estimated cost of Recreation Alternative A (without the Cultural Center) is $1,948,400.

(b) Recreation Alternative B

Recreation Alternative B (Trail #2) is the same as Alternative A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive, for a total of 5.13 trail miles. This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly. It includes the same features as Recreation Alternative A, but scaled to the shorter length of trail.

Recreation Alternative B would also include trail head signage, three parking lots, mileage markers, educational plaques along the trail system, concrete benches, rest stops, guard posts, and street crossing signage. As with Alternative A, it would also incorporate a restroom, habitat interpretive outdoor demonstration area, a 12' by 12' ramada, a small parking lot, four picnic tables, trash receptacles, benches and signs, associated with the proposed Cultural Center, located within the footprint of the ecosystem restoration project.

The estimated cost of Recreation Alternative B (without the Cultural Center) is $1,337,600.

(c) Recreation Alternative C

Recreation Alternative C includes all of the features of Alternative A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (Loop 101 Freeway) and Val Vista Drive. Total trail miles in this alternative are 13.64 miles. Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

Recreation Alternative C would also include trail head signage, three parking lots, mileage markers, educational plaques along the trail system, concrete benches, rest stops, guard posts, and street crossing signage. As with Alternatives A and B, it would also incorporate a restroom, habitat interpretive outdoor demonstration area, a 12' by 12' ramada, a small parking lot, four picnic tables, trash receptacles, benches and signs, associated with the proposed Cultural Center, located within the footprint of the ecosystem restoration project.

The estimated cost of Recreation Alternative C (without the Cultural Center) is $3,223,000.

5.7.8.2 Benefit Analysis

National Economic Development benefits arising from recreation opportunities created by a project are measured in terms of aggregate willingness to pay. Corps Principles and Guidelines describes three techniques which have been developed to estimate recreation demand and value. They include: 1) the Travel Cost Method; 2) the Contingent Value Method; and 3) the Unit Day Method. The Unit Day method was the method chosen for this analysis.

The Unit Day method does not attempt to account for the impact of price on visitation to a recreation site. Instead, an assigned user day value is applied to the total number of estimated visitors. User day values are simulated market values judgmentally derived from a range of values agreed to by Federal water resource agencies. It is intended to represent the user's average willingness to pay for a day of recreation activity at the site. When a properly formulated unit day value is applied to estimated use, an approximation of the area under the site demand curve is obtained, which is used in estimating recreation benefits.

A national schedule is available showing a range of values for both specialized and general recreation opportunities. A point rating system can be used to select a specific value from the published schedule of value ranges. Once alternatives have been formulated and recreation and environmental components identified and described, then unit day values can be selected with the input of Corps and local government agencies. These values are then applied to projected visitation.

(a) Visitation Projections

National Recreation and Parks (NRPA) standards for trail capacity and use range from 40 to 90 users per day per trail mile (or between 14,600 to 32,850 users per year per trail mile). The City of Mesa has estimated an average annual use of 40 users per day (or 14,600 per year) per mile, based upon use of existing trail systems, proximity to existing development and the unique features of the proposed environmental restoration project. This ratio reflects an average of 30 users per day per mile for the summer months of June through September, and 45 users per day per mile during the remaining months.

Visitation for each recreation option has been estimated by applying this visitation factor to the proposed length of trails.

Transfers of visitation from competing facilities are expected to be minimal due to the unique recreation opportunities and setting offered at the restoration site. The primary transfers are expected to be in the categories of education field trips, bird watchers, passive nature watchers, joggers and recreational cyclists.

(b) Unit Day Point Value Estimates

Unit day values will be calculated by assigning points to each activity (based upon Federal guidelines) and then converting total points to dollar recreation values (per the conversion table included in Economic Guidance Memorandum 04-03). Point values are derived by ranking the potential recreation resource according to five different criteria:

Criteria Values	Key Variables	Range of Point
Recreation Experience	Number and type of activities	0 – 30
Availability of Opportunity	Number of similar opportunities nearby	0 – 18
Carrying Capacity	Adequacy of facilities for activities	0 – 14
Accessibility	Ease of access to and within site	0 – 18
Environmental	Aesthetic quality of site	0 - 20
TOTAL		**0 – 100**

Based upon the total number of points assigned, UDVs (FY 04) can range from $3.00 to $9.01 per recreation day.

Separate UDV point values were derived for trail features (included in all options) and the cultural center (included all options). The following shows the results.

Table 67. Unit Day Value Assessment

Trails Criteria	General Rec. - Max Points	Total Points	Discussion
Recreation Experience	30	20	Several general recreational activities, e.g., hiking, bike riding, horseback riding, but in high quality setting
Availability of Opportunity	18	8	Several trail systems within a one hour travel time, but few in similar environment (e.g., Rio Salado Project)
Carrying Capacity	14	8	Adequate facilities to conduct recreation without deterioration of the resource
Accessibility	18	15	Good access to site provided by roads due to urban setting & links to existing parks
Environmental	20	15	High quality esthetic setting adjacent to environmental restoration project
	100	**66**	**UDV Dollar Equivalent = $7.17**

Based upon the visitation estimates and UDV values discussed above, Table 68 shows the expected annual benefits for each of the proposed recreation options.

Table 68. Expected Annual Benefits for Recreation Alternatives

Benefits	Alternative 1	Alternative 2	Alternative 3
Trails			
Trail Length	7.8	5.1	13.6
Average Users/Mile (Oct-May)	45	45	45
Average Users/Mile (June-Sept)	30	30	30
Average Users/Mile/Year	14,600	14,600	14,600
Estimated Annual Visitation	113,442	74,898	199,144
Less Transfers (5%)	5,672	3,745	9,957
Estimated Annual Visitation	107,770	71,153	189,187
Unit Day Value	$ 7.17	$ 7.17	$ 7.17
Annual Benefits	**$ 772,495**	**$ 510,025**	**$ 1,356,091**

(c) Recreation Costs & Benefit/Cost Analysis

Table 69 shows estimated costs for each recreation option. These values are approximate based upon information furnished by the City of Mesa and previous Corps reports. In addition, net benefits and benefit/cost ratios are also presented.

Table 69. Costs by Alternative and Benefit-Cost Analysis

Costs	Alternative A	Alternative B	Alternative C
Trail Length (Miles)	*7.77*	*5.13*	*13.64*
Trail Construction Cost	1,227,303	798,700	2,121,783
Restrooms/Interpretive Center	140,000	140,000	140,000
Total Construction Cost	1,367,303	938,700	2,261,783
Contingency (25%)	341,826	234,675	565,446
PED/EDC (11%)	150,403	103,257	248,796
S&A (6.5%)	88,875	61,016	147,016
Total First Cost	**1,948,400**	**1,337,600**	**3,223,000**
IDC (1 Year Construction Period)	54,000	37,100	89,400
Gross Investment	2,002,400	1,374,700	3,312,400
Annualized Investment Cost	120,400	82,700	199,200
O&M*	388,500	256,500	682,000
Total Annual Cost	508,900	339,200	881,200
Annual Benefits (rounded)	772,500	510,000	1,356,100
Net Benefits	263,600	170,800	474,900
Benefit/Cost Ratio	**1.52**	**1.50**	**1.54**

* O&M Includes $50,000/mile of trail.

Table 69 shows that each of the recreation options appears to be economically justified. The non-Federal sponsors have expressed their desire to pursue Recreation Alternative B to be incorporated in the restoration project.

5.8 Alternative Plans – Final Array

Since Alternatives A2, E2, O2, and F2 were determined to be economically justifiable, they have been carried forward into the final array of alternatives along with the No Action Alternative (Alternative P). The next step would be to compare these alternatives in terms of their contributions toward the four accounts under the System of Accounts as suggested by the U.S. Water Resources Council (USWRC). These plans are then compared against the four specific evaluation criteria: acceptability, completeness, effectiveness, and efficiency. The analyses will demonstrate which plan(s) would be the most rational choice for recommendation.

5.8.1 System of Accounts

A method of displaying the positive and negative effects of the various alternatives is to use the System of Accounts as suggested by the USWRC. The accounts are categories of long-term impacts, defined in such a manner that each proposed plan can be easily compared to another. The accounts used include National Economic Development, Environmental Quality which includes the National Environmental Restoration analysis, Regional Economic Development, and Other Social Effects.

5.8.1.1 National Economic Development (NED)

For all project purposes except ecosystem restoration, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment will be selected. The Assistant Secretary of the Army for Civil Works may grant an exception when there are overriding reasons for selecting another plan based on other Federal, State, local, and international concerns. Because the only element of the analysis that generates monetary benefits is that associated with the proposed recreational features of the final array of alternatives, an NED analysis was only conducted for those alternative plans, any of the three of which may be incorporated into the final recommended plan. The NED analysis is presented in Table 70.

5.8.1.2 Environmental Quality (EQ)

The EQ account is another means of evaluating the alternatives to assist in making a plan recommendation. This account is intended to display the long-term effects the alternative plans may have on significant environmental resources.

Ecosystem restoration is a major objective of this study process. For single-purpose ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, will be selected. The selected plan must be shown to be cost-effective and justified to achieve the desired level of output. This plan will be identified as the NER Plan.

Ecosystem restoration measures used in formulating the NER alternative plan are based on a combination of monetary and non-monetary benefits compatible with the Planning and Guidance (P&G) selection criteria as outlined in ER 1105-2-100. There are no universal environmental outputs; however, the outputs must increase ecosystem value and productivity and quantity and quality of measurable outputs.

The NER analysis for alternatives is shown in Table 71, under the Environmental Quality (EQ) Account. Details about the generation of Average Annual Functional Capacity Units (AAFCUs) are presented in the HGM Assessment Appendix. Details on the cost estimate and cost-benefit comparison are presented in the Cost Appendix and Economic Appendix, respectively.

A comparison of this and other effects that the proposed plans may have on the EQ resources is shown in Table 71.

5.8.1.3 Regional Economic Development (RED)

The RED account is intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. The comparison of possible effects that the plans may have on these resources is shown in Table 72.

5.8.1.4 Other Social Effects (OSE)

The OSE account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic, and man-made and natural resources. A comparison of the effects that the proposed alternatives would have on OSE resources is shown in Table 73.

Table 70. National Economic Development (NED) Account

Criteria	No Action	Recreation Alternative A	Recreation Alternative B	Recreation Alternative C
Total First Cost	-	1,948,400	1,337,600	3,223,000
IDC	-	54,000	37.100	89,400
Gross Investment	-	2,002,400	1,374,700	3,312,400
Annualized Investment Cost	-	120,400	82,700	199,200
O&M	-	388,500	256,500	682,000
Total Annual Cost	-	508,900	339,200	881,200
Annual Benefits (rounded)	-	772,500	510,000	1,356,100
Net Benefits	-	263,600	170,800	474,900
Benefit-Cost Ratio	-	***1.52***	***1.50***	***1.54***

317

Table 71. Environmental Quality Account

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Average Annual FCU	711	1,100	1,677	1,717	1,795
Increase in AAFCU	-	389	966	1,006	1,084
Average Annual Cost ($1,000s)	-	2,522	9,304	10,127	16,632
Average Annual Cost ($1,000) per AAFCU	-	6.5	9.6	10.1	15.3
Hydrology and Water Quality	Existing flooding and flood damage will continue at approximately the same level of magnitude and frequency. Water quality is expected to decline as the watershed continues to urbanize. Water quality will also be affected by development and runoff from surrounding properties. Erosion would continue at current rate and extent.	Temporary construction and O&M impacts to water quality would be slightly less than Alternatives E2, O2, and F2 because of the smaller construction area. There would be an anticipated long-term improvement in water quality due to the cleansing effect of vegetation and wetlands. This would be less effective than alternatives E2, O2, and F2, due to lesser acreages involved. Hydraulic modeling demonstrated no increases in water surface elevations in the project area.	Temporary construction and O&M impacts to water quality would be larger than alternative A2, but only slightly less than O2. There would be an anticipated long-term improvement in water quality due to the cleansing effect of vegetation and wetlands. This would be slightly less effective than alternative O2, due to lesser acreages involved. Hydraulic modeling demonstrated increases in water surface elevations in the lower and middle project reaches (2, 4, and upper segment of 5) associated with the establishment of cottonwood-willow and wetland vegetation in the main channel.	Temporary construction and O&M impacts to water quality would be similar to Alternative F2. There would be an anticipated long-term improvement in water quality due to the cleansing effect of vegetation and wetlands. This would be less effective than alternative F2, due to lesser acreages involved. Hydraulic modeling demonstrated increases in water surface elevations in the lower and middle project reaches (2, 4, and upper segment of 5) associated with the establishment of cottonwood-willow and wetland vegetation in the main channel.	Temporary construction and O&M impacts to water quality due to temporary discharges of soil and sediment into the river channel. Channel reshaping and vegetation planting activities have potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. Hydraulic modeling demonstrated increases in water surface elevations in the lower and middle project reaches (3, 4, 5, and 6) associated with the establishment of cottonwood-willow and wetland vegetation in the main channel.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Air Quality	No construction-related emissions would be generated.	Temporary construction and O&M impacts to air quality; total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be lower than Alternative F2.	Temporary construction and O&M impacts to air quality; total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be slightly lower than Alternative O2.	Temporary construction and O&M impacts to air quality; total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be lower than Alternative F2.	Temporary construction and O&M impacts to air quality.
Noise	No construction-related noise would be generated, no new project-related traffic would use area roadways, and no follow-on maintenance would occur.	Temporary construction-related noise generated; however, since the construction footprint for Alternative A2 is less than a third the size in Alternative F2, the duration of construction activities and noise impacts would be less than Alternative F2. New vehicle trips in the study area would be generated by recreational users traveling to visit the newly constructed site. This would contribute to traffic noise conditions on roadways.	Temporary construction-related noise generated; post-construction noise effects from new traffic and O&M activities would be identical to Alternative F2.	Temporary construction-related noise generated; post-construction noise effects from new traffic and O&M activities would be identical to Alternative F2.	Temporary construction-related noise generated; new vehicle trips in the study area would be generated by recreational users traveling to visit the newly constructed site. This would contribute to traffic noise conditions on roadways.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Habitat and Wildlife Diversity and Numbers	The study area would continue to suffer from a lack of habitat and wildlife diversity. There would be a long-term decline in both habitat quality and quantity. There would be a long-term decline in wildlife diversity and numbers.	The study area would show a substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term increase in wildlife diversity and numbers.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers. This alternative would result in slightly more habitat and wildlife diversity and numbers than Alternative E2, and considerably more than Alternative A2.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers. This alternative would result in slightly more habitat and wildlife diversity and numbers than Alternatives E2 and O2, and considerably more than alternative A2.
Vegetation	No Action would result in long-term habitat degradation and long-term increase in saltcedar. **Expected 17 percent decline in FCUs over period of analysis.**	There would be a substantial increase in the vegetation diversity and numbers of each type of vegetation within the study area. Increase in the CW due to the removal of saltcedar; Results in an **expected increase of 389 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 966 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 1,006 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 1,084 AAFCUs.**

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Habitat and Wildlife Diversity and Numbers	The study area would continue to suffer from a lack of habitat and wildlife diversity. There would be a long-term decline in both habitat quality and quantity. There would be a long-term decline in wildlife diversity and numbers.	The study area would show a substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term increase in wildlife diversity and numbers.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers. This alternative would result in slightly more habitat and wildlife diversity and numbers than Alternative E2, and considerably more than Alternative A2.	The study area would show a very substantial increase in habitat and wildlife diversity. There would be an immediate increase in both habitat quality and quantity. There would be a long-term significant increase in wildlife diversity and numbers. This alternative would result in slightly more habitat and wildlife diversity and numbers than Alternatives E2 and O2, and considerably more than alternative A2.
Vegetation	No Action would result in long-term habitat degradation and long-term increase in saltcedar. **Expected 17 percent decline in FCUs over period of analysis.**	There would be a substantial increase in the vegetation diversity and numbers of each type of vegetation within the study area. Increase in the CW due to the removal of saltcedar; Results in an **expected increase of 389 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 966 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 1,006 AAFCUs.**	Substantial increase in the habitat value in the region. Increase in the CW, new river bottom, and open water communities; results in an **expected increase of 1,084 AAFCUs.**

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Wildlife Species	No Action would result in long-term habitat degradation.	The primary benefit would be to riparian-obligate bird species from the removal of saltcedar to allow for CW growth. **No Cottonwood-Willow or wetland will be established in Alternative A2.**	The primary benefit would be to riparian-obligate bird species due to increases in Cottonwood-Willow and Mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. The benefit to wildlife species would be considerably greater than Alternative A2. **Because Alternative E2 establishes 287 acres of Cottonwood-Willow and 25 acres of wetlands, Alternative E2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternative A2.**	The primary benefit would be to riparian-obligate bird species due to increases in Cottonwood-Willow and Mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. The benefit to wildlife species would be considerably greater than Alternative A2. **Because Alternative O2 establishes 883 acres of Cottonwood-Willow and 200 acres of wetlands, Alternative O2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternatives A2 and E2.**	The primary benefit would be to riparian-obligate bird species due to increases in Cottonwood-Willow and Mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. The benefit to wildlife species would be considerably greater than Alternative A2. **Because Alternative F2 establishes 701 acres of Cottonwood-Willow and 187 acres of wetlands, Alternative F2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternatives A2 and E2.**

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Endangered Species	The decline in CW habitat value would result in the eventual decrease of optimal habitat available to the southwestern willow flycatcher and the Yuma clapper rail.	An increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail is anticipated. O&M activities may produce potential short-term impacts.	There would be a more significant increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail under Alternative E2. **Because Alternative E2 establishes 287 acres of Cottonwood-Willow and 25 acres of wetlands, Alternative E2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternative A2.** O&M activities may produce potential short-term impacts.	There would be a more significant increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail under Alternative O2. **Because Alternative O2 establishes 883 acres of Cottonwood-Willow and 200 acres of wetlands, Alternative O2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternatives A2 and E2.** O&M activities may produce potential short-term impacts.	There would be a slightly more significant increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail under Alternatives F2 than O2. **Because Alternative F2 establishes 701 acres of Cottonwood-Willow and 187 acres of wetlands, Alternative F2 has significantly greater value to riparian obligates and other riparian-dependent species than Alternatives A2 and E2.** O&M activities may produce potential short-term impacts.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Cultural Resources	Implementation of the No-Action Alternative will not result in any direct impacts on cultural resources. It is probable, however, that sites may be disturbed or lost both by other human actions that are not project related and through natural processes such as erosion.	Restoration activities under Alternative A2 are more limited in scope than under Alternatives F2 and E2 and would thus have the potential to affect fewer known cultural resources. Under this alternative, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. This would represent a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.	The potential impacts of Alternative E2 to cultural resources are similar to, but slightly smaller than, the impacts of Alternatives F2 due to a more limited work area. Under this alternative, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. This would still constitute a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.	Under Alternative O2, potential effects are similar to Alternative N because the alternative does not include channelization or bank stabilization. Similar to Alternatives F and N, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. Implementation of Alternative O2 would still represent a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.	Under Alternative F2, several known cultural sites have the potential to be adversely affected. This represents a significant and unavoidable impact. The exact number is being updated based on recent survey and subsurface testing. This represents a significant and unavoidable impact if any of them are determined to be eligible for the NRHP. The list of NRHP sites to be affected may be reduced or eliminated as the design of the project is refined. There may be opportunities to incorporate site preservation into project plans that would result in beneficial effects to cultural sites. This might be accomplished by providing for avoidance and/or isolation from future human impacts.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Aesthetics	The existing aesthetic environment would likely decline somewhat over the period of analysis, due to the loss of habitat, increasing development, and associated impacts to aesthetic qualities.	Although limited, restoration activities would improve the aesthetic quality of the area.	Alternative E2 would significantly improve aesthetic quality of the study area. Additional riparian vegetation corridors, wetland and upland habitats, and increased wildlife would result in perceived higher aesthetic quality improvement between this and Alternative A2.	Alternative O2 would result in a slightly higher improvement in aesthetic quality of the study area over that of Alternative E2. Additional riparian vegetation corridors, wetland and upland habitats, and increased wildlife would result in significantly higher aesthetic quality improvement between this and Alternative A2.	Alternative F2 would result in a slightly higher improvement in aesthetic quality of the study area over that of Alternative O2. Additional riparian vegetation corridors, wetland and upland habitats, and increased wildlife would result in higher aesthetic quality improvement between this and Alternative A2 and somewhat more than Alternative E2.

Table 72. Regional Economic Development Account

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Employment	No impacts on employment.	Ten months temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy.	Three years temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy.	Three years temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy.	Three years temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy.
Housing Stock and Business	Existing conditions would remain relatively unaffected.	Implementation of Alternative A2 would not require removal of any residences or displacement of businesses. The direct employment-related increase in personal income would result in associated short-term increases in spending on goods and services, temporarily benefiting both households and businesses within the local economy.	Same as Alternative A2.	Same as Alternative A2.	Same as Alternative A2.
Local Government Finance	No direct impacts on local government finance.	Non-Federal sponsor's initial investment of $13.5M for construction, $148,725 for water, and $56,588 for maintenance annually.	Non-Federal sponsor's initial investment of $47.8M for construction, $680,925 for water, and $228,815 for maintenance annually.	Non-Federal sponsor's initial investment of $50.7M for construction, $1,282,500 for water, and $130,729 for maintenance annually.	Non-Federal sponsor's initial investment of $87.65M for construction, $1,245,525 for water, and $323,355 for maintenance annually.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Growth Inducing Impacts	No direct impacts on growth in the area.	Although the proposed action would not directly construct housing or other facilities that would result in growth, Alternative A2 could potentially induce growth as a result of new recreational opportunities. Any potential growth in this area would be limited by market factors that are unrelated to elements of the proposed action.	Same as Alternative A2.	Same as Alternative A2.	Same as Alternative A2.

Table 73. Other Social Effects Account

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Public Health and Safety	Safety threats associated with flood hazards would continue to exist for properties within the floodplain. This alternative would not provide vector control beyond existing levels; thus, existing vector problems would persist.	Temporary construction-related water quality impacts; standing water, which may be present for a short time following heavy rainfall or irrigation in various portions of the project area, may have the potential to temporarily increase mosquito breeding in the project area.	Same as Alternative A2.	Same as Alternative A2.	Same as Alternative A2.
Recreation	Recreation conditions would stay substantially the same. Recreational experiences would also not be enhanced.	Long-term recreation benefits associated with Alternative A2 would be reduced in comparison to those of Alternative F2. New habitat development is limited to SD vegetation types, which could lead to lower wildlife diversity and may attract fewer recreationists in the central and western portions of the project area.	Long-term beneficial effects of Alternative E2 will increase compared to those of Alternative F2 due to the addition of the multi-use trails in Reaches 1 and 6.	Long-term beneficial effects of Alternative O2 will increase compared to those of Alternative F2 due to the addition of the multi-use trails in Reaches 1 and 6.	The habitat restoration would create attractive open space that is conducive to the development of new recreational opportunities. The increase in passive open space would enhance the overall experience of recreationists, and O&M activities would maintain this benefit.

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Transportation	No impact to transportation would occur. Traffic conditions would continue to increase as the surrounding areas become more developed.	Temporary increase in traffic on existing roadways during construction; no impacts are anticipated on traffic and circulation. Under Alternative A2, 16 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 10 daily round trips on local arterial streets over a period of 5 years.	Temporary increase in traffic on existing roadways during construction; no impacts are anticipated on traffic and circulation. Under this alternative, 86 haul trips would occur per day to deliver materials off-site to the project sites. Construction workers commuting to the project site would generate an additional 15 daily round trips on local arterial streets over a period of 5 years.	Temporary increase in traffic on existing roadways during construction; no impacts are anticipated on traffic and circulation. Under this alternative, 86 haul trips would occur per day to deliver materials off-site to the project sites. Construction workers commuting to the project site would generate an additional 15 daily round trips on local arterial streets over a period of 5 years.	Temporary increase in traffic on existing roadways during construction; no impacts are anticipated on traffic and circulation. Under this alternative, 144 haul trips would occur per day to deliver materials off-site to the project sites. Construction workers commuting to the project site would generate an additional 25 daily round trips on local arterial streets over a period of 5 years.

5.8.2 Associated Evaluation Criteria

The selection of a recommended plan from the alternative plans requires a combination of decision-making factors. As suggested by the USWRC, the alternative plans are compared using the following criteria: completeness, effectiveness, efficiency, and acceptability. The evaluation of the alternative plans by established criteria are described below and are presented in Table 74.

5.8.2.1 Completeness

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planned objectives. A complete alternative (1) meets the objectives, (2) needs no further actions for complete fulfillment of the project, (3) is consistent and reliable, (4) is capable of being physically implemented, and (5) mitigates unavoidable adverse environmental effects, as appropriate. All of the proposed recreation alternatives are fairly complete means of addressing recreation demand and opportunities within the study area. In general, all of the final alternatives are fully formulated and complete. No further measures are needed to allow for the functioning of the alternatives.

5.8.2.2 Effectiveness

Effectiveness is the extent to which an alternative resolves the identified problems and achieves the specified objectives. The proposed plans must restore the long-term health of the ecosystem structure, function, and dynamic processes in the Salt River. Alternatives A2, E2, O2, and F2 are effective, to varying degrees, in increasing habitat extent within the river corridor. This does not mean that they all increase habitat diversity, which is a measure of effectiveness. Alternative F2 is the most extensive of the three; Alternative A2's footprint is less than a third the size of Alternative F2. However, Alternative A2 only provides for establishment for one vegetation type: Sonoran desert scrub shrub. Alternative E2 is considerably more extensive than Alternative A2; however, it does not provide nearly the habitat acreages in Cottonwood-Willow and wetlands that Alternative O2 does, and therefore, cannot be considered as being nearly as effective. On the other hand, Alternatives O2 and F2 provide for establishment for a complete and diverse riparian system similar to the native riparian habitat typical of this area historically. The restored habitat areas of Alternatives O2 and F2 incorporate four different vegetation types: Sonoran desert scrub shrub, wetlands, cottonwood-willow, and mesquite. All of the proposed recreation alternatives are also effective means of

addressing recreation demand and opportunities within the study area. The No Action Alternative is ineffective in meeting any of the planning objectives.

5.8.2.3 Efficiency

Efficiency is the extent to which an alternative is the most cost-effective means of addressing the identified problems while realizing the specified objectives consistent with protecting the Nation's environment. Cost effectiveness analysis is performed to identify the least cost alternative plans. The ranking is based on the average annual cost per average annual functional capacity unit. As previously presented in Table 66, Alternative A2 provides the greatest output per dollar spent, at $6,500 per AAFCU, although it provides the *least* increase in FCUs over the existing condition. Alternative E2, at $9,600 per AAFCU, is the second-most cost-effective alternative. Alternative O2 is the third most cost-effective of the final array, at $10,100 per AAFCU. Alternative F2 provides the highest output, however, at a cost of $15,300 per AAFCU. All of the proposed recreation alternatives are also efficient means of addressing recreation demand and opportunities within the study area. Each possesses a positive benefit to cost ratio, and generates significant net benefits. It appears that Recreation Alternative C is the most cost-effective of the three, but all three alternatives are justified. The No Action Alternative is the least cost alternative, but fails to restore valuable habitats, which have suffered historic losses and provide important habitat to many species. It also does not address un-met recreation demand in the study area. The No Action Alternative represents a lost opportunity for improving environmental quality and quality of life issues within the study area.

5.8.2.4 Acceptability

Acceptability is the workability and viability of an alternative to other Federal agencies, affected State, tribal, and local agencies; and public entities, given existing laws, regulations, and public policies. The comparison of acceptability is defined as acceptance of the plan by the local sponsor and the concerned public. The relative acceptability of the alternatives is judged on the basis of feedback and tentative support indicated by the non-Federal sponsors and the public through the public review process. Initial public support for Alternative O2 has been established. The non-Federal sponsors have expressed interest and support in implementing Alternative O2 and Recreation Alternative B.

Table 74. Associated Evaluation Criteria

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Completeness	Does not meet objective.	Technically feasible; does not meet all habitat restoration objectives; provides only single habitat type restoration; limited size of vegetation establishment; least acreage of land required. *Rank: Moderate*	Technically feasible; meets habitat restoration objectives; includes all four vegetation types; acreage of land required is more than twice as in Alternative A2. *Rank: High*	Technically feasible; meets habitat restoration objectives; includes all four vegetation types; acreage of land required is more than twice as in Alternative A2. *Rank: High*	Technically feasible; meets habitat restoration objectives; includes all four vegetation types; acreage of land required is more than 3 times the size required in Alternative A2. *Rank: High*
Effectiveness	Does not meet objective.	Provides the least amount of vegetation establishment (approximately 650 acres). *Rank: Low*	Provides approximately 1,700 acres of vegetation establishment. Alternative E2 is considerably more extensive than Alternative A2; however, it does not provide nearly the habitat acreages in Cottonwood-Willow and wetlands that Alternative O2 does, and therefore, cannot be considered as being nearly as effective. *Rank: Moderate*	Provides approximately 1,700 acres of vegetation establishment. *Rank: High*	Provides the greatest amount of vegetation establishment (approximately 2,200 acres). *Rank: High*
Efficiency	Does not meet objective.	Provides the least output (389 AAFCUs) for the least cost ($6,500/AAFCU). *Rank: Low*	Provides more than twice the output (966 AAFCUs) of Alternative A2 for 48 percent greater cost per unit ($9,600/AAFCU). *Rank: High*	Provides more than twice the output (1,006 AAFCUs) of Alternative A2 for 55 percent greater cost per unit ($10,100/AAFCU). *Rank: High*	Provides the most output; 1,084 AAFCUs; more than 2.5 times that of Alternative A2; but at more than twice the cost per unit ($15,300/AAFCU). *Rank: Moderate*

Criteria	No Action	Alternative A2	Alternative E2	Alternative O2	Alternative F2
Acceptability	Does not meet objective.	Currently not supported by non-Federal sponsors. *Rank: Low*	Non-federal sponsors have not indicated support for Alternative E2. *Rank: Low*	Non-federal sponsors indicated support for Alternative O2 and Recreation Alternative B. Initial public support and satisfaction was established after the review of the draft document and at the public meeting held in June 2004. *Rank: High*	Currently not supported by non-Federal sponsors. *Rank: Low*

5.9 Alternatives Considered for Recommendation in the Feasibility Report

The NER Plan that was identified in this Feasibility Report is described below. It should be noted that the Locally Preferred Plan (LPP), if different from the NER Plan, and which may be ultimately recommended for implementation based on public acceptance and non-Federal sponsor input, would not be officially selected or approved until after the public review process.

5.9.1 National Economic Development Plan

A tentative NED Plan has been identified as Recreation Alternative B, which possesses the least net benefit and benefit to cost ratio of the three plans in the final array. However, this plan is subject to further refinement following the Public Meeting held to present the results of the study. Refinements may lead to a change in the costs and features of each plan, and therefore, the selection of the NED Plan. Cost-sharing of the recreation elements of the recommended plan will be 50-50 or 0-100, Federal and non-Federal, respectively, depending upon the features. Those features currently recommended for cost-sharing would be cost-shared at 50 percent Federal and 50 percent non-Federal.

5.9.2 National Ecosystem Restoration Plan

The NER Plan is identified by the Federal government as the plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. It is cost-effective and justified to achieve the desired level of outputs. The NER Plan is the restoration alternative that the Federal government will recommend in the Final Feasibility Report, unless an exemption from the NER is required, as with an LPP, for example. The Federal government will cost share up to the price of the NER Plan, at 65 percent Federal and 35 percent non-Federal for ecosystem restoration features including provisions of all lands, easements, rights-of-way, relocations, and disposal areas (LERRDs).

5.9.3 Locally Preferred Plan

A Locally Preferred Plan (LPP) may be identified in the Final Feasibility Report if the results of the Public Meeting and further coordination efforts indicate the unacceptability of the NER Plan. If increments of the NER Plan are not supported by the public; do not include particular increments desirable to the local sponsor; or are not capable of

implementation because of management or funding constraints of the local sponsor, it will not be recommended for implementation. When the LPP is clearly of lesser scope and cost and meets the Administration's policies for high-priority outputs, the Assistant Secretary for the Army (ASA) usually grants an exception for deviation. The increased scope of any plan more expensive than the NER Plan would not warrant Federal cost-sharing participation. Thus, if the LPP is larger in scope than the NER, the local sponsor would pay 100 percent of the difference between that plan and the NER.

5.9.4 Selection of the Recommended Plan

Alternative O2 was determined to be a best-buy plan during the cost-effectiveness and incremental cost analysis. Alternative O2 provides significant habitat benefits at one of the lowest costs per unit. And while Alternative O2 provides only an extra 40 AAFCUs and 70 total acres of habitat relative to Alternative E2, the additional cost is justified due to the types of habitats restored.

In the HGM model, all four vegetation types (Cottonwood-Willow, Mesquite, Sonoran Desert Scrub Shrub, and Wetlands) were assigned the same overall value. In other words, the FCU value of an acre of Cottonwood-Willow vegetation was assigned an equal value to that of Sonoran Desert Scrub Shrub. While it can be said that it is not possible to value one habitat type over another, there are inherent differences that should be taken into account. Given the rarity of Cottonwood-Willow and Wetlands habitats in this part of the American southwest, relative to desert scrub shrub, there would be more environmental gain if the more rare habitat were restored. For example, in the arid southwest, roughly 70 percent of listed threatened and endangered vertebrate species are considered riparian obligates (Johnson, 1989). Alternative O2 reestablishes 883 acres of Cottonwood-Willow and 200 acres of Wetlands. Alternative E2 established only 287 acres of Cottonwood-Willow and 25 acres of Wetlands, a difference of 596 acres and 175 acres, respectively. Alternative O2 would reestablish considerably more riparian habitat, and therefore provide a larger benefit to species associated with the riparian zone. It is the rarity of riparian vegetation, and its inherent value, that justifies the additional cost of Alternative O2.

For these reasons, Alternative O2 is identified as the NER Plan. This Plan meets the maximum number of feasibility study criteria discussed earlier in Chapter 5, on the basis of completeness, effectiveness, efficiency, and of public acceptability. Because of its ability to meet, to the greatest degree of those alternatives identified, all of the established

criteria for evaluation, and appears to possess strong non-Federal sponsor support, Alternative O2 is also identified as the recommended plan. Recreation Alternative B has been identified as the recreation component of the recommended plan.

CHAPTER VI
DESCRIPTION OF THE RECOMMENDED PLAN

6.1 The Recommended Plan

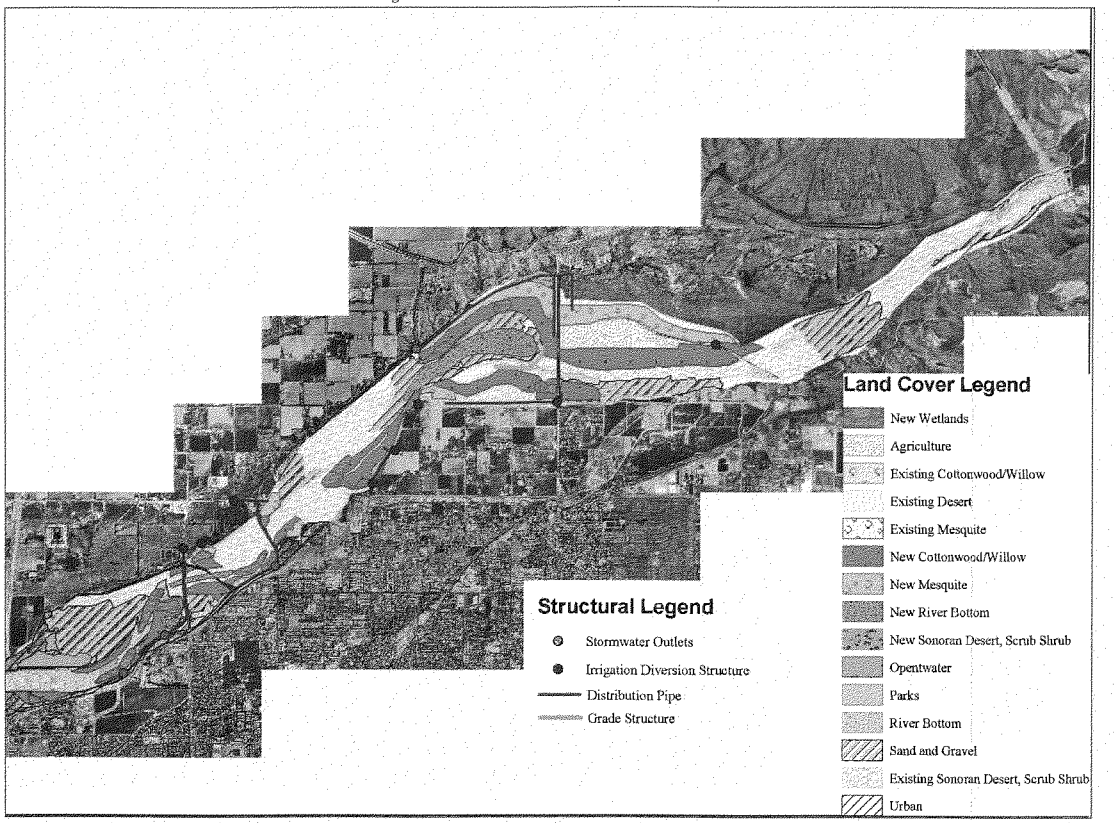
Based on the results of the analyses conducted during the most recent phases of the feasibility study, including the Cost-Effectiveness and Incremental Cost Analyses, Alternative O2 has been identified as the NER Plan. In addition, based on its achievement of project objectives, and its meeting of completeness, efficiency, effectiveness, and preliminary public acceptability criteria, Alternative O2 is also identified as the recommended plan. Recreation Alternative B has been identified as the recreation component of the recommended plan.

6.2 Plan Features

The Recommended Plan (Alternative O2) consists of a broad restoration of four key habitat types within all nine reaches of the study area (see Figure 55). These include the following habitat types with their associated acreages shown: Cottonwood-Willow (883 acres), Wetlands including River Bottom (425 acres), Mesquite (380 acres), and Sonoran Desert Scrub Shrub (24 acres).

Reach 1 would support one wetland feature and two cottonwood-willow stands within Sub-area 1.1. A cottonwood-willow stand would be established within the main channel, at the far southeast end of Sub-area 1.1. The percolation ponds found immediately outside of the southern bank in Sub-area 1.2 would be planted with cottonwood and willow. This area would be supported with water from the WWTP.

Figure 55. The Recommended Plan (Alternative O2)



Reach 2 would support a wetland feature surrounded by cottonwood-willow to the west, south, and east of Sub-area 2.4. These features would be supported by surface water outlets and maintained using a surface braided irrigation network (SBIN). Along the south bank of the river, in Sub-area 2.3, the alternative would support two wetland features and small areas of cottonwood-willow and mesquite habitat. One small stand of cottonwood-willow would surround the wetland; a second larger stand would be established in the eastern edge of Sub-area 2.3 and extend into Sub-area 2.2. The wetland would be located near the Country Club Storm Drain on the existing river bottom. In Sub-area 2.2, one wetland feature would be created in the old quarry located near Alma School Road. The small wetland to the north and the larger wetland to the east would be surrounded by a cottonwood-willow stand. The cottonwood-willow would be irrigated using a SBIN. A small area, south of the wetlands, would be reshaped and converted to new river bottom.

Reach 3 would contain cottonwood-willow and mesquite stands on the north and south banks of the river.

Reach 4 would contain cottonwood-willow, mesquite, and wetland habitat. The majority of Sub-area 4.1 would be left unvegetated due to the presence of the Tri-City Landfill. Sub-area 4.2, along the south bank, would support cottonwood-willow and mesquite habitat, and a large wetland feature. Two south bank surface water outlets would supply water to the SBIN used to irrigate the vegetation. The western outlet would support the wetland feature as well as surrounding cottonwood-willow and mesquite habitat.

Reach 5 would contain cottonwood-willow, mesquite, and Sonoran desert habitat. The SRS&R Beeline One Plant pit would be reshaped and converted to new river bottom in Sub-area 5.2. Cottonwood-willow, mesquite habitat, and a small pocket of Sonoran desert habitat would be located on the overbank area. The mesquite and Sonoran desert would be irrigated using groundwater from a new well. The water would be distributed using a SBIN. The channel in Sub-area 5.1 would be reshaped and converted to new river bottom. A wetland feature as well as cottonwood-willow habitat would be established at the Evergreen Drain and would be irrigated using groundwater from the new well. Sub-area 5.3, located along the south bank, would be vegetated with cottonwood-willow, a small stand of mesquite habitat, and a small wetland feature. Surface water and stormwater would be used to irrigate these areas. Irrigation of the cottonwood-willow and mesquite habitat would be done by a SBIN. The drop structure discussed earlier would be placed in Sub-area 5.2, in the main channel at the center point

of the SRS&R Beeline One Plant. This structure would protect the restored habitat and other riparian features within Reach 5. The structure would span the entire width of the riverbed, approximately 2,000 feet, and would be constructed of soil cement.

Reach 6 would contain large areas of cottonwood-willow and mesquite habitat within Sub-area 6.1. The cottonwood-willow habitat located south of the GRUSP site would be irrigated using SRPMIC surface water from the Hennessey Drain. The mesquite habitat is located north of the GRUSP site and would be irrigated using groundwater from the new well. In both areas, the water would be distributed using a SBIN. In Sub-area 6.2, located on the south bank of the river, one area of cottonwood-willow habitat would be planted in an abandoned quarry depression directly east of Gilbert Road within the 5-year floodplain. The area would be irrigated using surface water, and stormwater, when available. Sub-area 6.3 would have a cottonwood-willow stand on the north bank near the Hennessey Drain just outside the 10-year area of inundation.

No changes were proposed in Reach 7 due to the presence of an existing quarry. It was assumed there is a high probability that any vegetation planted would be damaged due to in-channel mining operation. The ongoing quarrying of the SRS&R Higley Plant may potentially cause scouring to occur along the main channel downstream, particularly in Reach 6. Based on the technical studies to date, the preservation of the corridor within Reach 7 is not required. However, if the detailed analysis during the design phase indicates that a narrow corridor is required to secure the benefits in Reach 6, then the appropriate control would need to be secured by way of the SRPMIC regulating the sand and gravel operation by preserving the corridor or reclaiming it to a grade required for an effective project.

Reaches 8 and 9 would contain only removal of invasive plant species, primarily saltcedar (*Tamarisk sp),* and only in those areas in which no threatened or endangered wildlife species are found. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place.

The water demand of the Recommended Plan is 8,550 acre-feet/year. Eight new irrigation diversion structures and one new well are required under the Recommended Plan.

The Recommended Plan would require excavation and stockpiling of 233,333 cubic yards of material for the low-flow channel, all of which would be spread on-site. Re-shaping of the riverbed outside the low-flow channel would require the excavation and

stockpiling of 1,320,489 cubic yards of material, fill of 751,803 cubic yards, the spreading of 568,686 cubic yards of material, and vegetation grading of 2,186,969 cubic yards.

Wetland feature restoration would require excavation and stockpiling of 1,689,960 cubic yards of material, the construction of a two-foot deep lining of clay totaling 422,490 cubic yards, the spreading of 422,490 cubic yards of coarser material two-feet thick on top of that lining, and the spreading of 1,689,960 cubic yards of excess material on-site.

Planting components include 74,172 Cottonwood and Willow trees, 24,700 Mesquite, 3,048 Sonoran Desert plants, and 200 acres of wetland vegetation plantings. A new water well is required in Reach 5. This well nourishes the vegetation planted on the terraces along the river.

The required grade control structure consists of 31,111 cubic yards of concrete used in the soil cement. Excavation and stockpiling of 58,331 cubic yards of material in the upstream area are required in its construction. The backfilling and compaction of 58,331 cubic yards of material in the upstream area are also required. Excavation and stockpiling of 8,332 cubic yards of material in the downstream upstream area are required in its construction. The backfilling and compaction of 3,000 cubic yards of material in the downstream area are required. Spreading of 5,332 cubic yards of excess material, and the installation of 8,888 cubic yards of rip-rap are required for construction of this feature.

The water distribution system utilized by the Recommended Plan would require 40,617 linear feet of 12-inch PVC pipe. Pump stations would be constructed at Alma School and Country Club Roads. A bridge crossing of 1,700 linear feet are required for each pump station.

Road crossings for the pipeline system would require 89 cubic yards of excavation, 12 tons of asphalt laid three-inches thick, 25 tons of six-inch ABC, and 55 cubic yards of backfill and compaction would be required.

The plant irrigation system would consist of 66 acres delivering 949 acre-feet in Reach 1, 226 acres delivering 3,140 acre-feet in Reach 2, 29 acres delivering 362 acre-feet in Reach 3, 152 acres delivering 2,113 acre-feet in Reach 4, 434 acres delivering 4,449 acre-feet in Reach 5, and 580 acres delivering 6,097 acre-feet in Reach 6. An irrigation

channel T-junction is also a required feature of the plan. Debris removal totaling 118,000 cubic yards of material would be required.

6.3 Project Outputs

The Recommended Plan provides a net habitat value of 1,717 FCUs or 239 percent of the functional capacity units under existing conditions. This is an increase of 1,006 units above existing conditions.

6.4 Cost Estimate

A more detailed estimate of construction costs was developed for the Recommended Plan utilizing the Corps' MCACES cost estimating software. Table 75 summarizes the results. It should also be noted that Monitoring and Adaptive Management, and Real Estate costs were added to the construction costs to derive a Total First Cost estimate.

Table 75. Detailed Cost Estimate – Recommended Plan
FY04 Price Levels, $5^{5}/_{8}$% Discount Rate

Item	Cost
Low Flow Channel	1,401,000
Channel Reshaping	20,714,000
Wetland Features	24,911,000
Planting	4,163,000
Water Well	244,000
Grade Control Structure	7,323,000
Water Distribution System	1,282,000
Road Crossing	5,000
Planting Irrigation System	6,315,000
SRPMIC Irrigation Channel	43,000
Debris Removal	9,332,000
Cultural Mitigation	300,000
Construction Cost	**76,033,000**
Contingency (25%)	19,008,300
PE&D (10%)	7,603,300
EDC (1%)	760,300
S&A (6.5%)	4,942,100
Total Construction Cost	**108,347,000**
Monitoring and Adaptive Mgt. (4%)	4,334,000
Real Estate	24,949,400
Total First Cost (Rounded)	**137,630,000**
Interest During Construction	7,742,000
Gross Investment	**145,372,000**
Annualized Investment Cost	**8,744,000**
OMRR&R	131,000
Associated Cost (Water Supply)	1,283,000
Total Annual Cost	**10,158,000**

6.5 Maintenance Considerations

Operation and maintenance activities (O&M) would occur after the project is constructed in order to keep project features functioning as designed. These activities may include:

- Maintenance and replacement of pumps, pipelines, and other water delivery and irrigation
- Infrastructure features
- Vector control
- Environmental monitoring
- Periodic removal of sediment, surface reshaping, or replanting of project features damaged by flood events

6.5.1 Drainage Maintenance

This maintenance activity consists of clearing debris from drainage structures, including outfalls and channels, and general earthwork maintenance. This is expected to occur on an as-needed basis (inspections would occur more frequently). Excess soil materials would be disposed of locally in areas that are not environmentally sensitive or subject to Clean Water Act permitting.

6.5.2 Maintenance and Replacement of Water Distribution System and Irrigation Infrastructure

Preventive maintenance and routine repairs would be performed on an as-needed basis on pumps and pipelines, diversion structures, irrigation canals and ditches, the SBIN, and drip irrigation equipment (inspections would occur more frequently).

6.5.3 Vector Control

Depending upon the duration and frequency of surface water flow in wetland and riparian habitat areas, the implementation of vector control management activities may be required to protect public health. Management activities that may be implemented to reduce potential habitat and inhibit the development of mosquito larvae include:

- Providing pulse flows/periodic flushes
- Removing vegetation to increase wind-driven circulation

- Scheduling irrigation to avoid creating shallow ponded areas
- Stocking mosquito fish in areas where a regular source of standing water is available
- Applying larvicides such as *Bacillus thuringiensis israeliensis* and *Bacillus sphaericus* would be applied by spraying at a frequency of every 2 to 4 weeks during the mosquito season
- Applying a broad spectrum adulticide such as Malathion in the event of an imminent public health threat

6.5.4 Sediment Removal

After periods of high flows in the river, substantial quantities of sediment may be deposited in channelized portions of the Salt River or in newly established habitat areas. To maintain the flow conveyance capacity of the river, channelized portions would need to be excavated and reshaped to restore design specifications if conveyance is significantly affected. Sediment removal would occur on an as-needed basis (inspections would occur more frequently). Sediments may also need to be removed to maintain the viability of areas vegetated for the project. This is anticipated to occur once each year on a rotating basis so that no more than 25 percent of the marsh area would be affected in any one year. The work would be performed outside the nesting season for birds. An estimated average of 50 cubic yards of sediment would be removed during each sediment removal event. This material would be provided to commercial sand and gravel operators for reuse or would be used in project repairs.

6.5.5 Maintenance Activities in Specific Areas

Maintenance activities in constructed wetlands would include performing work on outlets and berms to ensure proper functioning and to correct damage from beavers or other rodents that may colonize these areas. Saltcedar and other potentially invasive plant species would be removed on a periodic basis for the life of the project, since local seed sources would continue to be available. Vegetation removal would be done either by mechanical means or by burning in place. A burn permit would be required in the latter case.

Maintenance of cottonwood/willow areas would be limited to debris removal, minor saltcedar removal, minor grade adjustments, and replacement of plants if necessary. Work would not be performed during the nesting season for birds.

Maintenance in mesquite and Sonoran desert areas would consist of monitoring the success of vegetation establishment and replacing plants where necessary. Irrigation systems would need to be periodically inspected during the establishment period but may not be needed after establishment, except perhaps under excessive drought conditions.

6.6 Recreation Plan

The recreation component of the selected plan is designed to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy the study area's unique resource while developing an awareness, knowledge, and understanding of desert riparian habitat and its relationship to the surrounding environment. In addition, it presents an opportunity to acknowledge and understand the influence of the Salt River on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the study area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle, or on horseback.

In the recreation component, a 5.13-mile trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal.

The recreation plan would include trail head signage, three parking lots, mileage markers, educational plaques along the trail system, concrete benches, rest stops, guard posts, and street crossing signage. It would also incorporate cost-shareable features of a proposed Cultural Center located within the footprint of the ecosystem restoration project. These include a restroom, habitat interpretive outdoor demonstration area, a 12'-by-12' ramada, a small parking lot, four picnic tables, trash receptacles, benches, and signs.

The estimated cost of the Recreation Plan is $1,374,700.

6.7 Associated Non-Federal Considerations

The non-Federal sponsors for the project would be required to purchase all lands, easements, rights-of-way and disposal costs (LERRD) needed for project implementation, currently estimated at $24,949,400. The non-Federal sponsors would be responsible for remaining implementation costs required to bring the total non-Federal share to 35 percent of the total first cost of construction. The non-Federal sponsors would also be responsible for Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs estimated at $131,000 per year, and associated costs for water supply currently estimated at $1,283,000 per year. The non-Federal sponsors would also be responsible for 50 percent of the cost to implement the selected recreation plan. Annual OMRR&R costs of $256,500 associated with the selected recreation plan would also be the non-Federal sponsors' responsibility.

6.8 Monitoring and Adaptive Management Plan

Monitoring and adaptive management consists of the examination of terrestrial and aquatic plantings for a period of five years following construction to ensure survival of all plants needed in the restoration effort. Plants that expire within this period would be replaced in-kind. Areas that exhibit high rates of die-off may be evaluated and adaptive measures undertaken to reestablish either more appropriate plant types, or to modify features of the project, such as irrigation rates or locations, to achieve appropriate and maximum habitat value for that area of the project. It is expected that monitoring, and potential modification of irrigation rates and locations may be required to ultimately achieve maximum habitat value, structure, and potential diversity. Appendix C of the EIS contains detailed information on the monitoring and adaptive management plan prepared for this project.

CHAPTER VII
PLAN IMPLEMENTATION

This chapter summarizes cost-sharing requirements and procedures necessary to implement the Recommended Plan.

7.1 Study Recommendation

The Recommended Plan provides the maximum National Ecosystem Restoration (NER) benefits, while achieving the stated project objectives, and while meeting the criteria established by the study team and Federal Procedures and Guidelines. Because of its highly positive environmental contribution to restoration within the study area, the Recommended Plan is recommended for implementation.

7.2 Division of Plan Responsibilities

The Water Resources Development Act (WRDA) of 1986 (P.L. 99-662) and various administrative policies have established the basis for the division of Federal and non-Federal responsibilities in the construction, maintenance, and operation of Federal water resource projects accomplished under the direction of the Corps of Engineers. Anticipated Federal and non-Federal responsibilities are described in this section. The final division of specific responsibilities will be formalized in the project cooperation agreement (PCA).

7.2.1 Federal Responsibilities

The estimated Federal share of the total first cost of the project is 65 percent of first costs [first costs are all costs to implement project less lands, easements, rights-of-way, relocations, and disposals (LERRD) and O&M costs]. The Federal government responsibilities are anticipated to be:

a. Design and prepare detailed plans and specifications.

b. Administer contracts for construction and supervision of the project after authorization, funding, and receipt of non-Federal assurances.

c. Conduct all necessary cultural resource investigations and coordinate and implement any necessary preservation or mitigation measures.

d. Conduct periodic inspections with the non-Federal sponsor to determine adherence to the post-construction maintenance requirements

e. Identify the real estate needs for implementation of environmental work on Federal and private land.

7.2.2 Non-Federal Responsibilities

Non-Federal or local responsibilities are anticipated to be:

a. Provide 35 percent of the separable project costs allocated to ecosystem restoration and 50 percent of the separate project costs allocated to recreation, as further specified below:

   1. Enter into an agreement which provides, prior to execution of a project cooperation agreement for the project, 25 percent of design costs;

   2. Provide, during construction, any additional funds needed to cover the non-federal share of design costs;

   3. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

   4. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

   5. Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the separable project costs allocated to ecosystem restoration and 50 percent of the separable project costs allocated to recreation.

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State

laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

c. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

j. Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

l. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)).

m. Provide the non-Federal share of that portion of the costs of archeological data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with cost sharing provisions of the agreement;

n. Not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

o. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

p. For so long as the project remains authorized, provide the quantity of water for such periods that the Government determines is necessary to construct, operate, repair, replace, rehabilitate, and otherwise maintain the project.

7.3 Cost Apportionment

Cost sharing for construction of this project would be in accordance with applicable law whereby for environmental restoration projects, the non-Federal sponsor shall provide all lands, easements and rights-of-way, and dredged material disposal areas; provide relocations of bridges and roadways; provide alteration of utilities which do no not pass under or through the project's structure; and maintain and operate the project after construction. During the construction phase, the non-Federal sponsor shall contribute any additional funds as are necessary so that the non-Federal contribution would be at least 35 percent of total environmental restoration costs.

Table 76 provides a summary of project costs, apportioned between the Federal and non-Federal sponsors, for the recommended plan. The total project cost is currently estimated at $138,968,000 at October 2004 price levels, and at a current Federal discount rate of $5^5/_8$ percent. Based on the requirements of WRDA 1986, cost-sharing for ecosystem restoration features including provisions of all LERRDs would be 65 percent Federal and 35 percent non-Federal. Cost-sharing for recreation features would be 50 percent Federal and 50 percent non-Federal. Thus, the Federal share would be $90,128,560 and the non-Federal share would be $48,839,440.

USACE guidance (ER 1105-2-100, Appendix E) specifies that the level of financial participation by the Corps in recreation development may not increase the Federal cost of the project by more than 10 percent. Recreation cost for this project is currently estimated at $1,337,600, approximately at one percent. The cost for all operations and maintenance would be the responsibility of the non-Federal sponsor. Operations and maintenance of the ecosystem restoration is currently estimated at $131,000 annually and $256,500 annually for the recreation component. In addition, all water rights and costs associated with providing water to the project shall be borne by the non-Federal sponsor. The value of this water has been estimated at $1,283,000 annually.

Table 76. Cost Apportionment – Recommended Plan

Item	Federal	Non-Federal	Total
Construction of Ecosystem Restoration Features*	70,425,550	37,921,450	108,347,000
Monitoring and Adaptive Management	2,817,100	1,516,900	4,334,000
LERRDs**	-	24,949,400	24,949,400
Total First Cost of Ecosystem Restoration	**73,242,650**	**64,387,750**	**137,630,400**
Cost Share Adjustment***	16,217,110	-16,217,110	
Total Cost-Shared Costs – Ecosystem Restoration	**89,459,760**	**48,170,640**	**137,630,400**
Percentage of Total Cost-Shared Amount – Ecosystem Restoration	*65%*	*35%*	
Total Cost-Shared Costs for Recreation	**668,800**	**668,800**	**1,337,600**
Percentage of Total Cost-Shared Amount – Recreation	*50%*	*50%*	
TOTAL FIRST COSTS	**90,128,560**	**48,839,440**	**138,968,000**
Total Percentage	*65%*	*35%*	
Annual OMRR&R			
Ecosystem Restoration	-	131,000	131,000
Recreation	-	256,500	256,500
Water Supply	-	1,283,000	1,283,000
Total Cost-Shared Annual OMRR&R Costs	**-**	**1,670,500**	**1,670,500**
Percentage of Total Cost-Shared Amount – Annual OMRR&R	*0%*	*100%*	

* Construction, S&A, PED/EDC, and Contingency; does not include IDC or annual OMRR&R

** Lands, easements, rights-of-way, relocations, and disposal areas

*** Non-Federal cost-shared amount exceeds the 35 percent requirement for ecosystem restoration projects. Adjustment to the first cost amounts results to the 65-35 percent cost-sharing requirement.

7.4 Current and Future Work Eligible for Credits

There is no current and future work planned or in construction which is part of the Corps' Selected Plans, or which would be eligible for Section 104 credit.

7.5 Institutional Requirements

Upon implementation of the cost-shared project, the non-Federal sponsor will prepare the following preliminary financial analysis.

a. Assess project-related yearly cash flows (both expenditures and receipts where cost recovery is proposed), including provisions for major rehabilitation and operational contingencies and anticipated but uncertain repair costs resulting from damages from natural events.

b. Demonstrate ability to finance their current and projected-future share of the project cost and to carry out project implementation operation, maintenance, repair, and rehabilitation responsibilities.

c. Investigate the means for raising additional non-Federal financial resources including, but not limited to, special assessment districts.

d. Complete any other necessary steps to ensure that they are prepared to execute their project-related responsibilities at the time of project implementation.

7.6 Environmental Requirements

7.6.1 National Environmental Policy Act

The National Environmental Policy Act ensures public involvement and notification of a proposed project. An initial public meeting was held on January 24, 2002, and a final public meeting was held on June 3, 2004. Multiple public workshops, information sessions, and meetings were also held as part of the scoping process. Details can be found in Chapter 11 of the Final Environmental Impact Statement (FEIS).

7.6.2 Endangered Species Act

Endangered Species Act, Section 7 informal consultation was completed during the production of the study's FEIS. The U.S. Fish and Wildlife Service concurs with a determination of "may affect, not likely to adversely affect" for the Yuma clapper rail, southwester willow flycatcher, cactus ferruginous pygmy owl, California brown pelican, and bald eagle. This concurrence ends the Section 7 consultation process. Details can be found in Appendix F of the FEIS.

7.6.3 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) Report provided by the U.S. Fish and Wildlife Service listed six recommendations for implementing Alternative O. These include the following:

1. Pursue efforts to secure effluent and groundwater as a source of water to support vegetation.

2. Consider opportunities to provide additional surface water to the project area directly from the Salt and Verde Rivers through local coordination.

3. Perform assessments to ensure that site-specific micro habitat conditions are conducive to establishment and growth of planned vegetation types.

4. Complete Section 7 consultation and implement any conservation measures developed.

5. Encourage the non-Federal sponsors to work with the USFWS to evaluate the need for Safe Harbor Agreements, etc.

6. Work with the USFWS and Arizona Game and Fish Department on a programmatic basis to simplify the HGM methodology for future restoration within the State of Arizona.

Several of these recommendations have been considered or completed during the planning process (e.g., investigate effluent, groundwater, and surface water from the Salt and Verde Rivers; complete Section 7 consultation; encourage local sponsors to seek a Safe Harbor Agreement). Other recommendations will be implemented during the PED phase.

7.6.4 Clean Water Act, Section 404(b)(1)

The Selected Plan would result in discharge of fill material into waters of the United States during the period of construction. It also may result in discharges associated with operation and maintenance activities. A Section 404(b)(1) evaluation has been prepared to address practicable alternatives. Appendix A of the EIS presents detailed information on the Section 404(b)(1) evaluation. An NPDES permit will also be required for any water discharged to the river.

The EIS includes a 404(b)(1) analysis as part of the feasibility study. Based on this analysis, the feasibility report recommends that the project receive a 404(r) exemption, when Congress authorizes the project. The 404(r) exemption would cover both the construction period and the operation and maintenance activities, for as long as the project remains authorized.

7.6.5 National Historic Preservation Act

An archeological field survey of the proposed project Area of Potential Effects (APE) has been conducted in accordance with the National Historic Preservation Act of 1966 (36 CFR 800). If cultural resources are discovered during construction and cannot be avoided, work will be suspended in that area until the properties are evaluated for eligibility for listing in the NRHP in consultation with the Arizona State Historic Preservation Officer (SHPO). If the properties are determined to be eligible for the NRHP, the effects of the proposed construction will be taken into consideration in consultation with the SHPO; the Advisory Council on Historic Preservation will be provided the opportunity to comment in accordance with 36 CFR 800.11.

Mitigation measures and environmental commitments are presented in Chapter 8 of the EIS.

7.7 Sponsorship Agreements

The Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa, Arizona, have provided a Letter of Intent acknowledging sponsorship requirements for the Va Shly'ay Akimel Salt River Restoration Project. Prior to the start of construction, the non-Federal sponsor will be required to enter into an agreement with the Federal Government that it will comply with Section 221 of the Flood Control Act of 1970 (P.L. 91-611), and the Water Resources Development Act of 1986 (P.L. 99-662), as amended.

7.8 Procedures for Implementation

Future actions necessary for authorization and construction of the Selected Plan are summarized as follow:

a. This report will be reviewed by the Headquarters of the U.S. Army Corps of Engineers, Washington, D.C.

b. The Chief of Engineers will seek formal review and comments by the Governor of the State of Arizona and interested Federal agencies.

c. Following State and Agency review, the report will be sent to the Assistant Secretary of the Army for Civil Works.

d. Upon approval of the Assistant Secretary, the report will be forwarded to the Office of Management and Budget (OMB) to obtain the relationship of the project to programs of the President.

e. The final report of the Chief of Engineers will then be forwarded by the Assistant Secretary of the Army for Civil Works to Congress.

f. Congressional review of the feasibility report and possible authorization of the project would follow.

g. Pending project authorization for construction, the Chief of Engineers could include funds, where appropriate, in his budget requests for preconstruction engineering and design of the project. The objective is to ready each project for construction start established with the feasibility study.

h. Following receipt of funds, preconstruction engineering and design would be initiated and surveys and detailed engineering designs would be accomplished.

i. Following Congressional authorization of the project, plans and specifications would be accomplished by the District Engineer.

j. Subsequent to appropriation of construction funds by Congress, but prior to construction, formal assurances of local cooperation would be required from non-Federal interests.

k. Bids for construction would be initiated and contracts awarded.

CHAPTER VIII
SUMMARY OF COORDINATION AND PUBLIC VIEWS

8.1 Non-Federal Views and Preferences

The non-Federal views and preferences regarding environmental restoration measures, and the problems they addressed, in general were obtained through coordination with the local sponsor and with the other various local and regional public agencies, community activists, resource conservation groups, and the general public. These coordination efforts consisted of a series of public meetings held during the reconnaissance and feasibility phases, through surveys, through the maintenance of a point-of-contact that any interested party could discuss matters with, and a mailing list by which invitations to public meetings were distributed. Announcement of public meetings was made in local newspapers, giving date, time, place, and subject matter.

8.2 Views of Non-Federal Sponsor

The Salt River Pima Maricopa Indian Community and the City of Mesa have expressed willingness in continuing to be non-Federal sponsors for project implementation. Both have indicated support for the project and willingness to assume cost-shared financial obligations for its implementation. A Letter of Support acknowledging sponsorship requirements for the Va Shly'ay Akimel Salt River Project is presented as Figure 56.

The non-Federal sponsors generally support the results of the feasibility study. The non-Federal sponsors' interest in implementing environmental restoration solutions for the Va Shly'ay Akimel Salt River area is reflected by their willingness to enter into a cost-shared feasibility study to determine Federal interest. There currently exists within the community, and with the non-Federal sponsors, significant interest for providing environmental restoration solutions and recreation opportunities for the Va Shly'ay Akimel Salt River area.

8.3 Summary of Study Management, Coordination, Public Views, and Comments

The study team consisted of a multi-disciplinary group of several functional elements of the Corps and the non-Federal sponsors. The team included project managers, planners, hydrologic and hydraulic engineers, environmental specialists, cost estimators, designers, economists, appraisers, geotechnical specialists, real estate specialists, archeologists, and landscape architects.

The study was coordinated with a variety of agencies, interest groups, and individuals. Feedback from the public was incorporated in the plan formulation and evaluation process. Additional public views are summarized in the EIS.

Figure 56. Letter of Support from the Local Sponsor

April 28, 2004

Colonel Richard G. Thompson
United States Army Corps of Engineers
915 Wilshire Boulevard, Suite 14P00
Los Angeles, California 90017

Re: Letter of Support for the Va Shly'ay Akimel Recommended Plan
Va Shly'ay Akimel, Salt River Ecosystem Restoration Feasibility Study
Salt River Pima-Maricopa Indian Community and the City of Mesa, Arizona

Dear Colonel Thompson:

The Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa, as local sponsors, extend our support for the recommended plan contained in the Va Shly'ay Akimel Salt River Ecosystem Restoration Feasibility Report as an appropriate measure to restore riparian habitat to the Salt River. A majority of habitat has been lost due to urban development and construction of upstream water supply dams that have significantly altered the perennial flow from the Granite Reef Dam downstream through the lower Salt River. The project is located within the jurisdictions of the SRPMIC and the City of Mesa, along the Salt River between Granite Reef Dam and State Route 101.

This restoration project is consistent with the SRPMIC's and City of Mesa's overall goals for protection and restoration of our natural resources. Following the opportunity to review the public response to the recommended plan during the review period of the Draft Feasibility Document and the Draft Environmental Impact Statement, the SRPMIC and the City of Mesa are prepared to move forward, as the local sponsors, with the U.S. Army Corps of Engineers to design the Va Shly'ay Akimel Salt River Ecosystem Restoration project. Anticipating Congressional authorization of the project, the sponsors are prepared to commit to their local share of 25% of preconstruction engineering and design (PED) costs.

The sponsors will assume their obligation to acquire all Lands, Easements, Rights of Way, Relocations and Disposal areas and upon completion of construction, operate and maintain the project. We are prepared to meet our financial obligations to ensure completion of this project and look forward to executing an agreement for the Design phase of the Va Shly'ay Akimel project.

Sincerely,

Bryan Myers
Community Director
Salt River Pima Maricopa Indian Community

Mike Hutchinson
City Manager
City of Mesa

CHAPTER IX
RECOMMENDATIONS

I recommend that the plan herein for environmental restoration and recreation be authorized for implementation as a Federal project. The total first cost of the project is currently estimated at $138,968,000 under October 2004 prices ($137,630,400 for ecosystem restoration and $1,337,600 for recreation). The Federal share is currently estimated at $90,128,560 ($89,459,760 for ecosystem restoration and $668,800 for recreation).

I recommend that the plans recommended herein be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Act. The 404(r) will cover the construction phase and the operation and maintenance phase of the project, as described in the feasibility report and EIS.

My recommendation is subject to cost-sharing, financing, and other applicable requirements of Federal and State laws and policies, including Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, and in accordance with the following requirements, which the non-Federal sponsor must agree to prior to project implementation.

a. Provide 35 percent of the separable project costs allocated to ecosystem restoration and 50 percent of the separate project costs allocated to recreation, as further specified below:

    1. Enter into an agreement which provides, prior to execution of a project cooperation agreement for the project, 25 percent of design costs;

    2. Provide, during construction, any additional funds needed to cover the non-federal share of design costs;

    3. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

4. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

5. Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the separable project costs allocated to ecosystem restoration and 50 percent of the separable project costs allocated to recreation.

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

c. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project and otherwise perform its obligations in a manner that will not cause liability to arise under CERCLA.

j. Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

l. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly

40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)).

m. Provide the non-Federal share of that portion of the costs of archeological data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with cost sharing provisions of the agreement;

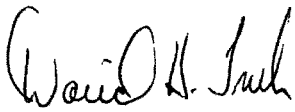
n. Not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

o. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

p. For so long as the project remains authorized, provide the quantity of water for such periods that the Government determines is necessary to construct, operate, repair, replace, rehabilitate, and otherwise maintain the project.

The plans presented herein are recommended with such modification thereof as in the discretion of the Commander, HQUSACE, may be advisable.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified as needed.



David H. Turk
Colonel, Corps of Engineers
District Engineer

CHAPTER X
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Volume 3 of 4 - Final Feasibility Report Technical Appendices

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Coordinated by:

U.S. Army Corps of Engineers
South Pacific Division
Los Angeles District

In partnership with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

FINAL FEASIBILITY REPORT
TECHNICAL APPENDICES

VOLUME 2 OF 4

LIST OF TECHNICAL APPENDICES

APPENDIX A HYDRAULICS AND HYDROLOGY
APPENDIX B WATER BUDGET ANALYSIS
APPENDIX C INTERIOR DRAINAGE
APPENDIX D GROUNDWATER MODEL
APPENDIX E GEOTECHNICAL
APPENDIX F DESIGN
APPENDIX G COST

APPENDIX

A

HYDRAULICS AND HYDROLOGY

INTRODUCTION 1
Purpose 1
Description of Study Area 1

DISCHARGE – FREQUENCY ANALYSIS 3

RUNOFF DISCUSSION 5

GROUNDWATER DISCUSSION 7

STUDY METHODOLOGY 10
Analysis Tool 10
Hydrology and Design Discharges 10
Determination of Manning's Roughness Coefficients 10
Environmental Features 10
Structural Features 11

HYDRAULIC ANALYSES & RESULTS 18
Without Project 18
Model 1 – Existing Conditions 18
Model 2 – Future Without Project 20
With Project 21
Model 3 – With Project (Alternative E) 21
Model 4 – With Project (Alternative F) 25
Model 5 – With Project (Alternative A) 28
Model 6 – With Project (Alternative N) 30
Model 6 – With Project (Alternative O) 30

SEDIMENT ANALYSIS 37
Without Project 37
With Project 38

GEOMORPHOLOGY DISCUSSION 44

RISK AND UNCERTANITY ANALYSIS 47

OPERATION AND MAINENANCE 48
Maintenance Considerations 48
Vegetation Damage 50

PERFERRED ALTERNATIVE 51

SUMMARY 57

REFERENCES 58

INTRODUCTION

Purpose

1. The purpose of this appendix is to document the hydrologic and hydraulic analyses completed in support of the Va Shly'ay Akimel Feasibility Study. The goals of the hydraulic analysis were to develop a one-dimensional model of the Salt River study area and model the conditions associated with the Existing Condition, Future Without Project Condition and the conditions associated with selected With Project alternatives.

Description of Study Area

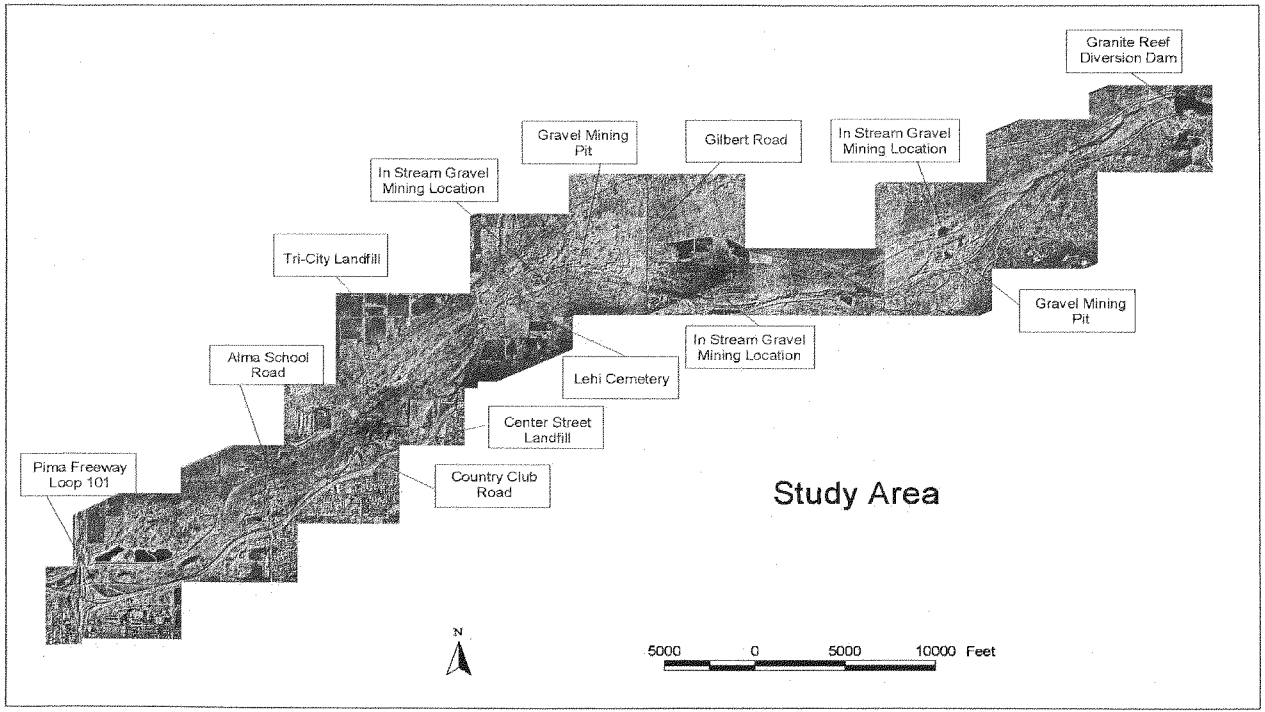
2. The Va Shly'ay Akimel study area is located within Maricopa County in central Arizona, the area has a general east to west orientation. The study area includes the section of the Salt River that begins at Granite Reef Diversion Dam (Granite Reef Dam) on the east side of the study area and extends downstream to the west for a distance of approximately 15 miles to the Pima Freeway (State 101), Figure A-1.

3. The majority of the study area is within the jurisdiction of the Salt River Pima-Maricopa Indian Community (SRPMIC). A portion of the project is within the jurisdiction of the City of Mesa located in the southwest part of the study area.

4. The channel of the Salt River within the study area contains several active and historic sand and gravel mining pits. There are active and inactive landfills along the north bank and there are storm drains and irrigation drains that discharge to the channel. Salt River Project (SRP) operates the Granite Reef Underground Storage Project (GRUSP) on the Salt River overbank area in the central part of the study area and the City of Mesa operates a recharge project on the west end of the study area.

5. The Salt River was a perennial stream until the construction of upstream dams, with associated reservoirs, regulated the flow. There are four dams on the Salt River and two dams on the Verde River, a tributary to the Salt River. These structures have changed the hydrologic condition of the Salt River below Granite Reef Dam into an ephemeral river. Granite Reef Dam is a diversion structure, not a water storage or flood control structure. This dam diverts the flow in the Salt River into two major irrigation canals, the Arizona Canal on the northside and the Southern Canal on the southside. Flows only occur through the study area when there are flood releases from the upstream reservoirs. The flood flows vary in duration, quantity and magnitude depending on the nature of the flood releases.

Figure A-1. VaShly Akimel study area map (West, 2002).



DISCHARGE – FREQUENCY ANALYSIS

DISCHARGE-FREQUENCY ANALYSIS

6. The Salt River is characterized by infrequent events, spilling over, on average, once every three years. The maximum rate of flow for each event was determined based upon a water control plan developed for the flood control pool at Modified Theodore Roosevelt Dam. The analysis is described in Corps of Engineers report prepared by the Los Angeles District, (USACE, 1996a). The following table shows the maximum discharge simulated for historic flow events from 1914 to present.

Table A-1. Summary of Simulated Salt River Flows.

Period of Flow Start Date	Period of Flow End Date	Flow Event Maximum Daily Average Flow (cfs)
2/7/1914	7/2/1914	15,800
1/29/1915	8/18/1915	18,700
1/15/1916	5/15/1916	79,100
9/8/1916	2/4/1917	21,100
4/17/1917	5/15/1917	23,400
3/7/1918	3/26/2018	28,400
11/25/1919	13/14/1919	46,200
1/4/1920	4/25/1920	87,800
12/26/1921	1/9/1922	24,100
2/8/1922	2/18/1922	10,000
3/16/1922	4/10/1922	18,000
9/18/1923	9/22/1923	24,100
12/26/1923	1/8/1924	42,800
3/31/1926	4/16/1926	28,800
2/14/1927	3/19/1927	49,800
9/12/1927	9/20/1927	16,200
4/4/1929	4/19/1929	17,200
2/12/1931	2/20/1931	22,900
2/9/1932	3/29/1932	48,700
2/6/1937	3/25/1937	36,981
2/28/1939	3/17/1939	58,739
2/5/1941	5/25/1941	32,206
12/21/1965	1/12/1966	64,000
2/20/1973	6/5/1973	22,273
2/28/1978	4/11/1978	95,800
12/16/1978	4/19/1979	110,000
1/29/1980	6/3/1980	137,725
2/2/1983	6/17/1983	30,000
9/27/1983	10/24/1983	39,878
12/24/1983	1/24/1984	11,200
12/21/1984	6/1/1985	25,604
12/22/1991	6/21/1992	12,898
8/21/1992	9/8/19992	13,615
12/28/1992	6/4/1993	99,396
1/20/1995	5/2/1995	53,316

DISCHARGE – FREQUENCY ANALYSIS

7. A flow frequency distribution was developed the Salt River Watershed under dammed, (USACE 1996a). The following table summarizes the discharges that were analyzed for the models. Change in flow is due to storage within floodplain.

Table A-2. Flow Frequency for Salt River.

Return Period	Flow at CP – 40 in ft^3/s (upstream limit at River Station 13.64)	Flow at CP – 109 in ft^3/s (River Station 7.55 just upstream of Gilbert Road)
3-Year	2,200	2,200
5 – Year	22,000	21,000
10 – Year	60,000	58,000
20 – Year	100,000	95,000
50 – Year	150,000	145,000
100 – Year	175,000	172,000
200 – Year	210,000	207,000
500 - Year	250,000	246,000

8. The average rainfall for the Phoenix area is summarized on the following table. Climate data for Phoenix is recorded at Phoenix Sky Harbor Airport located seven miles west of the downstream section of the Va Shly'ay Akimel project area. Summer thunderstorms can produce local precipitation that exceeds the monthly average and results in local flooding of streets, drainage channels and washes. The intensity and duration of the precipitation varies depending on the location of the individual storm cells. A maximum amount of rainfall at Sky Harbor from a storm may be greater or less than the amount that occurs within the project area

Table A –3. Rainfall Pattern for the Phoenix Area

Month	Rainfall in Inches
January	0.67
February	0.68
March	0.88
April	0.22
May	0.12
June	0.13
July	0.83
August	0.96
September	0.86
October	0.65
November	0.66
December	1.00
Annual Total	7.66

RUNOFF DISCUSSION

RUNOFF DISCUSSION

9. The winter months are typically when large regional storms or series of storms occur. These storms may include an accumulation and subsequent melt of the snow pack in the Salt River and Verde River watersheds and result in the releases of water into the Salt River system that can flow over Granite Reef Dam into the study area. While the river stages may be high for an extended period, the quantity and intensity of accompanying storm precipitation is generally reduced in the lower elevations, including the study area.

10. During the middle to late summer months the monsoon storm pattern is typical. These storms produce intense, short-duration thunderstorms with significant precipitation. During these storms the river stages are low because the storms are localized and because the upstream reservoirs usually have the capacity to store the local runoff from the watershed.

11. Interior drainage is an assessment of the storm water runoff that accumulated on the up gradient side of levees. The Va Shly'ay Akimel does not include levees and this means there are no interior drainage conditions to address. A report was completed to assess the interior drains, or side drains, that outfall into the Salt River within the study area (Knight Piésold, 2002b). These drains were evaluated to assess the potential damage that frequent inundation or high discharge velocities may cause to the restored habitat and the potential to use this water to support the restored vegetation. Canal drains and storm drains were the two types of interior drains identified that outfall into the Salt River.

12. Canal drains release water from the major SRP canals and discharge to the Salt River as an operational mechanism to control flow in the canal system. The Evergreen Drain and Hennessey Drain are canal drains and do not intercept a significant amount of storm water runoff. The peak flow rates in these canal drains are governed by the amount of water that SRP releases into the drain from the irrigation canal and not by storm events.

13. The Evergreen Drain is associated with the Evergreen Canal. The canal is operated by the SRPMIC and the drain is operated by SRP. This drain is located on the north side of the Salt River. The peak flow rate for the Evergreen Drain between 1992 and 2001 was 313 ft^3/s.

14. The Hennessey Drain is located on the southside of the Salt River. It is operated by SRP and currently is used to provide water to the GRUSP recharge project in the riverbed. The peak flow rate for the Hennessy Drain between 1992 and 2001 was 846 ft^3/s.

15. Storm drains collect runoff generated by major storm events to protect developments from occasional nuisance flooding. Storm drainage flows vary in duration, quantity and intensity depending on the rainfall event. The most significant events occur during the summer months associated with the thunderstorms of the monsoon season. These localized storms can produce intense rainfall and generate significant local runoff.

RUNOFF DISCUSSION

16. The Price Drain intercepts storm runoff from a drainage area of approximately 31.2 square miles on the southside of the Salt River. The recorded maximum daily flow rate for the brief period of record in 2001 was 236 ft^3/s. The peak flow rate for the 100-Year storm event was estimate to be approximately 10,000 ft^3/s. However, the maximum capacity of the channel is 6,800 ft^3/s, which governs the maximum flow rate possible in this channel. This flow rate would generate a discharge velocity of 8.2 ft/sec.

17. The Tempe Drain intercepts storm runoff from a drainage area of approximately 10.0 square miles on the southside of the Salt River. The peak flow in this drain is governed by storm events in conjunction with canal releases. The recorded maximum daily flow rate for the period from 1992 through 2001 was 531 ft^3/s. However, the peak flow rate for the 100-Year storm event was estimate to be approximately 4,000 ft^3/s. The maximum capacity of the channel is 4,000 ft^3/s, and this would generate a discharge velocity of 8.0 ft/sec.

18. The remaining storm drains within the study area could generate peak flow rates as great as 300 ft^3/s with a discharge velocity of 10.6 ft/sec. The peak flow rates generated by the drainage areas for these drains may be greater than 300 ft^3/s. However, detention facilities and the maximum capacity of the outlet pipes govern the maximum discharge rate to the Salt River.

19. A summary of the average annual runoff (Knight Piésold, 2002b) is presented on the following table.

Table A-4. Storm Drain Average Annual Runoff Volumes
Runoff is in acre-feet

Interior Drain	Drainage Area (SqMi)	Month												Annual
		Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
Price Drain	31.2	195.7	201.5	257.0	64.3	35.0	38.0	242.4	280.4	251.2	189.8	192.8	292.0	2,240.0
Tempe Drain	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740.0
Price Road Freeway Local Drainage	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30.0
Dobson Road Storm Drain	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140.0
McLellan Road Storm Drain	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80.0
Country Club/McKellips Storm Drain	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300.0
Red Mountain Freeway Local Drainage	Not Known	Minimal												
Natural Drainage	2.0	Minimal												
Alma School Storm Drain	Not Known	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

GROUNDWATER DISCUSSION

GROUNDWATER DISCUSSION

20. Depth to the groundwater table varies throughout the study area as a result of the hydrogeologic conditions and dams constructed on the Salt and Verde Rivers. Granite Reef Dam was constructed to divert the Salt River flow into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the project area. Although not intended to be a storage reservoir, some water is retained up stream of the dam at all times. Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP reported that water seeps through the radial gates because the gates do not form a tight seal with the granite bedrock. The result is a continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records.

21. The local geology helps to maintain this seepage as a surface flow. A bedrock shelf overlain by a veneer of sedimentary materials extends downstream from Granite Reef Dam. The seepage is sufficient to saturate these alluvial sediments. This flow has been sufficient to establish and support abundant wetland vegetation. In addition, areas of open water provide riparian and aquatic habitat. This pattern continues for approximately one mile downstream.

22. The depth to the bedrock shelf rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream from Granite Reef Dam. As the bedrock depth increases, the surface flow that supports wetland vegetation upstream becomes subsurface water and part of the groundwater supply. Regional groundwater pumping resulted in a general lowering of the water table throughout the area from predevelopment conditions. In addition, dams located upstream on the Verde River and Salt River prevent perennial flow in the river channel and limit natural recharge. The result is that the general groundwater depth beneath the Salt River ranges from 50 ft at the recharge sites to approximately 175 ft south of Granite Reef Dam, Figure A-2. The majority of the study area has a depth to groundwater of 100 ft (Knight Piésold, 2002c).

Figure A-2. Groundwater depth in 2001 (Knight Piésold, 2002c).

GROUNDWATER DISCUSSION

23. There are two groundwater recharge projects in the study area that impact the groundwater table. SRP recharges water into the upper alluvial aquifer through the Granite Reef Underground Storage Project (GRUSP). SRP recharges approximately 90,000 acre-feet of water per year. The recharge basins cover approximately 216 acres of the river channel. SRP's recharge permit allows a maximum of 200,000 acre-feet per year. However, this would produce a groundwater mound that could impact other facilities and SRP limits the quantity of water recharged to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87. This results in a water level that is about 50 to 60 feet below the river channel in the immediate GRUSP area.

24. The second recharge project is located near the downstream end of the project area. Effluent from the Northwest Water Reclamation Plant (NWWRP), owned and operated by the City of Mesa, is discharged into a series of recharge ponds where the effluent is allowed to infiltrate into the Salt River sediments. Approximately 5,000 to 6,000 acre-feet of water is recharged annually into these ponds. The SRPMIC owns five ponds on the northside of the river totaling 75 acres; these ponds have received an average of 330 acre-feet of effluent each month. Mesa owns four ponds on the southside of the river totaling 27 acres; these ponds have received an average of 140 acre-feet of effluent. The groundwater mound produced by this recharge raises the local water table in this area to within 50 to 60 feet below the river bed.

STUDY METHODOLOGY

STUDY METHODOLOGY

Analysis Tool

25. The HEC River Analysis System (HEC-RAS), Version 3.1.1, was used for the modeling (USACE, 1998a). A series of eight flow profiles were developed for each model based on the 3, 5, 10, 20, 50, 100, 200 and 500 -Year Events.

Determination of Manning's Roughness Coefficient

26. The Existing Condition Manning's roughness coefficients ("n" values) were used for the initial channel conditions in the models. The USACE calculated the "n" value of the different environmental features by the procedure where "n" may be computed by:

27. $n = (n_0 + n_1 + n_2 + n_3 + n_4)m_5$

28. Where n_0 is a basic "n" value for a straight, uniform, smooth channel in the natural riverbed materials. Then n_1 is added to correct for the effect of the surface irregularities, n_2 is added to account for variations in shape and size of the channel cross-section, n_3 is added for channel obstructions and n_4 is a value added for vegetation and flow conditions. The m_5 value is to correct for the meandering of the channel. In this study the Existing Condition Manning's "n" value varied from 0.028 to as much as 0.2 (West, 2002).

Environmental Features

29. The Va Shly'ay Akimel study area has locations where there is existing vegetation supported by precipitation, seepage, periodic flood flows, stormwater runoff and irrigation discharges. The USACE developed 15 alternatives in the Feasibility Study F4 and the goals of the alternatives were to increase the native riparian vegetation, increase the vegetation connectivity and stabilize bank sections where needed. A mixture of five environmental features are included in the With Project alternatives. These include: Cottonwood/Willow, Mesquite, Wetlands, Upper Sonoran Desert and River Bottom.

30. Cottonwood/Willow (CW). The existing CW stands are located near saturated soil conditions near river overbank areas. CW a water table within 25 feet of the land surface or supplemental irrigation will be required to support the vegetation. Initial plantings will require irrigation to achieve a high survival rate. Once established, CW areas will need drip irrigation or water from the Surface Braided Irrigation Network (SBIN) to supply water. Uneven grading of the river bottom and overbank areas to create pockets to retain water will help maintain the CW. In the model, the CW areas were assigned an "n" value of 0.098.

31. Mesquite (MS). The MS vegetation is commonly located about 5 to 20 feet above the river channel. The water table must be within 30 feet of the surface to support established MS. Irrigation will be needed to help the MS get established but then flood irrigation or

STUDY METHODOLOGY

water from the SBIN will support the vegetation. In the model, MS was assigned an "n" value of 0.073.

32. Wetlands (WT). The WT areas can include open water, submerged vegetation and muddy shorelines. These features require a high water table at or near the surface or may need to be lined to retain water from other sources. The WT features will require excavation in the riverbed to construct the basins and this changes the configuration of the channel bed. Some WT features may need both inflow and outflow channels. The WT areas were assigned an "n" value of 0.048.

33. Sonoran Desert (SD). The SD includes a wide range of vegetation species and the species developed in any area will be dependent on the aggregate soil type. Once established, precipitation and periodic floods will maintain the SD. The "n" value assigned to SD was 0.058.

34. River Bottom (RB). RB will require some reshaping to fill in large depressions and to create mounds to reduce flood flow impacts to the restoration features. The RB areas may be hydro-seeded with native river bottom shrub and grass species but this vegetation should not impact the hydraulic capacity of the river. The "n" value assigned for RB was 0.035.

Structural Features

35. There are several structural features within the study area including bridges, grade control structures and sand and gravel mining operations.

36. There are three bridges in the study area at Alma School Road, Country Club Road and Gilbert Road. There is a grade control structure downstream of the Alma School Road Bridge.

37. There are active sand and gravel mining pits in the channel and on the overbank within the study area. The pits in the channel are located at River Station 6.4 about one mile downstream from the Gilbert Road Bridge, at River Station 8.0 about one mile upstream of the Gilbert Road Bridge and at River Station 10.5 about three miles upstream of the Gilbert Road Bridge. There are two sand and gravel mining operations on the overbank area; located 800 feet downstream from the Gilbert Road Bridge and about three miles upstream of the Gilbert Road Bridge.

38. Additional structural features were incorporated in the alternatives when necessary. These structural features include: low flow channel, buried guide dikes, bank stabilization, grade control structure, wetland creation, concrete spillways and surface braided irrigation network. The structural descriptions provided are only preliminary and will be developed more thoroughly, if necessary, during the Preliminary Engineering and Design Phase (PED).

STUDY METHODOLOGY

Low Flow Channel

39. A low flow channel was included in the design along two segments of the Salt River, River Station 9.6 to 7.65 and 4.4 to 2.2. Purposes of the channel were to increase conveyance to offset the increased roughness caused by new vegetation proposed in the main channel and to collect excess irrigation water that could be used to irrigate wetland habitat and river bottom areas. The low flow channel was designed to convey 11,000 ft^3/s (corresponding recurrence interval is greater that the 3-Year event but less than the 5-Year). Initial channel dimension were: average bottom width of 300 feet to 400 feet, average depth of 6 feet, design slope of 0.2%, side slope of 1 vertical for 3 horizontal and a channel Manning's roughness coefficient of 0.035. A 200 foot buffer was included on both sides of the channel to allow for lateral migration. The low flow channel configuration followed the existing river thalwag. Initially the channel design was unlined to allow lateral migration. The low flow channel was included in alternatives F, I and O.

Distribution Channel

40. A distribution channel was designed to convey irrigation water from the source points to vegetated areas throughout the project area. Alternatives H, B, C, E and G include the distribution channel in their design. The channel consists of a lined, 40 feet wide, 3.5 feet deep channel with a slope of 0.01%. Segments of the channel will be damaged during river flow events.

Buried Guide Dikes

41. Buried guide dikes are used to control lateral migration of the low flow channel. Guide dikes were only recommended for Alternative I. The guide dikes are trapezoidal soil cement structures buried perpendicular to the low flow channel. The guide dikes will have a top width of 5 ft, bottom width of 20 ft, and have an average length of 700 ft. The length of the guide dikes will depend on the position of the guide dikes with respect to the second terrace. A longitudinal spacing of 1,000 ft was included in the analysis. The preliminary design for the buried guide dikes was based on a previous design, Rio Salado Restoration Project. In addition, engineering judgment, an initial analysis of the channel configuration and morphology and a conservative approach, were all taken into account when estimating the size and location of the structures.

Bank Stabilization

42. Bank Stabilization was evaluated for locations along the project area where the bank appeared unstable, prone to erosion caused by lateral migration of the channel and required protection to prevent damage to project features or existing structures (Gilbert Road Bridge). All alternatives have bank stabilization components included in the design except alternatives A, K, N and O.

43. Locations 22, 51, 52, 53 and 62 were considered for stabilization, Figure A-3.

STUDY METHODOLOGY

1) Location 22, bank erosion appears to be a problem along south bank because of the existing channel configuration in this reach. Hard banking the south bank with soil cement, as shown on Figure A-3, is recommended to prevent a southerly migration of the river and damage to project features and to the 101 Freeway. Soil cement bank protection will be 3,000 feet long, 40 feet tall (height) and 6 feet in depth (thickness).

2) Location 51 may require bank stabilization because of the elevation difference between the main channel and the quarry pit invert. It is possible that without sufficient bank stabilization, the river may migrate north into the quarry pit. This could cause head cutting which would impact Gilbert Road Bridge, (West, 2002), and produce scouring downstream that could damage both a nearby landfill and several project features. The quarry needs to be reshaped, the existing north banked stabilized and a spillway should be constructed to allow water to flow into the quarry area to prevent these impacts from occurring. The surface water re-connection of the quarry would provide minimal flood mitigation, increase river bottom, increase groundwater recharge and provide more suitable conditions to establish CW, SD and MS. The soil cement bank protection will be 6,500 feet long, 30 feet tall (height) and 6 feet in depth (thickness). It is important to remember that because the mining operations continue within the river channel, sediment deposition, areas of erosion and excavation locations are continually changing.

3) Location 52 lies along the south bank of Reach 5 extending from downstream of Gilbert Road to Lehi Cemetery. The Lehi Cemetery is a culturally sensitive area that is being threatened by erosion along the southern bank of the river. This is also the site proposed for several project features in some alternatives. Cottonwood and other dense riparian vegetation would reduce conveyance and shear stresses along the south bank and prevent the erosion from continuing to threaten both the cemetery and the newly established vegetation. The reduced conveyance will, however, force more flow north of the island, potentially causing erosion and requiring additional widening or deepening of the main channel. The structure would be 5,000 feet long, 30 feet tall (height) and 6 feet in depth (thickness).

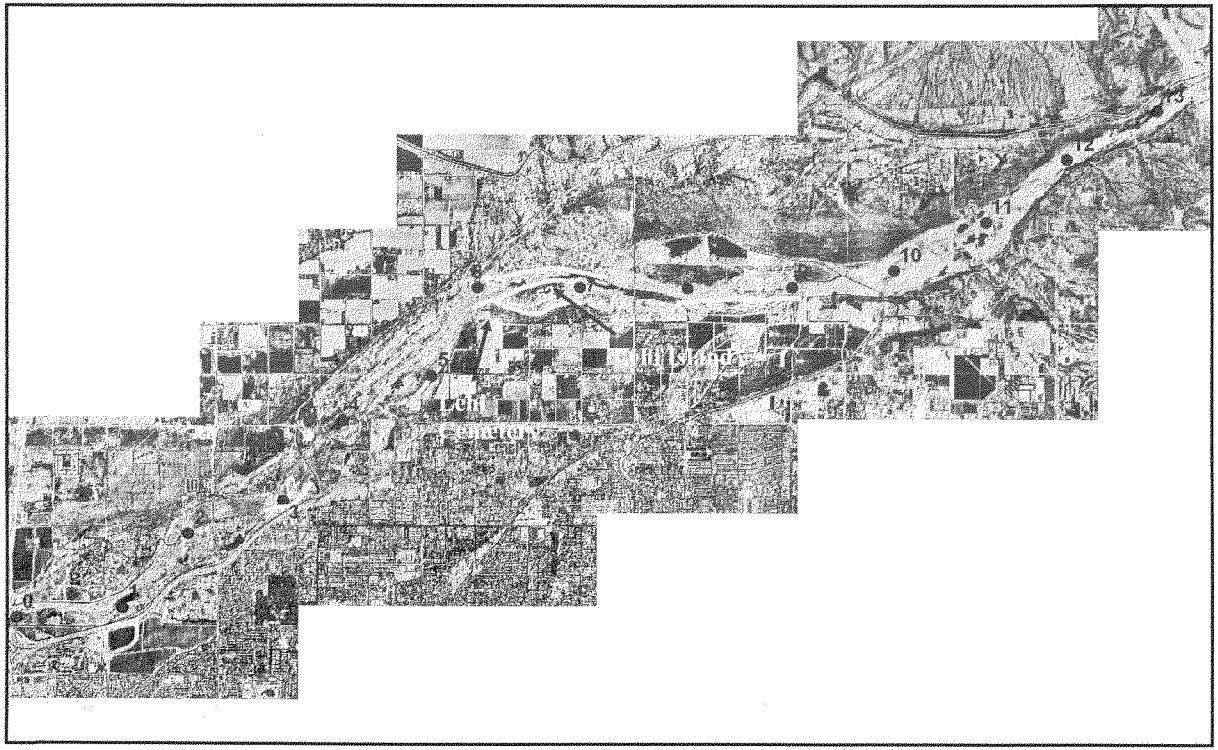
   Active mining in the main channel downstream of Gilbert Road has increased the conveyance in the channel this could reduce stresses that caused the bank erosion around Lehi Cemetery. Analyses may show that lowering the main channel increases conveyance reducing shear stresses along the south bank, eliminating the need for bank stabilization along Location 52. Soil cement, although not recommended for this location, should be examined. In addition, mining may necessitate the need for protection along the north side of the Lehi Island, Figure A-3.

STUDY METHODOLOGY

4) Location 53, bank stabilization may be necessary to offset erosion concerns along the north side of the island caused by mining. The soil cement bank protection for Location 53 is 5,500 ft long, 30 ft tall (height) and 6 feet in depth (thickness).

5) Location 62 lies along the south bank between River Station 8.98 and 8.1. An old quarry on the south bank, with a maximum depth below riverbed of 40 ft, is oriented such that the quarry pit could encourage the river to be redirected south into the pit, causing bank erosion along the south bank and a headcut migration upstream and down cutting downstream of the quarry (West, 2002). The headcut would adversely affect any attempts of vegetation establishment within Reach 6 and may affect the Gilbert Road Bridge. There are two measures that could be applied to prevent this from occurring. First, it is recommended that the pit be partially filled with material and second, that the south bank be reestablished north of the quarry, with the riverside hard banked.

Figure A-3. Bank stabilization locations (yellow) and river stations (red).



STUDY METHODOLOGY

Grade Control Structure

44. Mining along the Salt River within the project area has created large depressions with active area of flow conveyance and sediment transport. The large depressions alter the hydraulic conditions encouraging scouring upstream and downstream of the depressions and bank instability. Quarry locations are shown in Figure A-1. Gilbert Quarry, located between River Station 7.32 to 6.4 approximately 20 to 30 ft bellow the existing channel bottom creating a steep vertical drop from the river to the quarry. Head cutting upstream is a likely scenario that would damage project features located upstream of the Gilbert Road Quarry refer to the without project sedimentation analysis (West, 2002). A grade control structure was recommended to prevent this scenario from occurring, Figure A-4. A description of this feature is discussed in Design and Cost Appendix. A grade control structure was included in Alternatives D, F, L, K, N and O.

Figure A-4 Grade Control Structure Location.

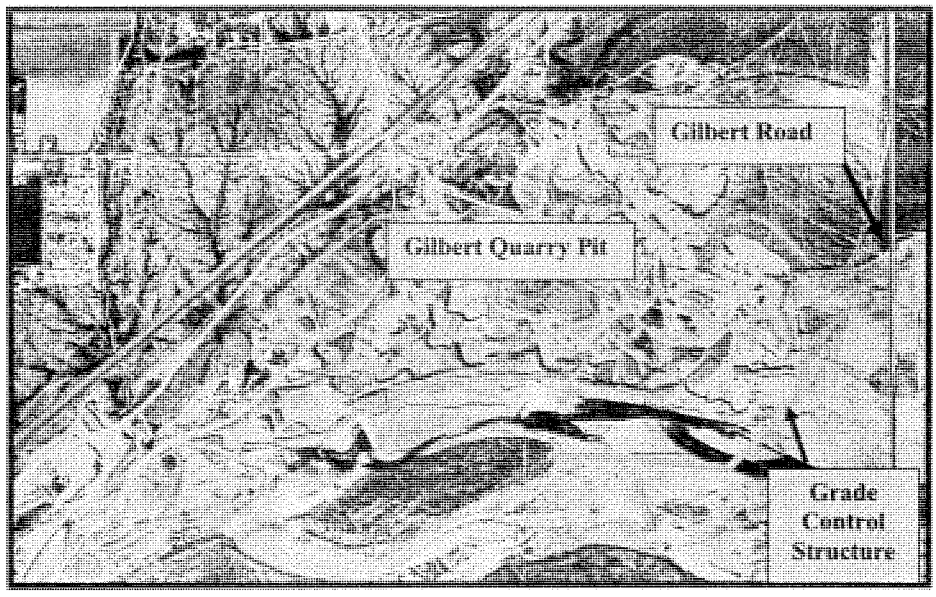


Figure A-5. Longitudinal Profile for the Salt River (West, 2002).

Hydraulic Analysis

HYDRAULIC ANALYSIS

45. West consultants completed a hydraulic analysis of the existing and future without project conditions using HEC-RAS (West, 2002). The hydraulic analysis was based on a digital terrain model generated from aerial survey's completed in December of 2001. The results generated for the West existing model were referred to as Model 2. Since December 2001, additional mining has changed the terrain along the Salt River, specifically in the Gilbert Road Quarry area. Mining operators have also informed the USACE study team that mining will continue in the future at both Gilbert Road Quarry and at the Higgley Plant, see Figure A-1. Assuming that additional mining will continue, the hydraulic model developed by West was modified to take into account the mining. It was assumed that mining would lower the riverbed elevation from River Station 7.3 to 6.0, within the Gilbert Road Quarry area. The USACE project team and sponsors developed an initial series of 15 alternatives, identified as alternatives A through O, for the Va Shly'ay Akimel project based on the mining assumption. The 15 alternatives were evaluated using the Hydro-Geomorphic Model (HGM) to assess habitat values, from which five preferred alternatives were chosen. The baseline model was then modified to assess each of the five preferred alternatives impact on existing hydraulic conditions. These are Alternative A, Alternative E, Alternative F, Alternative N and Alternative O. In all, eight models are discussed in this report, Table A-5.

Table A-5. Hec-Ras models and description.

Hec Ras Model	Description
11	Baseline
9	Alt O
6	Alt N
5	Alt A
4	Alt F
3	Alt E
2	Future Without Project
1	West Existing

Without Project

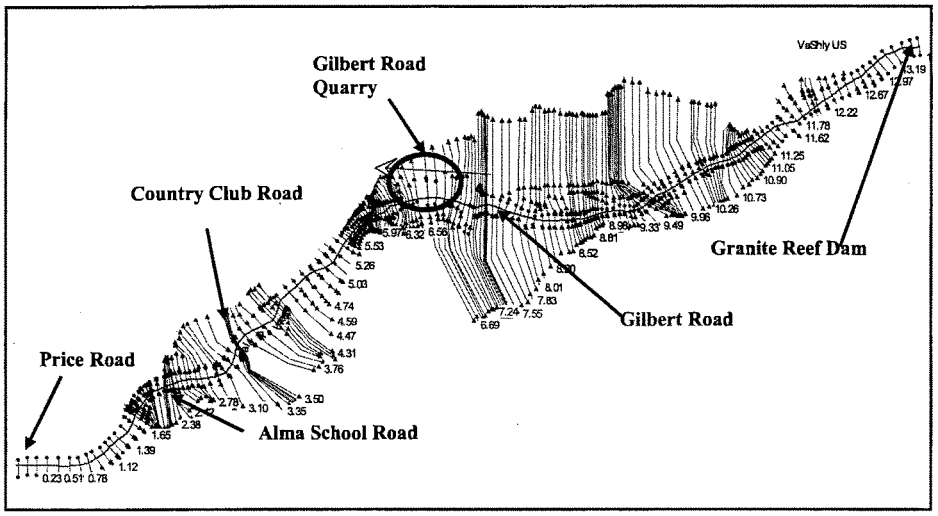
Model 11 – Baseline Condition, With Future Mining

46. The Baseline Condition, Model 11, is the without project condition at the target year 2011, the baseline hydraulic condition along the Salt River from Granite Reef Dam to Pima Road assuming future mining. The cross-section information was based on a digital elevation model generated from a 2001 LIDAR survey. Future mining was taken into account at the Gilbert Road Quarry Area. Mining assumptions were based on SRPMIC future plans. Lay out of the Salt River Model is shown in Figure A-6. The model consists of the main Salt River channel and the overbank area (West, 2002). It was assumed that

Hydraulic Analysis

the Gilbert Quarry Pit would be completely mined out. The mining would create a large depression in the channel. The mines are identified by drops elevation at River Stations 7.17 and 9.0. Additional mining was taken into account for mine operations occurring at River Station 7.17.

Figure A-6. VaShly HEC-RAS model.



47. It was assumed that the channel and overbank Manning's roughness coefficients were 0.035. In certain locations the model developers set the Manning's roughness coefficient to 5 to make the area ineffective. The "n" value used at the Pima Freeway (State 101) identified as River Station 0.00 was 0.035 and decreased upstream to 0.028 at Granite Reef Dam.

48. Peak discharges listed in the Discharge Frequency Analysis section were used in the Baseline Condition model simulations.

49. The calculated water surface elevation in the Baseline Condition is super critical at four locations within the study area. These are River Stations 2.12, 7.24, 8.68 and 9. The critical flow is due to abrupt changes in slope caused by sand and gravel mining at these locations.

50. Water surface elevations computed in the West model and the Baseline Condition were compared to the Flood Control District of Maricopa County (FCDMC) model. Some differences were evident between the models. The water surface dips at River Station 9.39 during high flows because there is a significant decrease in channel width. The water surface elevation at Alma School Road Bridge was 0.3 feet higher in Baseline Conditions than in the FCDMC model due to a larger bridge pier width used in the Baseline Conditions. The water surface elevation at the Country Club Road bridge was

four feet higher than the FCDMC model. The differences are due to the channel elevations at the bridge boundary. The calculations produced in the Baseline Condition are assumed to be more accurate. The flow at the Gilbert Road Bridge was were two feet higher than in the FCDMC model. The flow areas in the Baseline Condition model define a narrower width and produced the higher water surface elevation.

51. Hydraulic results for the Baseline Condition are found in the Exhibits section of the Hydraulics and Hydrology Appendix.

Model 2 – Future Without Project

52. Model 2, Future Without Project Condition, was developed using the altered cross section profiles generated from one dimensional sediment transport model, HEC-6T. The sediment model was run for a simulation period of 50 years, simulation flow record was based on estimated flow records for the Salt River. The model consists of the 2001 terrain information for the main Salt River channel and a side channel located at the Gilbert Road Quarry (West, 2002). The future mining assumption was not taken into account due to the uncertainty and the complexity of the sedimentation model. It was decided that for the F5 level of analysis the Future Without Project condition could adequately be represented by the 2001 survey information.

53. The future without project HEC-RAS model was run to simulate the 5-, 10-, 20-, 50-100-, 200-, and 500-Year events. The Pima Freeway (State 101) starting water surface elevation was computed using the water surface elevations in the HEC-6T results for the different frequencies at the end of the 50 year periods.

54. It was assumed that the channel Manning's roughness coefficient and the ineffective flow areas did not change from the Base Case Condition throughout most of the study area. The overbank "n" values were adjusted between River Stations 4.47 to 5.47, 6.09 to 7.24 and 7.71 to 10.06 to produce a consistent flow distribution in the channel and overbank sections.

55. It was assumed that the Salt River flowed through a gravel mining pit located upstream of Gilbert Road along the south bank, River Station 8.98 to 8.10.

56. The Future Without Project water surface elevations were compared to the Baseline Condition. The data showed that under the Future Without Project, the water surface elevations are lower between River Stations 0.00 to 10.95 when compared to the Existing Condition. The long-term scour of the riverbed throughout most of the study area produced lower water surface elevations.

57. Between River Stations 10.95 and 11.99, the Future Without Project simulations of the 5- through the 50-Year events produced higher water surface elevations than modeled in the Baseline Condition. The differences ranged from + 2 feet at 10.95 to 0.5 feet at 11.99. The deposition at the in-stream sand and gravel mining pit produced the rise in the water surface elevation.

Hydraulic Analysis

58. Upstream of River Station 11.99 the water surface elevations in the Future Without Project simulations were equal to or less than the Baseline Condition.

59. Future mining will increase the amount of deposition that occurs in depositional areas and exasperate the amount of scouring that occurs upstream and downstream from depositional areas.

With Project

60. A series of five models were developed to assess the "with project" impacts on the Baseline hydraulic conditions. The five alternative modeled were: Alternative E (Model 3), Alternative F (Model 4), Alternative A (Model 5), Alternative N (Model 6) and Alternative O (Model 9). Vegetation layout figures are provided for each alternative. The 10- and 100-Year event areas of inundation are for existing without project conditions.

61. To properly simulate the with project conditions several changes had to be made to Baseline Condition model. Changes included modifications to the ineffective flow areas, Manning's roughness coefficient values and the inclusion of a secondary channel between River Station 9.04 to 8.10. The secondary channel was included to simulate split flow conditions due to a large quarry, South Quarry Pit, located between River Station 9.04 to 8.10. The quarry was assumed to be the main channel in the original existing without project hydraulic analysis. For the with project conditions a split flow computation option was used to simulate this area. The split flow method allows more flexibility in assessing the hydraulic impact due to alternatives in this area. Additional mining was taken into account for in the Gilbert Quarry Pit area.

62. In the models, the channel and overbank Manning's roughness coefficients varied from 0.035 to 0.2 based on the analysis of local conditions. The causes of the high roughness values were due to surface irregularities, n_1, channel cross section variation, n_2, and channel obstruction, n_3. In other locations the Manning's roughness coefficient was set to 5 to make the area ineffective

63. When modifying the with project conditions, the Manning's roughness coefficient n_0 = 0.028 (coarse gravel), n_1 = 0.002 to 0.02 (minor to severe surface irregularities), n_2 = 0.0 to 0.015 (gradual to frequently alternating channel cross section), n_3 = 0.005 to 0.05 (negligible to severe effect of obstructions), n_4 = 0.00 to 0.050 (no to very high vegetation) and m_1 =1.0 (minor meandering).

Model 3 – With Project (Alternative E)

64. Model 3, With Project Alternative E, represents the hydraulic model including reshaping and increased roughness due to vegetation. The Baseline Condition geometry file was modified to account for the features included in Alternative E.

Hydraulic Analysis

65. As a part of Model 3 development several assumptions were made for conditions in the project area. It was assumed that the channel and overbank Manning's roughness coefficient was 0.035. In other locations the roughness coefficient was set to 5 to make the areas ineffective.

66. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has an assigned roughness coefficient of 0.035. In certain locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative E model.

67. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s; a lateral spillway was incorporated in the design and that bed material is transported downstream in the main channel.

68. Based on site observations made during site visits to the Salt River near Gilbert Quarry, it was determined that additional mining had occurred within the main channel of the Salt River after the original Future Without Project model was completed. It was decided that the additional mining would be included in Model 3, With Project (Alternative E).

69. The existing channel geometry was modified to account for new mining that has occurred after the existing survey was completed. The mining had occurred within the main channel of the Salt River between River Station 6.91 to 6.38 and it was estimated that mining lowered the channel bottom 24 to 5 ft.

70. In addition, Model 3 required a secondary channel to be included in the design. A split flow condition was included on the Salt River from station 9.04 to 8.01. This differed from the original existing HEC-RAS model.

Results

71. Alternative E included the establishment of new vegetation primarily outside the existing 10-Year area of inundation. Overflow spillways were included at River Stations 8.90 and 8.1 to control surface flows into the South Quarry Pit and to stabilize this reach of the Salt River, Figure A-7.

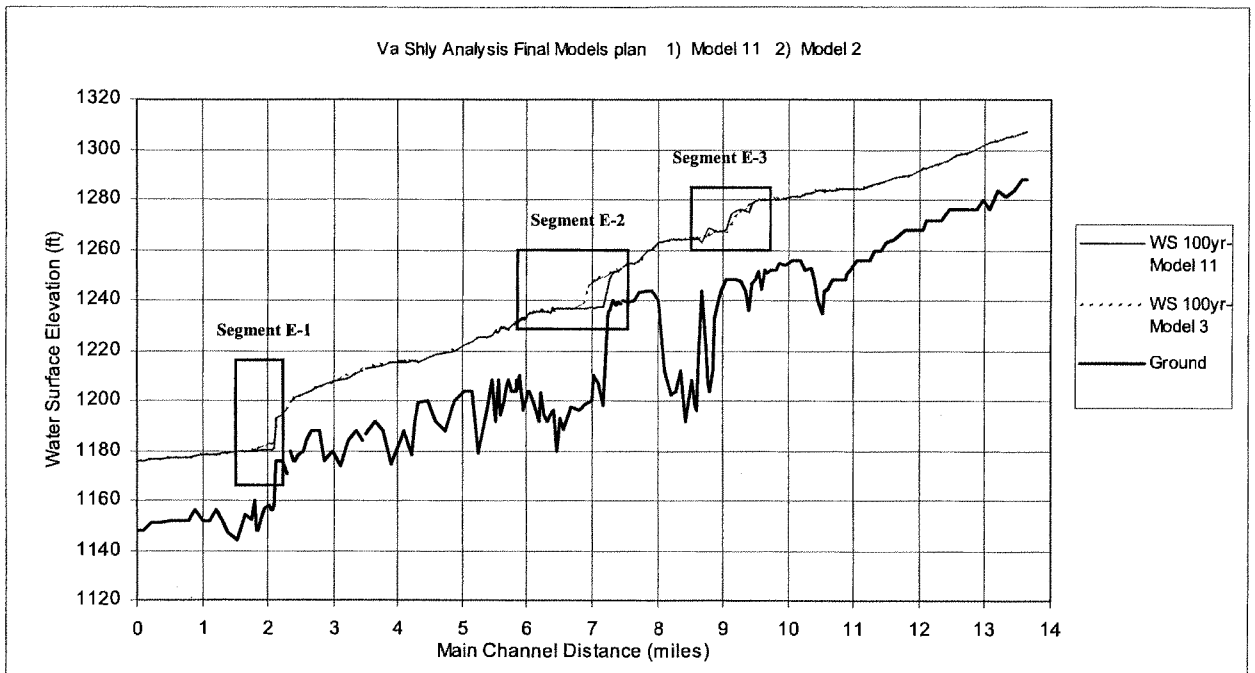
72. The result of hydraulic modeling showed limited change throughout much of the project area, Figure A-7. Changes that did occur were in sections from River Stations

Hydraulic Analysis

1.76 to 2.01 (Segment E-1), 6.45 to 7.24 (Segment E-2) and 9.39 to 10.4 (Segment E-3). Areas where water surface elevations are higher than Baseline Conditions may not increase flood damages. However, if flood damages are increased, modifications will be made to the design in the F5 Phase to lower water surface elevation to existing condition levels.

73. The increase in water surface elevation observed in Segment 1 was caused by the establishment of Upper Sonoran Desert vegetation in the main channel. Water levels increased by a 1 foot in the 100-Year event, Figure A-8. Water surface levels were lowered in Segment 2 as a result of the lowering of the channel bottom due to mining. Water level dropped about 10 feet for the 100-Year event and velocities were reduced (channel slope through segment lowered). However, the drop in elevation at River Station 7.04 increased channel velocities from River Station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. In Segment 3 water level increased for the 100-Year event due to the establishment of Sonoran Desert vegetation along the main channel.

Figure A-7. Alternative E water surface profile for the 100-Year event.



Hydraulic Analysis

Model 4 – With Project (Alternative F)

74. Model 4, With Project Alternative F, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative F.

75. As part of the Model 4 development several assumptions were developed based on the conditions in the project area. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level because both factors would require a varying roughness coefficient and for the feasibility study it was believed that this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has an assumed roughness coefficient of 0.035. In other locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative F model.

76. Baseline Condition cross sections were modified to account for the design of a low flow channel, channel realignment, grade control structure and quarry reshaping.

77. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s; a lateral spillway has been incorporated in the design and that bed material is transported downstream in the main channel.

78. A drop structure was included in the design. The drop structure was necessary to prevent headcutting that could damage rehabilitated areas upstream of River Station 6.8 and at the Gilbert Road Bridge.

79. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project conditions model was completed. The mining occurred within the main channel of the Salt River between River Station 6.91 to 6.38. It was assumed that mining lowered the channel bottom 24 to 5 feet.

80. In addition, the Salt River from River Station 9.04 to 8.01 was modeled as a split flow condition which differed from the original existing HEC-RAS model. The With Project model required the split flow condition to allow for new alternative features to be incorporated into the model.

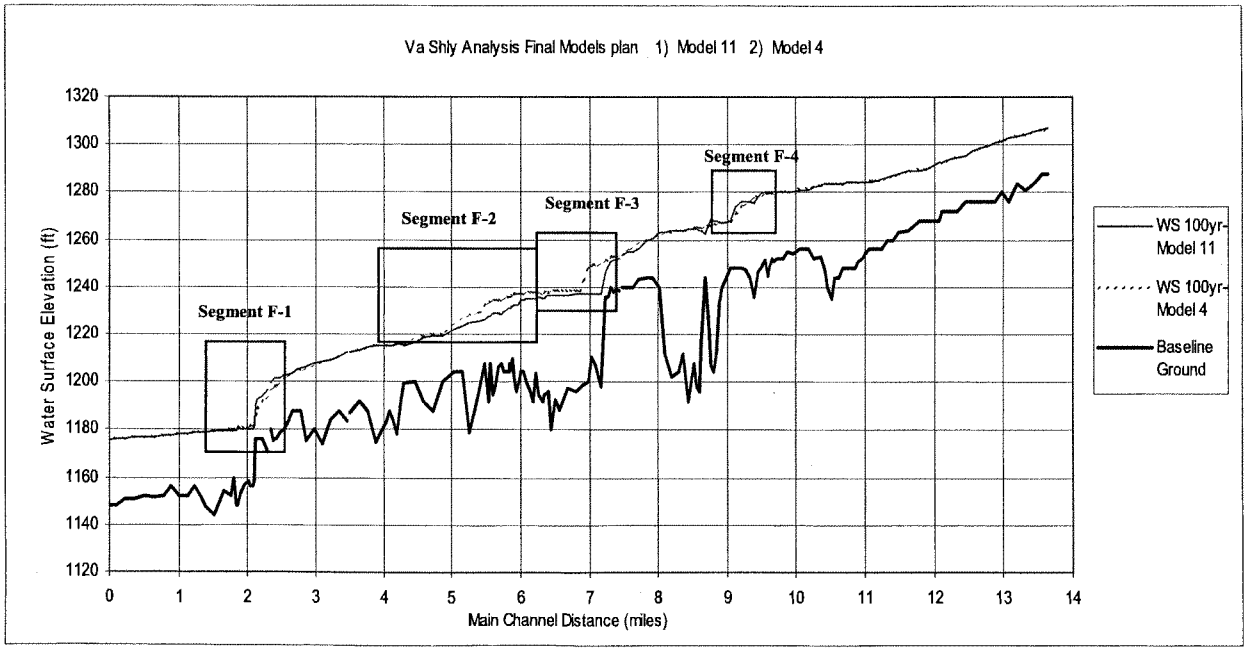
Hydraulic Analysis

Results

81. Alternative F included the establishment of new vegetation throughout the project area both in the active area of conveyance,10-Year area of inundation, and along the overbanks. A low flow channel was included in the design to offset the increased roughness along reaches of the project area. Overflow spillways were also included at River Stations 7.32, 8.10 and 8.90. Areas where water surface elevations are higher than Baseline Condition may not increase flood damages. However, if flood damages are increased, modifications will be made to the design in the F5 Phase to lower water surface elevation to existing condition levels.

82. The hydraulic results showed changes occurred from River Station 4.24 to 6.45 (Segment F-2), River Stations 2.12 to 2.65 (Segment F-1), River Stations 6.45 to 7.24 (Segment F-3) and River Stations 7.44 to 8.01 (Segment F-4), Figure A-8. The higher water surface elevation in Segment F-2 was caused by the establishment of cottonwood/willow and wetland vegetation in the main channel. Water surface elevations decreased along Segment F-1 because of the low flow channel. Segment F-3 had a lower water surface elevation because of the additional mining. However, the drop in elevation at station 7.04 increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. Segment F-4 had an increase in water surface elevation due to the establishment of cottonwood/willow vegetation along the main channel. A low flow channel was included in the design but results show that the design conveyance was not sufficient to offset the additional vegetation based on the 100-Year event results, Figure A-8.

Figure A-8. Alternative F water surface profile for the 100-Year event.



400

HYDRAULIC ANALYSIS

Model 5 – With Project (Alternative A)

83. Model 5, With Project Alternative A, includes the increased roughness due to vegetation. The Existing Condition geometry file was modified to incorporate the features included in Alternative A.

84. As part of the Model 5 development several assumptions were incorporated into the database based on conditions in the project area. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was not necessary for the feasibility study. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative A model.

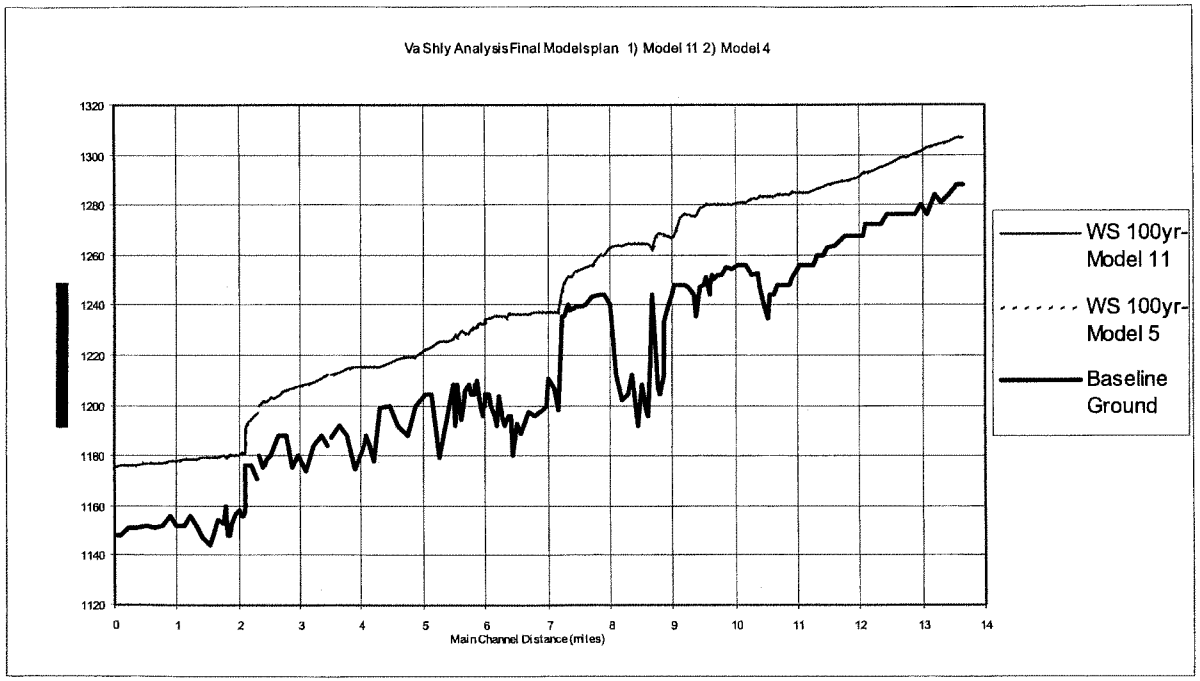
85. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model was completed. The mining occurred within the main channel of the Salt River between River Station 6.91 to 6.38. It was assumed that mining lowered the channel bottom 24 to 5 feet.

86. In addition, the Salt River from River Station 9.04 to 8.01 was modeled as a split flow condition. This differed from the original existing HEC-RAS model. The With Project model required the split flow condition so that new alternative features can be incorporated into the model.

Results

87. Alternative A included the establishment of new vegetation along the overbank area but was limited to outside the existing 10-Year area of inundation.
The results of hydraulic modeling showed no change to the existing conditions, Figure A-9.

Figure A-9. Alternative A water surface profile for the 100-Year event.



402

HYDRAULIC ANALYSIS

Model 6 – With Project (Alternative N)

88. Model 6, With Project Alternative N, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative N.

89. As with the other models a series of assumptions were developed based on the local conditions. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations, the Existing Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative N model.

90. Baseline Condition cross sections were modified to account for quarry reshaping. No bank stabilization was included in this alternative.

91. It was assumed that the Gilbert Road Quarry Pit diverted flow from the main channel for events greater than the 5-Year peak discharge, 31,000 ft^3/s.

92. A drop structure was included in the design. The drop structure was necessary to prevent head cutting upstream which would damage project areas and the Gilbert Road Bridge. The grade control structure is located at River Station 7.24.

93. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model completed. The mining simulated in Alternative N was more extensive than that which was assumed for Alternative E, F and A. In the model for Alternative N, mining lowered the channel bed between River Station 7.17 to 6.38 24 to 10 feet. The additional mining takes into account new information provided by the mine operators.

94. Alternative N model needed a split flow condition at River Station 8.10 and 8.98 to simulate a flow diversion occurring from station 9.04 to 8.01. This differed from the Future Without Project model. In addition, because of the extensive mining that occurred between River Station 7.17 and 6.38, it was assumed that the original north bank was removed.

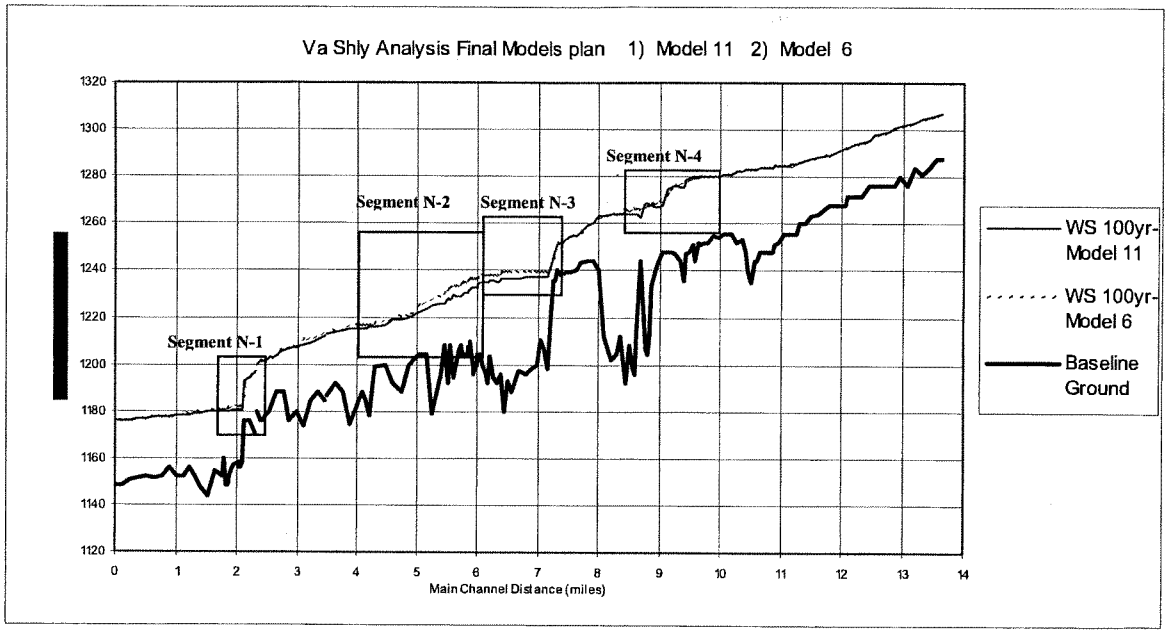
HYDRAULIC ANALYSIS

Results

95. Alternative N included the establishment of new vegetation in the active area of conveyance, 10-Year area of inundation, and on the overbank. Areas where water surface elevation are higher than Without Project conditions may not increase flood damages. No additional changes were made to the design because Alternative N was not the preferred alternative

96. The result of hydraulic modeling showed changes occurred along River Station 2.12 to 2.65 (Segment N-1), 4.24 to 6.45 (Segment FN-2), 6.45 to 7.24 (Segment N-3) and 7.91 to 9.04 (Segment N-4), Figure A-10. The changes in Segment N-1 and N-2 were a result of the establishment of cottonwood/willow and wetland vegetation in the main channel. Segment N-3 had lower water surface elevation due to the additional mining. However, the drop in elevation at River Station 7.17 increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85. Segment F-4 had an increase in water surface elevation due to the establishment of cottonwood/willow and wetlands within the main channel.

Figure A-10. Alternative N water surface profile for the 100-Year event.



HYDRAULIC ANALYSIS

Model 8 – With Project (Alternative O)

97. Model 9, With Project Alternative O, represents the hydraulic model that included reshaping, increased roughness due to vegetation and the inclusion of a drop structure. The Baseline Condition geometry file was modified to take into account the features included in Alternative N with additional vegetation in sub-areas 1 and 2. A low flow channel was included, channel extended from River Station 2.78 to 2.13.

98. As with the other models a series of assumptions were developed based on the local conditions. It was assumed that Manning's roughness coefficient did not change with respect to stage and was independent of vegetation maturity level. This was because both factors would require a varying roughness coefficient and for the feasibility study it was believed this level of detail was unnecessary. The maximum roughness coefficient was used for all vegetation types. Cottonwood/Willow has a roughness coefficient of 0.098, Mesquite has a roughness coefficient of 0.073, Upper Sonoran Desert has a roughness coefficient of 0.058, Wetland has a roughness coefficient of 0.048 and river bottom has a roughness coefficient of 0.035. The area not altered by the project has a roughness coefficient of 0.035. In other locations, the Baseline Condition model was set with a roughness coefficient of 5 to make areas ineffective, this was preserved in the Alternative N model.

99. Baseline Condition cross sections were modified to account for channel reshaping. No bank stabilization was included in this alternative.

100. A drop structure was included in the design. The drop structure was necessary to prevent head cutting upstream which would damage project features in sub-area 5.2 and 6.2 and the Gilbert Road Bridge. The grade control structure is located at River Station 7.24.

101. The existing channel geometry was modified to account for new mining that occurred after the Future Without Project condition model completed. The mining simulated in Alternative O was more extensive than that which was assumed for Alternative E, F and A. In the model for Alternative O, mining lowered the channel bed between River Station 7.17 to 6.38 24 to 10 feet. The additional mining takes into account new information provided by the mine operators.

102. Alternative O model needed a split flow condition at River Station 8.10 and 8.98 to simulate a flow diversion occurring from station 9.04 to 8.01. This differed from the Future Without Project model. In addition, because of the extensive mining that occurred between River Station 7.17 and 6.38, it was assumed that the original north bank was removed.

HYDRAULIC ANALYSIS

Results

103. Alternative O included the establishment of new vegetation in the active area of conveyance, 10-Year area of inundation, sub-area 2.2, 2.3 and 2.4, and on the overbank. The proposed low flow channel offset the addition of vegetation Figure 11. The abrupt drop in elevation found in Segment O-3 and O-4 were due to mining operations.

104. The result of hydraulic modeling showed minimal changes along River Station 1.22 to 2.12 (Segment O-1), 5.0 to 6.45 (Segment O-2), 6.45 to 7.24 (Segment O-3), and 7.91 to 9.04 (Segment O-4), Figure A-12. In Segment O-1 water surface elevation were slightly lower due to the addition of a low flow channel that offset the reduction of conveyance because of vegetation. Segment O-2 had higher water surface elevation due to additional vegetation between River Station 4.5 and 6.0. The rise in water levels does not increase the 100-Year area of inundation. The drop in elevation at River Station 7.17 was due future mining in the Gilbert Quarry area. The change in elevation increased channel velocities from station 6.85 to 7.28 and lowered velocities from 6.0 to 6.85, Figure A-12. To offset the change increase in velocity a drop structure was proposed at this location. Segment O-3 had an increase in water surface elevation due to the establishment of cottonwood/willow and wetlands within the main channel.

Figure A-11. Alternative O vegetation layout.

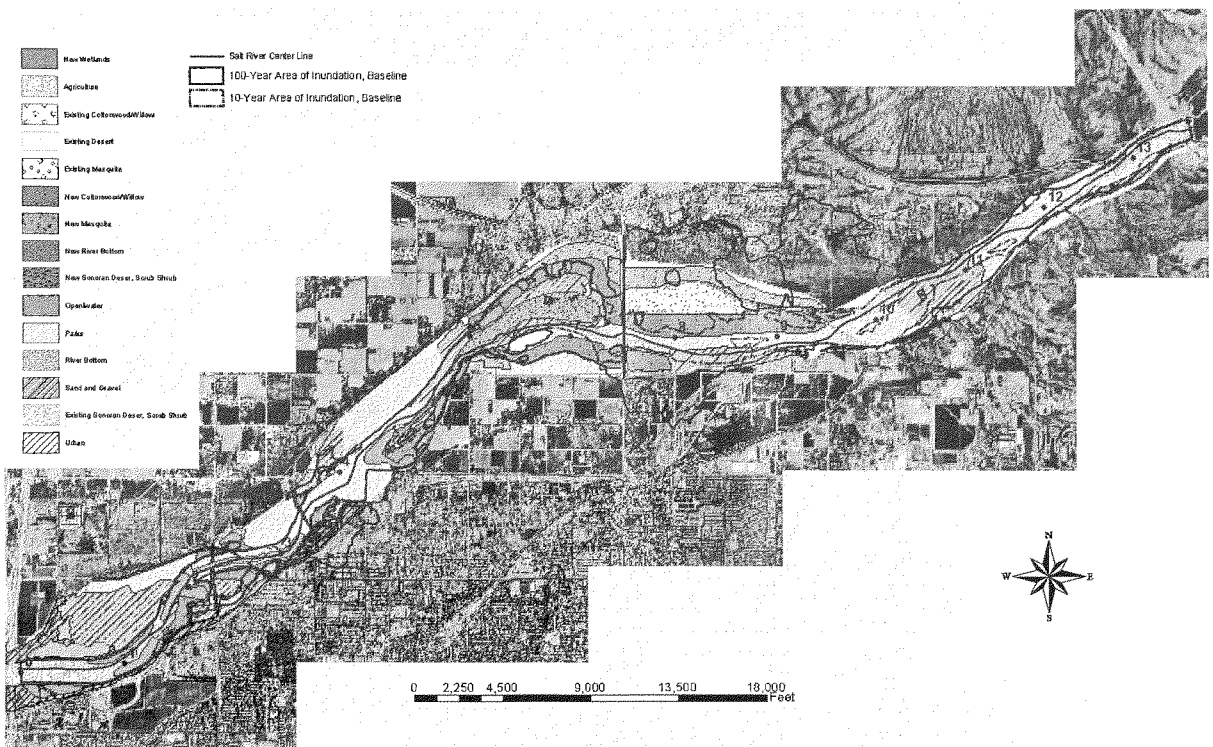
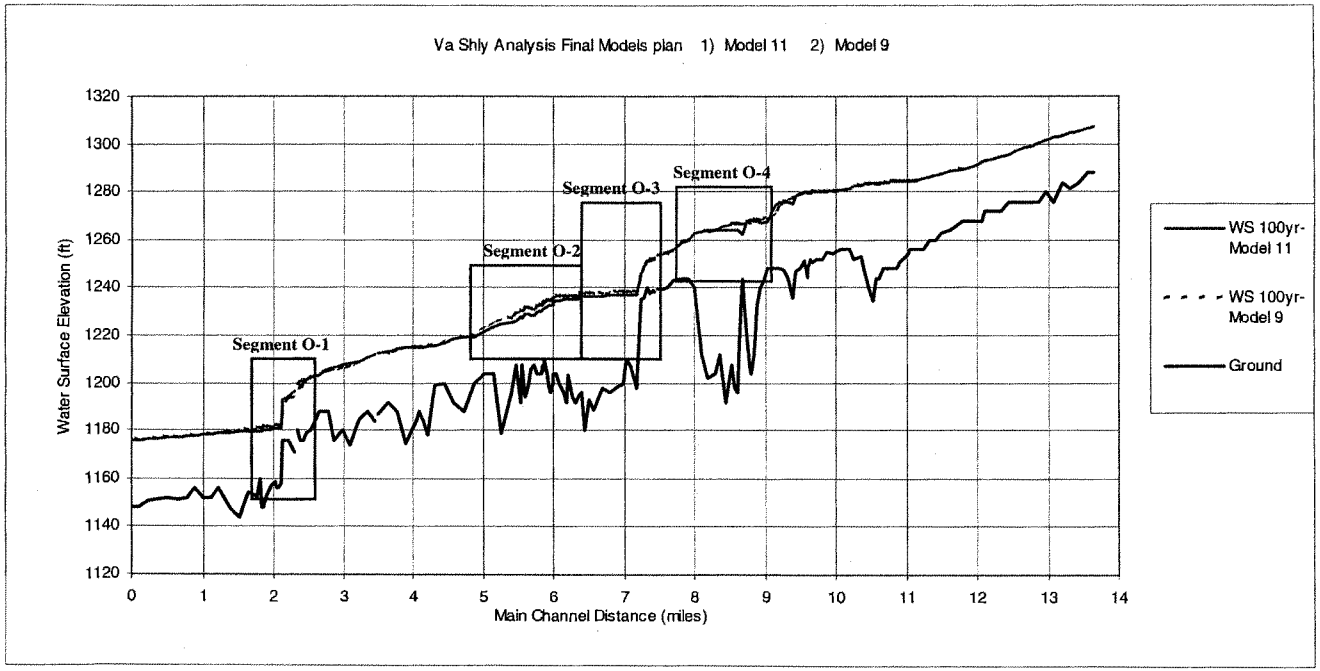


Figure 12. Alternative O water surface profile for the 100-Year event.



409

SEDIMENT ANALYSIS

SEDIMENTATION ANALYSIS

Without Project

105. The without project sedimentation analyses showed that the overall trend of the area appears to be degrading, Figure A-14 and Figure A-16, (West, 2002). Quarry operations had a significant impact on altering channel hydraulics to encourage deposition at quarry locations and initiate scouring upstream and downstream of these locations. The sedimentation analysis did not take into account future mining operations within the study area.

106. The HEC6T model was calibrated by comparing the water surface elevation from the HEC-6T model to the HEC-RAS model for the 5-, 10-, 20-, 50- and 100-Year peak flows. The differences in the computed water surface elevations were on average less than 0.01 feet and the channel velocity differences were within 0.5 feet per second. The sedimentation model simulates 50 years of channel hydraulic conditions to estimate the rates of scouring or deposition occurring along the Salt River from Granite Reef Dam to the 101 Hwy.

107. Bed sediment samples were collected at 16 locations within the study area. The measured bed gradation data were input into the HEC-6T model. The channel bed materials were composed of sand (30 %), gravel (50 %) and cobbles (20 %). The channel bed material is primarily sand and gravel. There is a high percentage of gravel in the bed and thus WEST used the Toffaleti, Meyer-Peter and Muller (TMPM) combination transport model in the HEC-6T sediment transport models to simulate the transportation of gravel and sand.

108. The sediment transport model could not be directly calibrated to historic conditions because detailed historic bed elevations are not available and sand and gravel mining and channelization has changed the bed elevations. An equilibrium bed material load at the upstream section of the study area was calculated for a range of discharges up to 200,000 ft^3/s and this was used as the basis for inflowing sediment load for the HEC-6T model.

109. The upstream limit of the study area is Granite Reef Dam. The USACE suggested that the equilibrium load be used as a reasonable estimate for the inflowing bed load material because the Granite Reef Dam diverts water and does not store water, therefore it does not significantly reduce the sediment load transported by the Salt River. WEST did not find evidence of deposition or scour downstream of the Granite Reef Dam and this confirms that the equilibrium load assumption is realistic. A more comprehensive discussion for estimating the equilibrium bed load is found in the WEST report (West, 2002).

110. Overall, the VaShly Project area appeared to be degrading based on the sedimentation analysis, Figure A-14, Model 11 and 2, Baseline and Future Without Project Conditions. The longitudinal profile shows an overall lowering of the channel invert. The Future Without Project conditions model does not take into account

additional mining that has or will occur after year 2001, topographical information was based on 2001 survey information. If the additional mining that was taken into account in Models 3, 4, 5, 6, 9 and 11, was incorporated in the Future Without Project model, the amount of scouring would increase predominantly in Areas C, E and G. A more comprehensive evaluation of the sedimentation analysis is provided in the West report (West, 2002) .

111. There are 7 areas that are of particular concern, Areas A, B, C, D, E, F and G, Figure A-20. Areas A and B show a 50-Year aggradation trend from 1-9 ft, while Area C shows some degradation, 4 to 9 ft. These areas appear to be directly influenced by mining operations. The more severe areas are D, E, F and G., mining has altered the channel profile causing scouring up to 22 ft, Area E and G, and aggradation up to 10 to 30 ft, Areas D and F. Areas D and F are old quarry pits that filled in during the 50-Year simulation period. Refer to the West report for a more detailed discussion of without project sedimentation analysis results (West, 2002).

With Project

112. Due to time constraints a detailed sediment transport analysis was not completed for the with project conditions phase of the study. The without project sedimentation analysis and with project hydraulic results were used to assess the with project sedimentation trends. The preferred alternative will be analyzed in the PED phase of the study using the 1-D sedimentation analysis computer program HEC-6T.

113. Mining operations are a factor impacting the sedimentation trends throughout the project area. Based on the Without Project sedimentation analysis, seven areas were identified as having depths of deposition or scouring that appeared to be greater than would be considered stable, Figure A-16. These areas, under existing conditions could damage project features or increase maintenance in and around these areas. Sub-area numbers were used to refer to specific locations in the With Project sedimentation analysis, as shown on Figure A-13. In addition, mining operations in the future will impact project features. To prevent damages from occurring, future mining operations need to be understood and taken into account in PED phases.

114. Alternative E. There are concerns for features in sub-area 2.2, because the features appear susceptible to damage due to deposition. Sub-area 6.2, along the south bank, will not be damaged due to deposition because the overflow spillway and bank stabilization will reduce the amount of material flowing into this area. There appear to be no other areas of concern. Features in sub-area 5.2 will be susceptible to damage due to aggradation of coarse material and the lateral migration of the main channel.

115. Alternative F. There are concerns for features in sub-area 4.1, appear susceptible to scouring. With the recommended modification in sub-area 6.2, the low flow channel appears to be susceptible to some scouring during extreme events. Sub-area 3.2 and 3.1 appears to be susceptible to both scouring and deposition. Because the north and south banks will be stabilized and spillways constructed in sub-area 5.2, bed load material will

SEDIMENT ANALYSIS

be confined to the main channel. The aggradation trend for the existing without project condition will be reduced in Area D because water and bed material will be forced through the existing main channel. There may be some damages but the features can be designed in F5 to account for accumulation of material.

116. Alternative A. There are no sedimentation concerns

117. Alternative N. There are erosion concerns for features in sub-area 6.1 and 4.1. No bank stabilization or diversion structures were included in Alternative N. This was intended to allow the river to naturally aggrade and meander in Area D. To minimize damage to features, cottonwood and mesquite vegetation was placed outside the Without Project area of aggradation, Figure A-16.

118. Alternative O. There are erosion concerns for features in sub-area 2.2, 2.3 and 4.1. No bank stabilization or diversion structures were included in Alternative O. This was intended to reduce construction and maintenance costs. Under this situation, the Salt River will continue to change, the most sensitive areas are in Area D, E and F. Cottonwood and mesquite vegetation was placed outside the Without Project area of aggradation to minimize damage to features. Cottonwood and wetland features located in sub-area 2.2, 2.3 and 4.1 are susceptible to damage because they are located in the 10-Year area of inundation and assumed a high velocity zone. This makes the features susceptible to high velocities when flow events do occur. Mining in the future could threaten the project features. To better understand the impact of mining further analysis is necessary prior to construction during the PED phase. Refer to Figure A-16, Area F, for quarry location, and erosion and deposition trends.

Figure A-13. Sub-area and river station numbers for project area. Sub-area numbers are in yellow.

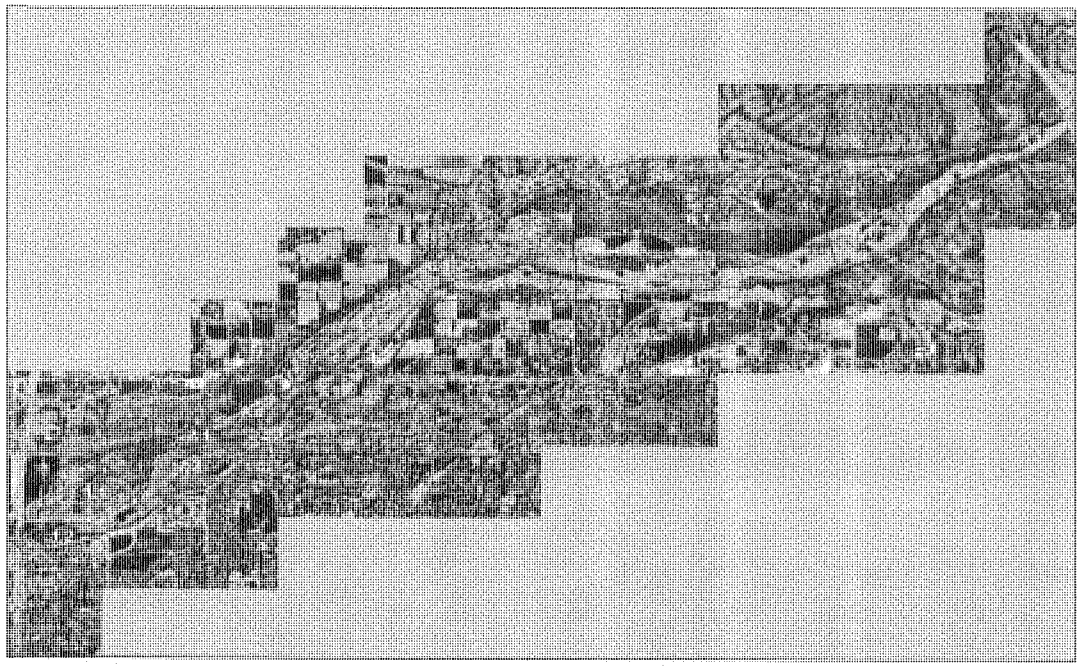


Figure A-14. Without project water surface profiles for the 100-Year Event for the Baseline, Model 11, and Future Without Project, Model 2.

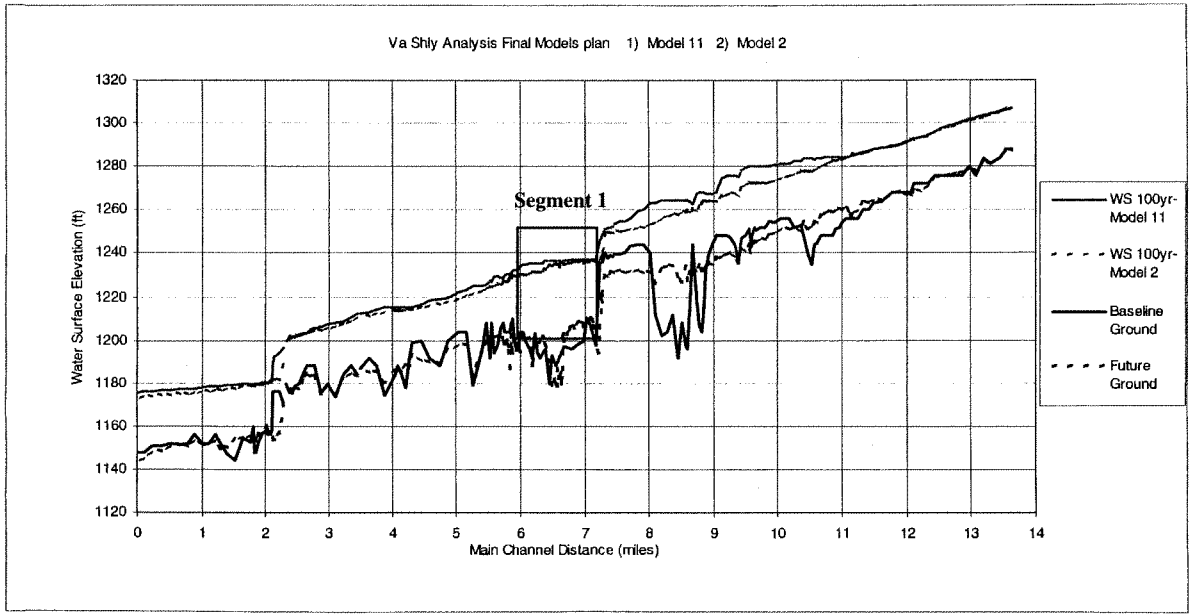


Figure A-15. Baseline, Model 11, and Future Without Project, Model 2, main channel average velocity for the 100-Year Event.

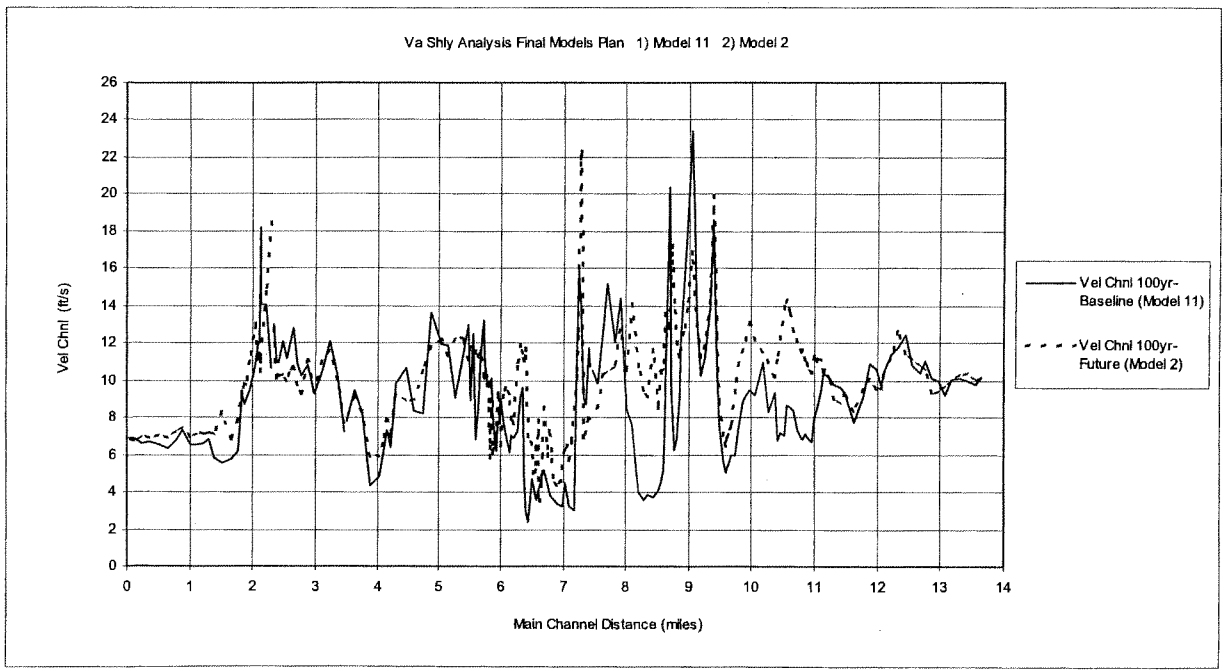
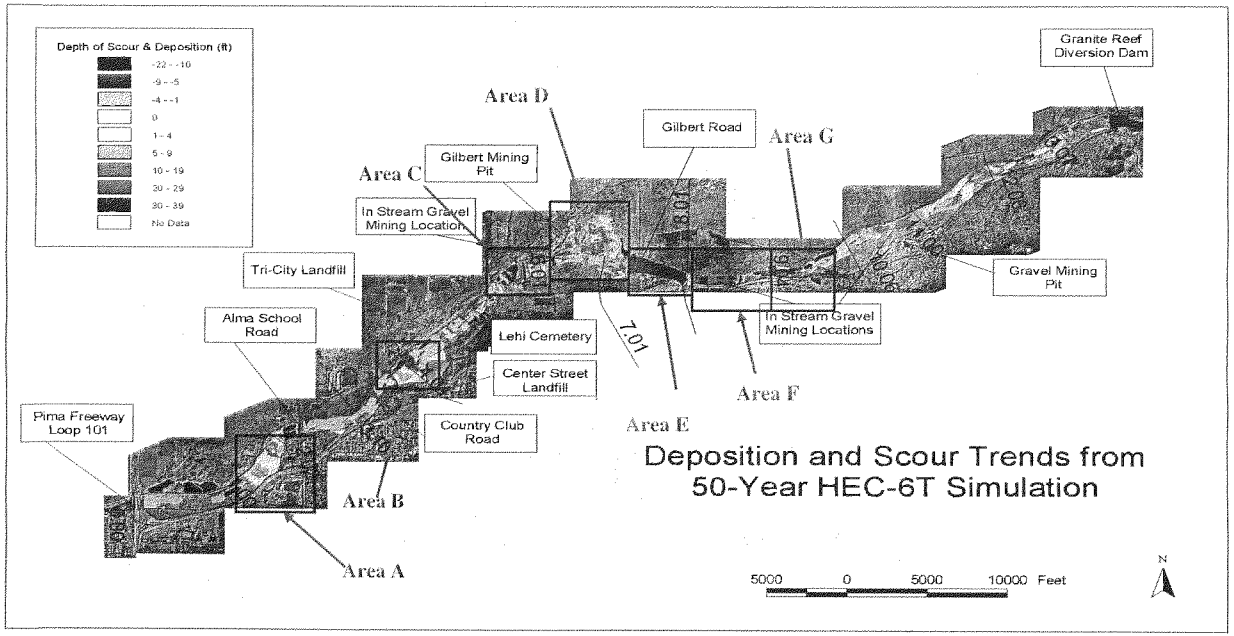


Figure A-16. Deposition and Scour Trends from 50-Year HEC-6T Simulation and sedimentation areas of concern (West, 2002).



GEOMORPHOLOGY DISCUSSION

GEOMORPHOLOGY DISCUSSION

119. Historic records indicate an increase in human influences on the Salt River exemplified by the encroachment of urban, commercial and gravel mining areas. Long-term channel responses are entirely dependent on future development in and around the channel. If there is no additional gravel mining, the channel will reach a state of equilibrium but only after all the gravel pits have reached a sediment transport balance through the natural migration of the river system or restoration activities have been conducted (West, 2002).

120. A significant concern on the stability of the river is the influence of gravel mining on the erosion and planform evolution of the channel. Gravel pits in the channel act as a reach of zero slope and serve to trap sediment. Downstream of the gravel pits, sediment supply to the channel is reduced due to the trapping of sediments within the pits. In order to meet sediment transport capacity, the downstream channel may erode its bed to reduce its slope and corresponding sediment transport capacity. According to Lane (1957), as the slope is reduced the channel would transition form a braided to intermediate planform condition.

121. The historic migration of the Salt River from Granite Reef Dam to Price Road is depicted in bank migration pattern from 1935 to 2002, Figure A-17. It clearly shows that the Salt River still actively changes channel configuration, conforming to the river flows. However, hard banking and other encroachments throughout the 100-Year Floodplain have confined the lateral migration of the river.

122. For a more detailed discussion on the Geomorphology of the Salt River within the study area refer to West report (West, 2002).

Erosion Concerns

123. Lehi Cemetery located along the south bank at River Station 6 is an area that does not appear to be in any immediate threat to erosion. Currently, the river is constricted by the Tri City Landfill on the north bank and a geological outcrop on the south bank. The south bank has been actively eroding for the past 65 years, Figure A-17. Because of the erosion that has occurred local sponsors have expressed erosion concerns over Lehi Cemetery. Using aerial photos from 1935, 1957, 1979 and 2002, the bank lines were determined and an average rate of migration calculated. From 1935 to 2002 the south bank moved south 740 ft at an average rate of 11 ft/yr. This area has shown a consistent pattern of change, that is, the channel has gradually got wider. Because bank migration rates are dependent on the number of river flow events, peak discharge and duration, in addition to changes in the channel geometry, it is difficult to determine a rate of migration. For this report it was assumed that the average rate of migration was 11 ft/yr. Assuming this rate the Lehi Cemetery will be impacted in 33 years. However, other factors such as the mining operations have substantially changed the landscape and the channel geometry. Steeper and taller channel banks may decrease bank stability which

GEOMORPHOLOGY DISCUSSION

would encourage erosion. On the other hand due to the gradual widening of the channel the boundary shear stress for a given discharge has reduced.

124. Another important point is that due to the increase in the Rio Salado Watershed storage capacity upstream of the Granite Reef Dam, because of current climate conditions and increased reservoir storage, flows in the future have a lower probable peak discharge than in the past. Thus, unless climate conditions change, i.e. more precipitation, expected river flows will be less.

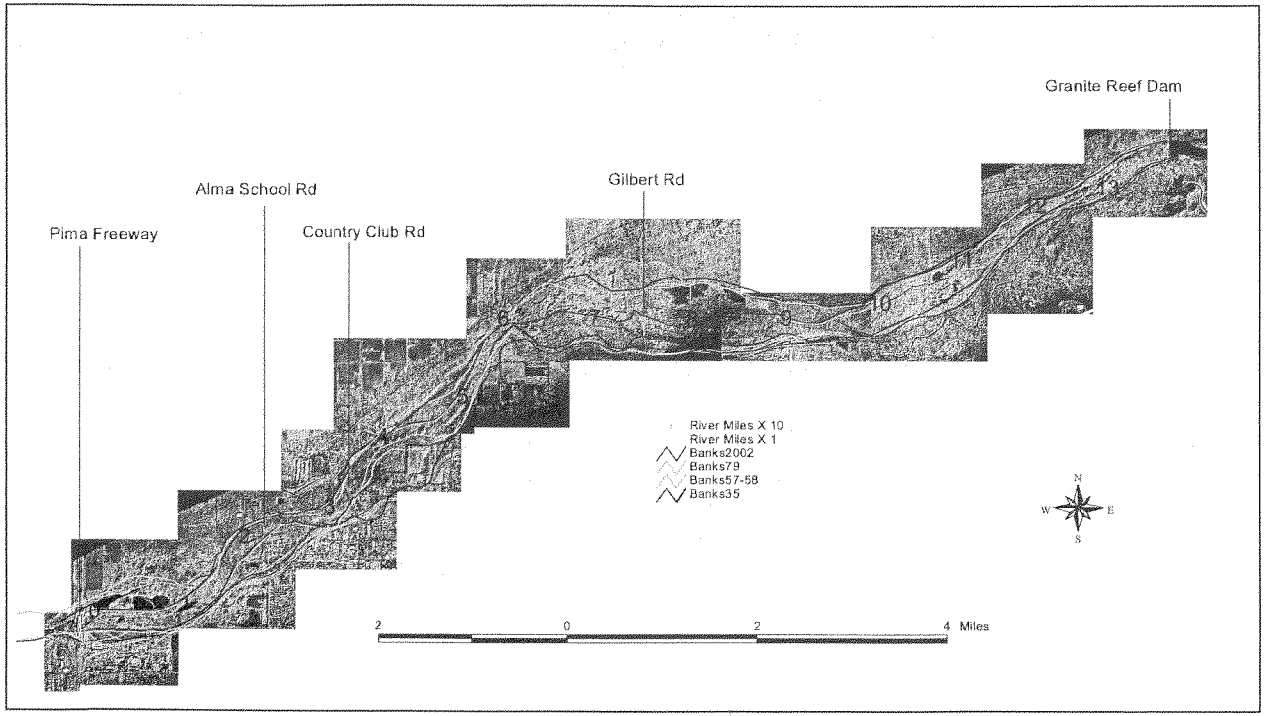
125. Because of the complexity of estimating erosion and future erosion conditions it was decided that another approach would be to compare flow conditions at Lehi Cemetery to the entire study reach for the100-Year event. Baseline Conditions average channel velocity in this area ranges from 6 to 10 ft/s for the 100-Year event. This range is comparable to the other areas along the Salt River.

126. For the Future Without Project condition the average channel velocity remains relatively the same, Figure A-15. With project conditions shows equal or lower channel velocity conditions, model results found in appendix exhibits. Thus, for the Lehi Cemetery area bank erosion was not a concern based on the feasibility analysis and no bank stabilization was proposed for this area.

127. Another area of concern is the south bank at River Station 3. Because of the geometry of the Salt River, a 45 degree bend, aerial photos indicate the south bank has been actively eroding, Figure A-17.

128. Scouring affects the stability of the channel (changes in lateral and vertically channel geometry) and hydraulic conditions (changes in velocity and water surface elevations). These changes in the future would impact with project features by increasing the potential of damages associated to scouring. Based on the existing sedimentation model the areas most susceptible to damages for Alternative O are found between River Station 9.5 to 7.5. In addition, results show that minimal amounts of erosion occur downstream of Gilbert Quarry. Future mining was not taken into account in the model. If additional mining was taken into account, it can be assumed that erosion rates would be increased for future conditions.

Figure A-17. Historic channel bank locations superimposed on 2002 imagery (West, 2002).



RISK AND UNCERTAINTY ANALYSES

RISK AND UNCERTAINTY ANALYSIS

129. Procedures outlined in EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies" (USACE, 1996b), were followed to determine the standard deviation for computed water surface profiles at specific index locations. Specifically, Section 5-4, "Uncertainty in Stage for Ungauged Stream Reaches," and Section 5-5, "Uncertainty in Stages for Computed Water Surface Profiles," were followed. Only the 100-Year event standard deviation was calculated using these methods because the computer program HEC-FDA (HEC 1998) adjusts the standard deviation for the other stage discharge values. For discharge values greater than the 100-Year event discharge, the standard deviation is assumed equal to the standard deviation of the 100-year event discharge. For discharge values smaller than the 100-Year event discharge, the standard deviation is the standard deviation of error associated with the 100-Year event discharge multiplied by the ratio of the given discharge to the 100-Year event discharge. A summary of the uncertainty analysis for the different alternatives at the index locations is presented in Table A-6. The standard deviation for each alternative is tabulated under the column heading "Stotal."

Table A-6. Risk analysis standard deviation.

Reach and Index Cross Section Rio Salado Vashly	Frequency	Q (cfs)	Stotal (ft)	Reach and Index Cross Section Rio Salado Vashly	Frequency	Q (cfs)	Stotal (ft)
	500-YR	246000	0.7		500-YR	250000	0.7
	200-YR	207000	0.7		200-YR	210000	0.7
Reach 1	100-YR	172000	0.7	Reach 6	100-YR	175000	0.7
Cross-Section .89	50-YR	145000	0.6	Cross-Section 7.63	50-YR	150000	0.6
0 to 1.52	20-YR	95000	0.4	6.45 to 8.98	20-YR	100000	0.4
	10-YR	58000	0.2		10-YR	60000	0.2
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.7		500-YR	250000	0.8
	200-YR	207000	0.7		200-YR	210000	0.8
Reach 2	100-YR	172000	0.7	Reach 7	100-YR	175000	0.8
Cross-Section 2.47	50-YR	145000	0.6	Cross-Section 9.64	50-YR	150000	0.7
1.52 to 3.23	20-YR	95000	0.4	8.98 to 10.06	20-YR	100000	0.5
	10-YR	58000	0.3		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.8		500-YR	250000	0.8
	200-YR	207000	0.8		200-YR	210000	0.8
Reach 3	100-YR	172000	0.8	Reach 8	100-YR	175000	0.8
Cross-Section 3.76	50-YR	145000	0.7	Cross-Section 11.05	50-YR	150000	0.7
3.23 to 4.27	20-YR	95000	0.4	10.06 to 11.17	20-YR	100000	0.5
	10-YR	58000	0.2		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.7		500-YR	250000	0.7
	200-YR	207000	0.7		200-YR	210000	0.7
Reach 4	100-YR	172000	0.7	Reach 9	100-YR	175000	0.7
Cross-Section 5.03	50-YR	145000	0.6	Cross-Section 12.1	50-YR	150000	0.7
4.27 to 5.88	20-YR	95000	0.4	11.17 to 12.33	20-YR	100000	0.5
	10-YR	58000	0.2		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01
	500-YR	246000	0.8		500-YR	250000	0.7
	200-YR	207000	0.8		200-YR	210000	0.7
Reach 5	100-YR	172000	0.8	Reach 10	100-YR	175000	0.7
Cross-Section 6.05	50-YR	145000	0.7	Cross-Section 12.97	50-YR	150000	0.7
5.88 to 6.40	20-YR	95000	0.5	12.33 to 13.64	20-YR	100000	0.5
	10-YR	58000	0.3		10-YR	60000	0.3
	5-YR	21000	0.1		5-YR	22000	0.1
	3-YR	2200	0.01		3-YR	2200	0.01

OPERATION AND MAINTENANCE

OPERATION AND MAINTENANCE

130. The Baseline Condition and With Project hydraulic results and the Without Project sedimentation results were used to asses the operation and maintenance concerns for this project. During this F5 phase of the study, the With Project sediment analysis was not undertaken. Instead, results from the With Project hydraulic analysis and Without Project sediment analysis (West, 2002) were used to estimate the frequency that environmental features are damaged in each alternative. The method of analysis was to compare the Baseline Condition area of inundation for the 5 and 10-Year events to the vegetated area, Arc-View was used to perform this comparison. It was assumed that the Baseline Condition 5 and 10-Year area of inundation represented the area of highest velocities. Because the alternatives did not significantly alter the existing flow path, it was assumed that the Baseline Condition area of inundation would be sufficient to complete the With Project damage assessment. Damage due to duration of inundation was not taken into account in this analysis. Note that the frequency of vegetation replacement was not analyzed in this study.

Maintenance Considerations

131. It was assumed that all vegetated areas require an irrigation system to establish and maintain the vegetation. Two types of irrigation systems were analyzed, surface braided irrigation system and drip irrigation. An in depth maintenance assessment was not be performed as a part of this analysis. Estimating the maintenance requirements for the irrigation system required the assumption that the With Project vegetated area inundated by the Baseline Condition 10-Year events would require maintenance. The total vegetated area inundated is shown in Table A-7. The area represents Wetlands, Cottonwood/Willow, Mesquite and Upper Sonoran Desert. The area damaged for the 20 to 500-Year events corresponds to a percentage of the vegetated area inundated by the 10-Year event. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 % of the area inundated was damaged. For the 20-Year event, 80% of the area and 90 % for the 50 to 500-Year events. These assumptions are based on engineering judgment applicable for the F4 phase of this investigation. Alternative F and Alternative O had the greatest amount of damages, Table A-8.

Table A-7. Vegetated area inundated by the 5 and 10-Year events for the without project existing conditions.

	5-Year	10-Year
Alternative	Area (acres)	Area (acres)
A	32	95
E	268	395
F	454	754
N	337	582
O	336	537

OPERATION AND MAINTENANCE

Table A-8. Irrigation area requiring maintenance based on recurrence interval.

	5-Year	10-Year	20-Year	>50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
A	16	67	76	86
E	134	277	316	356
F	227	528	603	679
N	169	407	466	524
O	168	376	430	483

132. A low flow channel was included in the design of Alternative F. It was assumed that maintenance would be required when the low flow channel average velocity exceeds the maximum permissible velocity for the bank material d_{50}. The low flow channel from River Station 9.6 to 7.65, the d_{50} for the bank material = 0.9 mm. The corresponding permissible velocity = 5 ft/s, permissible velocity for graded silt to cobble, noncolloidal, for water transporting noncolloidal material (Julien, 1998). The low flow channel from River Station 4.4 to 2.2, the d_{50} for the bank material = 19.3 mm. The corresponding permissible velocity = 6.5 ft/s, permissible velocity for small cobble and shingles, for water transporting noncolloidal material (Julien, 1998).

133. The low flow channel from River Station 9.6 to 7.6, the main channel average velocity exceeds the maximum permissible velocity for flows equal to or greater than the 5-Year event. Because the channel was designed to allow the channel to migrate laterally, it was assumed that maintenance would occur after events greater than the 10-Year event.

134. The low flow channel from River Station 4.4 to 2.2, the main channel average velocity exceeds the maximum permissible velocity for flows equal to or greater than the 10-Year event. The channel was designed to allow the channel to migrate laterally and thus it was assumed that some maintenance would occur after events greater than the 20-Year event.

135. A water distribution channel will be incorporated in the design for Alternatives H, B, C, E and G. Based on a similar analysis as performed for the low flow channel it was assumed that for velocity's greater than 5 ft/s, distribution channel will be damaged. Because most of these channels will be planned in or near the 10-Year flow event it was assumed that 40% of the channel was damaged for flow equal to the 5-Year event, 50% for flows equal to the 10-Year event, 60% for flows equal to the 20-Year event and 80% for flows greater than the 50-Year event. Percent damages were based on engineering judgment. The resulting damage to the distribution channel is shown in Table A-9. Alternative G and H have the most damages to the distribution channel.

OPERATION AND MAINTENANCE

Figure A-9. Distribution channel damages based on recurrence interval.

Alternative	Distribution Channel Length (ft)	5-Year Level of Damage (ft)	10-Year Level of Damage (ft)	20-Year Level of Damage (ft)	>50 - Year Level of Damage (ft)
G	68,500	27,400	34,250	41,100	54,800
H	68,500	27,400	34,250	41,100	54,800
C	25,000	10,000	12,500	15,000	20,000
B	3,000	1,200	1,500	1,800	2,400
E	3,000	1,200	1,500	1,800	2,400

136. Maintenance may also be necessary to minimize or control the spreading of large woody vegetation into the main channel. This is necessary to maintain an area of conveyance great enough to maintain existing conditions.

Vegetation Damage

137. The vegetation damage was evaluated using a similar method as was used for the maintenance considerations. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 % of the area inundated was damaged. The area damaged for the 20 to 500-Year events corresponds to a percentage of the vegetated area inundated by the 10-Year event. For the 5-Year event it was assumed that 50% of the area inundated was damaged. For the 10-Year event, 70 percent of the area inundated was damaged. For the 20-Year event, 80% of the area and 90 % for the 50 to 500-Year events. These assumptions are based on engineering judgment applicable for the F5 phase of this investigation. Alternative F and Alternative O had the most damage, Table A-10.

Table A-10. Vegetation damaged area for a given recurrence interval.

	5-Year	10-Year	20-Year	> 50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
A	16	67	76	86
E	134	276	316	355
F	227	528	603	678
N	168	407	465	523
O	204	463	529	595

PREFERRED ALTERNATIVE

Preferred Alternative: Alternative O

138. It was determined that the recommended alternative was Alternative O. The following section provides additional information concerning project features, with project hydraulic conditions and impact to project features.

139. Alternative O consists of the following vegetation types: 883 acres of Cottonwood/Willow, 380 acres of Mesquite, 200 acres of wetland, and 24 acres of Sonoran Desert. A majority of the vegetation planned for lies outside the 10-Year (determined as the active area of conveyance), 336 acres of the total 1463 acres are located within the 10-Year area of inundation. By minimizing the amount of vegetation within the 10-Year area of inundation the impact to the hydraulic conditions was reduced and the damage risk to vegetation minimized.

140. The Alternative O project features are shown on Figure A-23. The most significant impediment to the river flows are the wetland features found in sub-area's 1.1, 2.2, 2.3 and 4.1. It was assumed for the F5 hydraulic analysis study that the roughness value would remain constant for all flows. This is a conservative estimate of what would actually occur but for the scope of this study it was deemed appropriate. Some of the cottonwood/willow vegetation along the river bank affects high flow conditions, but it was deemed not significant based on water surface elevation profiles for the with project condition. Where water levels were significantly impacted a low flow channel was designed to offset the reduction of conveyance in the channel, sub-area 2.1 to 2.3.

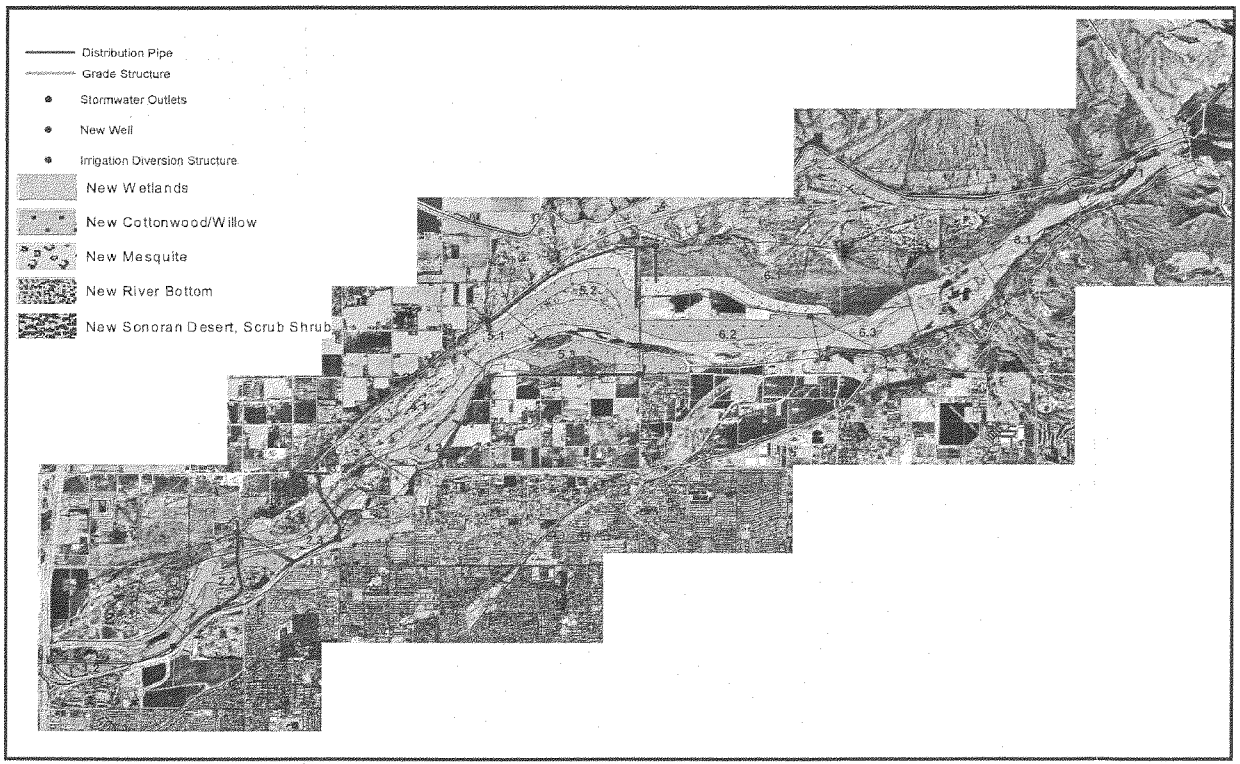
141. In addition to high flows, mining operations impact the project features. Sub-areas 5.1, 5.2, 6.2 and 6.3 are the areas with the greatest risk of damage due to mining activities that have occurred in past and have been proposed in the future. It was assumed that future mining activities would increase the pit size in sub-area 5.2 and 7.1. To minimize the risk to project features, vegetation in 6.2 was placed only on the north bank and a grade control structure was proposed in 5.2. The wetlands placed in sub-areas 1.1, 2.2, 2.3 and 4.1 have a higher associated risk but the damage can be minimized based on the wetland design and the sponsor willingness to allow for some changes to the features.

Hydraulic Conditions

142. The with project conditions for Alternative O shows minor increases in water surface elevations. Due to the minor change in water surface elevation it was assumed that the area of inundation for flow events with a recurrence interval greater than the 50 or 20 Year events. Refer to Exhibit A-2 for additional hydraulic information

143. Hydraulic results for Alternative O are found in the Exhibits section of the Hydraulics and Hydrology Appendix.

Figure A-18 Project features for Alternative O. Sub-Area shown in Red.



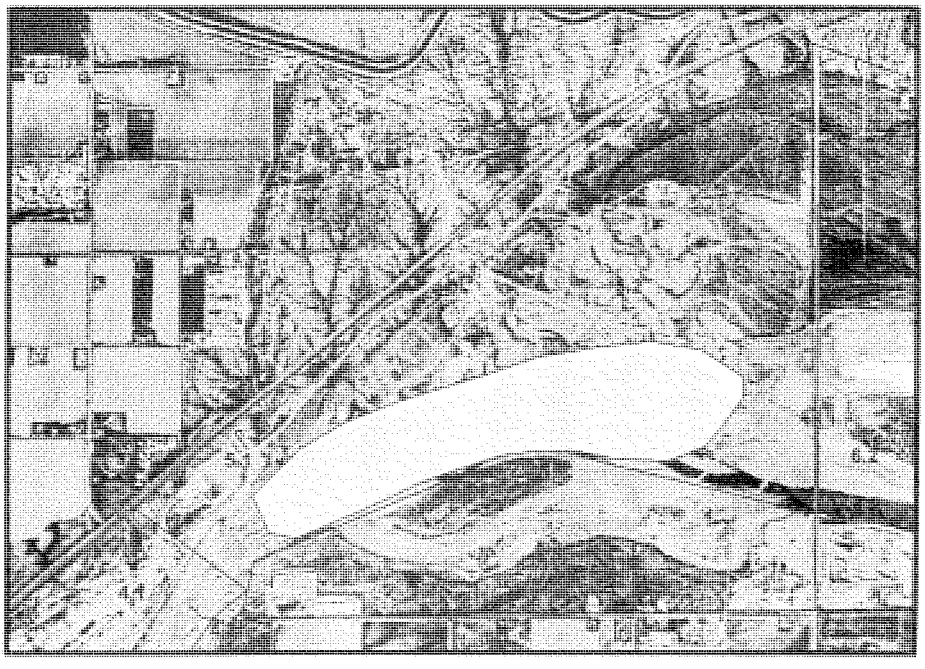
PREFERRED ALTERNATIVE

Sedimentary Conditions

144. Having minimal vegetation in active areas of conveyance reduces the damage risk due to excessive scouring and deposition. Several areas remain that may be susceptible to sedimentary conditions. Mining occurring in sub-area 7.1, Higgley Plant, can cause sediment starved flows that can cause excessive rates of erosion in sub-areas 6.2 and upstream portions of 6.3. Based on existing topographic information it was assumed that the disturbance would be focused along the southern bank of the Salt River. No vegetation was proposed in this area. Future mining in sub-area 7.1 or 6.3 will significantly impact vegetation in sub-area 6.2 and 6.3.

145. Gilbert Quarry Pit located in sub-area 5.2 has been extensively mined and will be further mined in the future. In the development of the Alternative O, as well as all the alternatives, the future mining was taken into account. It was assumed that the additional mining would remove all material within the main channel of the Salt River. Future mining is shown in yellow on Figure A-24. To prevent headcutting that would migrate upstream and damage project features in sub-areas 5.2, 5.3 and 6.2, a grade control structure was proposed in sub-area 5.2, shown in brown in Figure A-21.

Figure A-19. Assumed area of future mining (yellow). Proposed grade control structure (brown).



146. The with project sedimentation analysis for Alternative O was not completed for the F5 phase and will be completed during PED. Because the vegetation had minimal affect

on the hydraulic conditions, it can be assumed for the feasibility study that the vegetation will have minimal additional affect on the sedimentary processes. The largest human impact on the channel stability of the Salt River appears to be the mining operations. Alternative O project features over laid with scouring and deposition trends are shown on Figure A-20.

Risk Assessment

147. As discussed in the text above, the features with the highest risk are associated with those features located in the main channel area, or within the 10-Year area of inundation. However not all vegetation found in this area was or should be assumed to damages during flow events. Because of the complexity of risk assessment to vegetation due to hydraulic and sedimentary conditions, it was assumed that a percentage of vegetation within these limits would be at risk to damage, see Operation and Maintenance, Vegetation Damage Section, for more info. Based on those assumption the at risk area amounts were determined, Table A–12. Of that amount, only a portion is located along the riverbed where the highest stresses are found. The wetland features found in sub-areas 1.1, 2.2, 2.3 and 4.1 are the features most susceptible to damage. In all, 167 acres of wetlands are found in the 10-Year area of inundation. Wetlands can be engineered to resist high shear stresses such that vegetation will reestablish after larger flow events. Wetland design will be completed in the PED phase.

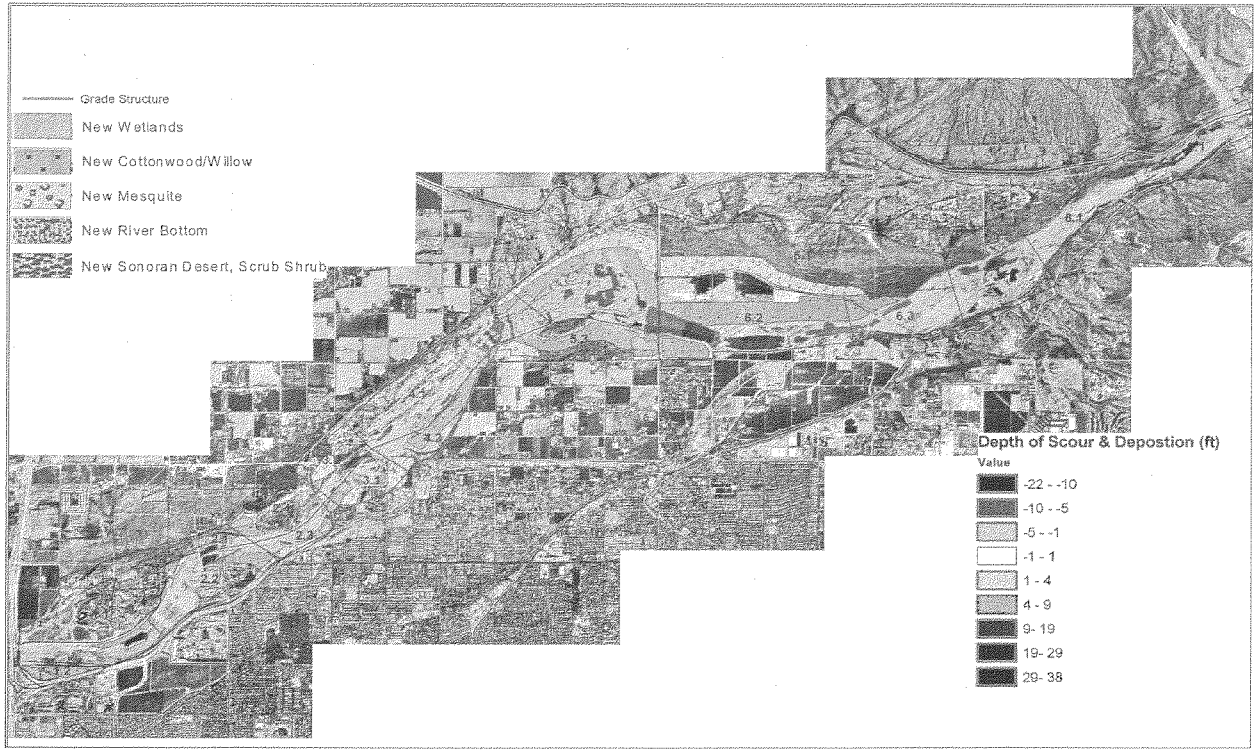
Table A-11. Vegetation amount within the 10-Year area of inundation

Vegetation	Area (acres)
Cottonwood	368
Mesquite	2
Wetland	167
Sonoran Desert	0

Table A-12. Vegetation damaged area for a given recurrence interval

	5-Year	10-Year	20-Year	>50-Year
Alternative	Area (acres)	Area (acres)	Area (acres)	Area (acres)
O	168	376	430	483

Figure A-20. Scour and deposition trends with Alternative O project feature locations.



PREFERRED ALTERNATIVE

148. It was assumed that the main areas of concern would be associated to areas with extreme rates of scouring or deposition (i.e. extreme was assumed to be rates of scouring or deposition greater than 5 ft). Sedimentation results were based on without project conditions, the grade control structure at Gilbert Quarry Pit was not included in the model. Thus, scouring occurring upstream and downstream of Gilbert Road will be reduced by to the addition of the grade control structure. The grade control structure will also reduce the amount of deposition that occurs in sub-area 5.2. The with project sedimentation analysis will be completed in the PED phase.

SUMMARY

Summary of Results

149. Alternative O was the preferred alternative. The alternative did not significantly raise water surface elevation, Figure A-15. To offset the addition of vegetation in areas 1 and 2 a low flow channel was proposed in sub-area 2.2 and 2.3 and a majority of the woody vegetation was placed in low or no conveyance areas. Results show minor changes in water surface elevation between the with project and Baseline conditions.

150. A more significant factor impacting the baseline hydraulic condition was the influence of mining in the project area. It was assumed that additional mining would occur in the Gilbert Quarry area. This additional mining lowered water surface elevations but also increased velocity at the upstream transition point, River Station 7.10 or 7.32 depending on alternative. A grade control structure was included in the design to prevent head cutting that could damage project features, culturally significant areas and the Gilbert Road Bridge, sub-areas 5 and 6, Figure A-20. The sedimentation analysis was not completed during the F5 phase, the sedimentation model for the final alternative will be completed during the PED phase.

151. Vegetation will be damaged during flow events greater than the 5-year event. This occurs naturally and is important in the design of this project. The SBIN or flood irrigation systems allows the most flexibility for irrigating large areas of new vegetation and the ability to modify irrigation patterns to respond to changes in the project area. It also mimics more natural conditions and the recruitment of other species. The drawback to the SBIN or flood irrigation compared to the drip irrigation is a higher water loss and potentially more reshaping after flow events for greater than the 5 to 10-Year event.

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HYDRAULICS AND HYDROLOGY EXHIBITS

Exhibit A – Area Map

Exhibit B – HEC-RAS Model Figure, Baseline Condition (Model 11)

Exhibit C – Water Surface Profile, Baseline Condition (Model 11)

Exhibit D – Hydraulic Results, Baseline Condition (Model 11)

Exhibit E – HEC-RAS Model Figure, Alternative O (Model 9)

Exhibit F – Water Surface Profile, Alternative O (Model 9)

Exhibit G – Hydraulic Results, Alternative O (Model 9)

Exhibit H – Area of Inundation Map, Alternative O (Model 9)

EXHIBT A – AREA MAP

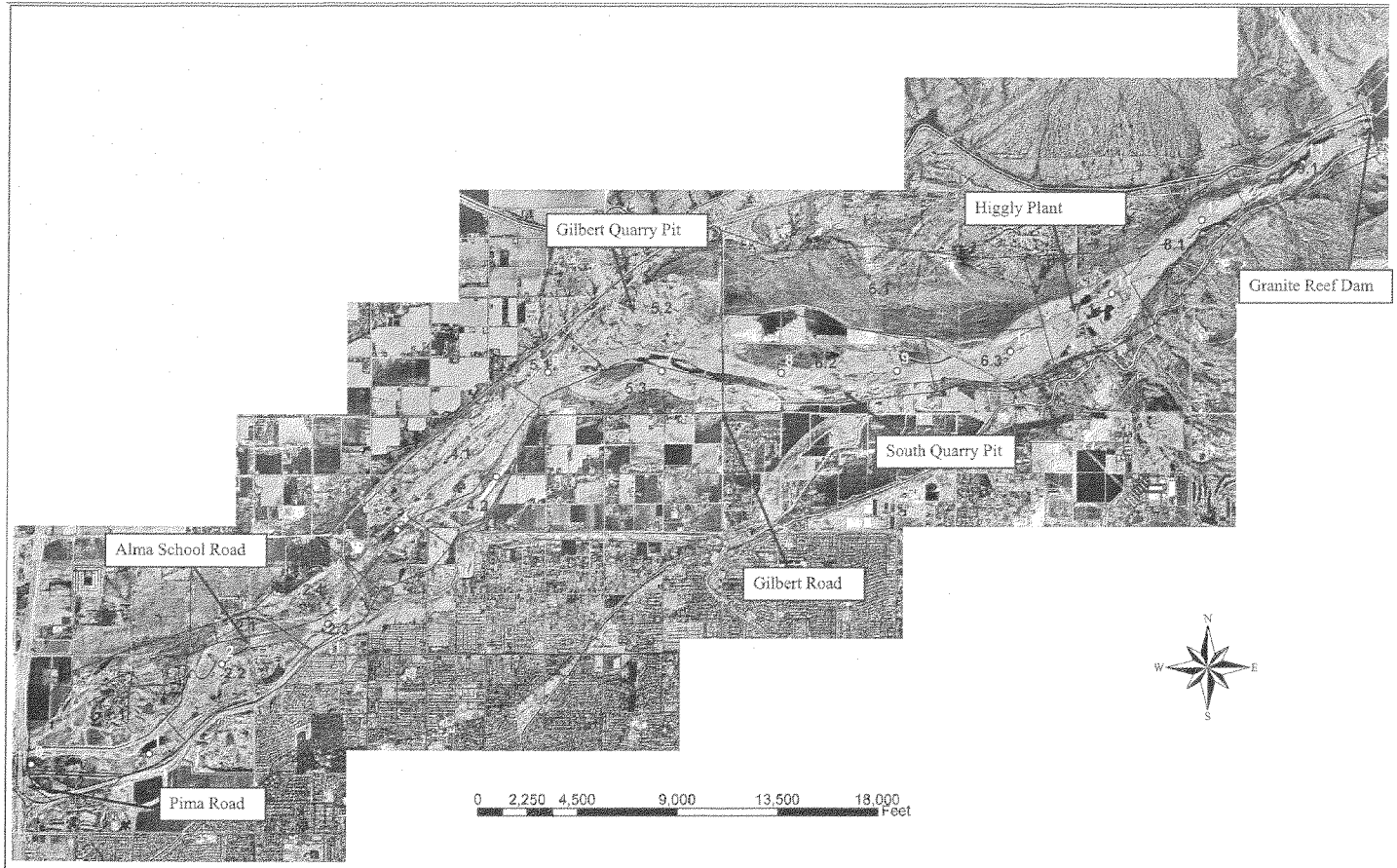


EXHIBIT B – HEC-RAS FIGURE BASELINE CONDITION

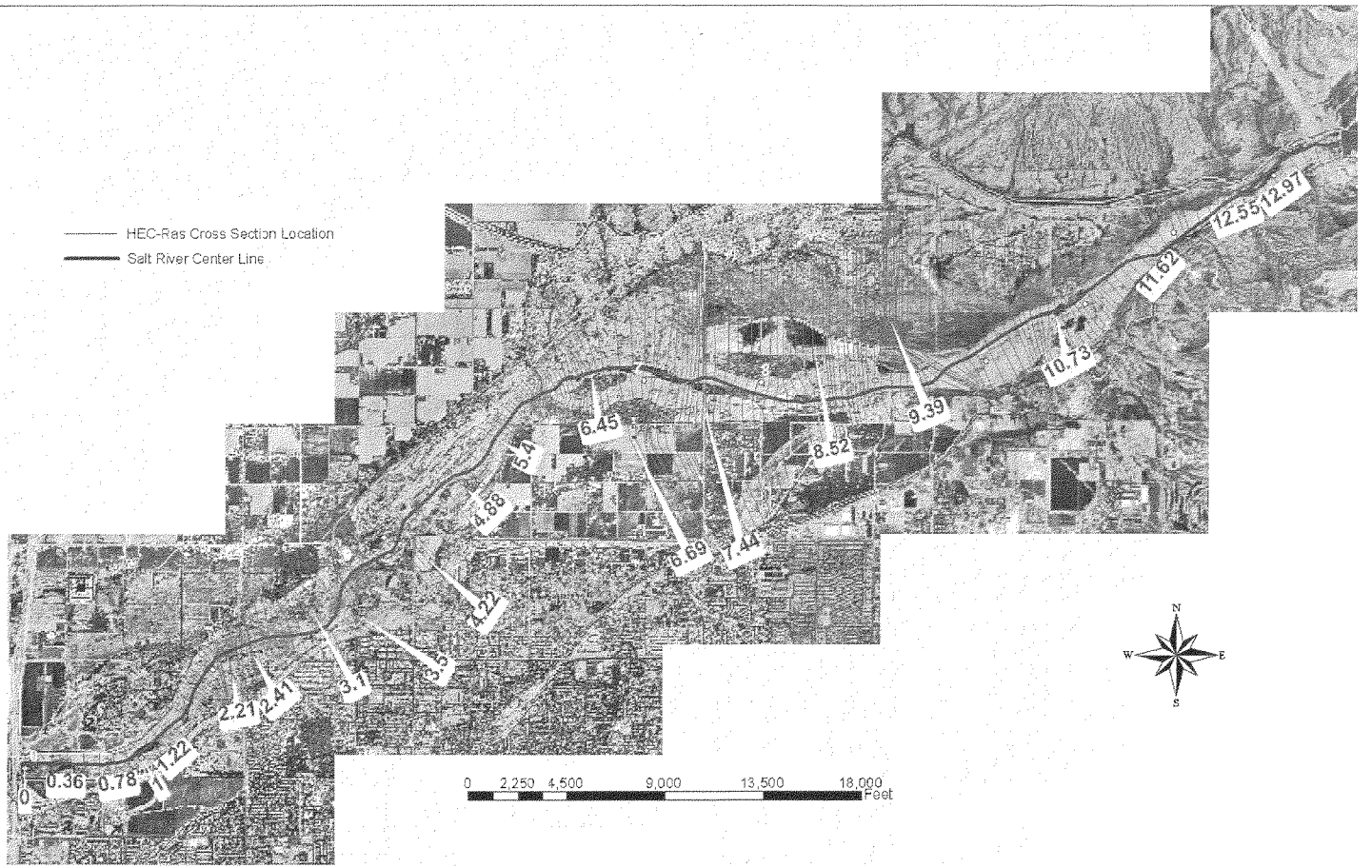


EXHIBIT C – WATER SURFACE PROFILE, BASELINE CONDITION (MODEL 11)

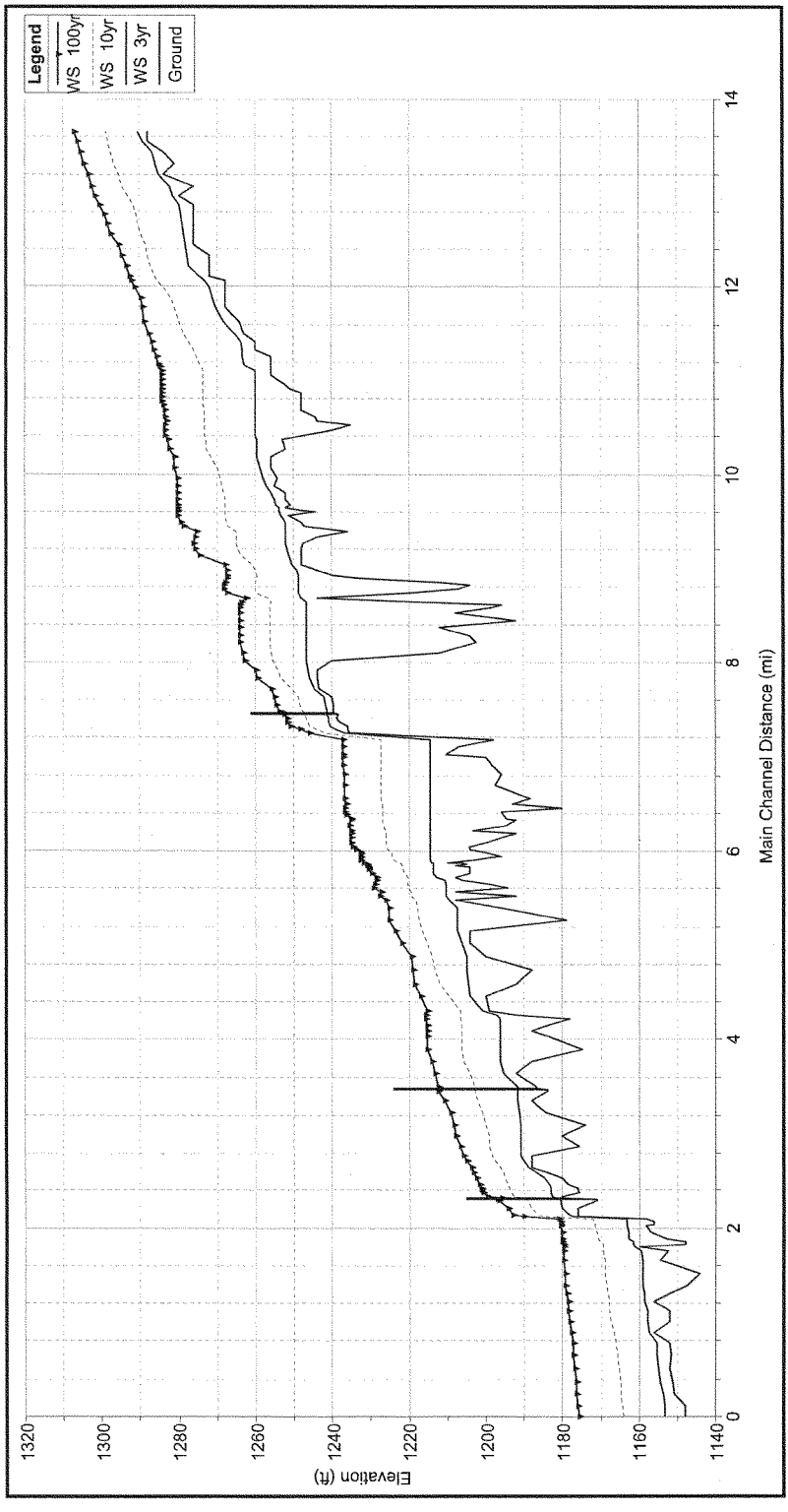


EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

Exhibit D.1 Hydraulic Results, Baseline Condition (Model 11) for the 3-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	2200	1288	1290.63	1290.75	0.001711	2.81	0.35
13.55	2200	1288	1289.36	1289.5	0.005398	3	0.54
13.44	2200	1284	1286.96	1287.14	0.002499	3.35	0.42
13.31	2200	1281.3	1286.05	1286.11	0.00055	1.95	0.21
13.19	2200	1284	1285.11	1285.4	0.009344	4.31	0.73
13.07	2200	1276	1282.21	1282.27	0.000397	1.9	0.18
12.97	2200	1280	1281.59	1281.88	0.00578	4.32	0.61
12.87	2200	1276	1279.95	1280.01	0.000549	2.02	0.21
12.77	2200	1276	1279.56	1279.64	0.000955	2.32	0.27
12.67	2200	1276	1279.18	1279.23	0.000602	1.92	0.21
12.55	2200	1276	1278.82	1278.88	0.000563	1.91	0.21
12.44	2200	1276	1278.32	1278.42	0.001214	2.51	0.3
12.33	2200	1272	1277.91	1277.94	0.000405	1.41	0.17
12.22	2200	1272	1277.29	1277.51	0.002722	3.8	0.45
12.1	2200	1272	1274.32	1274.94	0.008089	6.32	0.76
12.06	2200	1268	1273.28	1273.53	0.002117	4.08	0.41
11.99	2200	1268	1272.16	1272.51	0.003692	4.73	0.53
11.88	2200	1267.94	1271.07	1271.16	0.000815	2.49	0.26
11.78	2200	1268	1270.44	1270.57	0.001683	2.92	0.35
11.62	2200	1264	1268.47	1268.62	0.003616	3.17	0.47
11.49	2200	1263.04	1265.31	1265.61	0.005977	4.4	0.62
11.41	2200	1260	1263.83	1264	0.001338	3.32	0.33
11.32	2200	1260	1263.39	1263.49	0.000835	2.6	0.26
11.25	2200	1256	1263.16	1263.22	0.000463	2.03	0.2
11.17	2200	1256	1262.8	1262.92	0.001551	2.78	0.33
11.14	2200	1256	1261.95	1262.37	0.018316	5.21	0.66
11.1	2200	1256	1260.07	1260.18	0.00177	2.64	0.35
11.05	2200	1256	1259.91	1259.94	0.000168	1.28	0.12
11	2200	1254.01	1259.89	1259.9	0.000044	0.74	0.06
10.95	2200	1252	1259.89	1259.89	0.000009	0.44	0.03
10.9	2200	1250.83	1259.89	1259.89	0.000007	0.42	0.03
10.86	2200	1248	1259.88	1259.89	0.000004	0.38	0.02
10.81	2200	1248	1259.88	1259.89	0.000002	0.3	0.02
10.78	2200	1248	1259.88	1259.89	0.000002	0.3	0.02
10.73	2200	1248	1259.88	1259.88	0.000002	0.31	0.02
10.67	2200	1248	1259.88	1259.88	0.000006	0.43	0.03
10.61	2200	1244.2	1259.88	1259.88	0.000003	0.37	0.02
10.56	2200	1244	1259.88	1259.88	0.000003	0.35	0.02
10.52	2200	1234.97	1259.88	1259.88	0.000001	0.23	0.01
10.46	2200	1240	1259.88	1259.88	0.000003	0.35	0.02
10.41	2200	1247.67	1259.88	1259.88	0.000002	0.33	0.02
10.36	2200	1253	1259.77	1259.87	0.000815	2.55	0.26
10.26	2200	1252	1259.61	1259.62	0.000031	0.8	0.06
10.18	2200	1256	1259.46	1259.59	0.001077	2.79	0.29

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	2200	1256	1258.68	1258.81	0.001557	2.92	0.34
9.96	2200	1254.13	1258.07	1258.15	0.000743	2.21	0.24
9.87	2200	1254.92	1257.29	1257.54	0.005079	4.02	0.57
9.8	2200	1252	1255.71	1256.04	0.003116	4.63	0.49
9.73	2200	1252	1254.9	1255.06	0.001687	3.15	0.36
9.67	2200	1250.78	1254.42	1254.55	0.001325	2.88	0.32
9.64	2200	1252	1253.9	1254.25	0.00632	4.75	0.65
9.61	2200	1248.2	1253.66	1253.72	0.000361	1.87	0.17
9.59	2200	1244.4	1253.64	1253.67	0.00025	1.51	0.14
9.55	2200	1251.37	1253.34	1253.55	0.004141	3.69	0.52
9.49	2200	1248	1252.34	1252.46	0.002216	2.69	0.38
9.44	2200	1247.05	1252.13	1252.15	0.00015	1.35	0.12
9.39	2200	1236	1252.07	1252.12	0.000093	1.64	0.1
9.33	2200	1244	1252.04	1252.08	0.000173	1.68	0.13
9.26	2200	1247.57	1251.94	1251.99	0.000389	1.91	0.18
9.2	2200	1248	1251.78	1251.84	0.000512	1.98	0.2
9.13	2200	1248	1251.49	1251.58	0.001021	2.4	0.28
9.04	2200	1248	1250.42	1250.75	0.00495	4.59	0.59
8.98	2200	1244	1249.08	1249.38	0.003702	4.34	0.52
8.92	2200	1239.59	1248.66	1248.71	0.000196	1.79	0.14
8.88	2200	1233.08	1248.66	1248.68	0.000043	1.04	0.07
8.85	2200	1212	1248.67	1248.67	0.000002	0.4	0.02
8.81	2200	1204	1248.67	1248.67	0	0.22	0.01
8.77	2200	1206.87	1248.67	1248.67	0	0.18	0.01
8.74	2200	1220	1248.67	1248.67	0.000001	0.3	0.01
8.68	2200	1244	1248.16	1248.63	0.013099	5.51	0.88
8.63	2200	1216	1246.64	1246.64	0.000001	0.27	0.01
8.6	2200	1196	1246.64	1246.64	0	0.17	0.01
8.57	2200	1198.17	1246.64	1246.64	0	0.16	0
8.52	2200	1208	1246.64	1246.64	0	0.13	0
8.44	2200	1192	1246.64	1246.64	0	0.09	0
8.36	2200	1212	1246.64	1246.64	0	0.1	0
8.29	2200	1204	1246.64	1246.64	0	0.08	0
8.2	2200	1202.29	1246.64	1246.64	0	0.09	0
8.1	2200	1212	1246.64	1246.64	0.000001	0.23	0.01
8.01	2200	1240	1246.62	1246.64	0.000057	0.85	0.07
7.91	2200	1244	1246.44	1246.57	0.002274	2.84	0.39
7.83	2200	1244	1245.79	1245.84	0.000936	1.82	0.25
7.71	2200	1243.41	1244.58	1244.78	0.00919	3.6	0.7
7.63	2200	1240	1242.13	1242.2	0.001649	2.13	0.32
7.55	2200	1239.6	1241.72	1241.74	0.000476	1.28	0.18
7.47	2200	1239.83	1241.41	1241.46	0.001192	1.73	0.27
7.45	Bridge						
7.44	2200	1238.53	1241.24	1241.26	0.000518	1.23	0.18
7.4	2200	1239.06	1241.07	1241.11	0.000995	1.65	0.25
7.36	2200	1238.07	1240.93	1240.95	0.000511	1.24	0.18

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.32	2200	1240	1240.65	1240.75	0.007151	2.52	0.58
7.28	2200	1236	1239.19	1239.49	0.006186	4.38	0.63
7.24	2200	1235.58	1236.78	1237.14	0.019729	4.8	1
7.17	2200	1197.93	1214.63	1214.63	0.000008	0.36	0.03
7.1	2200	1206.84	1214.63	1214.63	0.000013	0.34	0.03
7.03	2200	1210.44	1214.62	1214.62	0.000056	0.61	0.07
6.99	2200	1200	1214.61	1214.61	0	0.12	0.01
6.91	2200	1198.45	1214.61	1214.61	0.000001	0.18	0.01
6.8	2200	1196	1214.61	1214.61	0.000001	0.17	0.01
6.69	2200	1197.62	1214.61	1214.61	0.000019	0.46	0.04
6.56	2200	1188.55	1214.6	1214.6	0.000001	0.15	0.01
6.5	2200	1192.83	1214.6	1214.6	0.000001	0.22	0.01
6.45	2200	1180	1214.6	1214.6	0	0.08	0
6.4	2200	1196	1214.6	1214.6	0	0.1	0
6.38	2200	1195.4	1214.6	1214.6	0.000001	0.21	0.01
6.35	2200	1194.53	1214.6	1214.6	0.000003	0.39	0.02
6.32	2200	1192	1214.6	1214.6	0.000002	0.35	0.02
6.27	2200	1194.49	1214.6	1214.6	0.000002	0.34	0.02
6.22	2200	1203.46	1214.58	1214.6	0.000041	1.11	0.07
6.18	2200	1192	1214.57	1214.59	0.000034	1.02	0.06
6.14	2200	1196	1214.58	1214.58	0.000002	0.31	0.01
6.09	2200	1200	1214.58	1214.58	0.000006	0.45	0.03
6.05	2200	1204	1214.57	1214.58	0.000015	0.59	0.04
6.01	2200	1204	1214.57	1214.57	0.000518	0.67	0.04
5.99	2200	1200	1214.54	1214.55	0.000012	0.49	0.03
5.97	2200	1198.59	1214.54	1214.54	0.000006	0.38	0.02
5.95	2200	1196	1214.54	1214.54	0.000003	0.31	0.02
5.93	2200	1198.79	1214.54	1214.54	0.000003	0.31	0.02
5.91	2200	1203.31	1214.54	1214.54	0.000026	0.59	0.04
5.88	2200	1209.96	1214.24	1214.51	0.024652	4.14	0.47
5.87	2200	1206.22	1213.79	1213.85	0.002417	1.83	0.17
5.86	2200	1205.11	1213.75	1213.78	0.00013	1.36	0.11
5.85	2200	1208	1213.74	1213.77	0.000046	1.46	0.12
5.84	2200	1204	1213.69	1213.76	0.000379	2.16	0.18
5.82	2200	1204	1213.66	1213.72	0.000367	2.04	0.18
5.8	2200	1204	1213.66	1213.68	0.00012	1.34	0.11
5.76	2200	1204	1213.6	1213.65	0.000375	1.77	0.18
5.73	2200	1208	1212.95	1213.46	0.017365	5.7	0.99
5.69	2200	1206.01	1210.55	1210.61	0.000412	1.89	0.18
5.65	2200	1198.67	1210.55	1210.55	0.000007	0.51	0.03
5.6	2200	1194.35	1210.55	1210.55	0.000002	0.34	0.02
5.56	2200	1208	1210.39	1210.53	0.002365	3.01	0.4
5.53	2200	1192	1210.27	1210.27	0.000004	0.46	0.02
5.47	2200	1208	1209.71	1210.22	0.012738	5.71	0.88
5.4	2200	1196	1207.54	1207.56	0.000033	1.05	0.06
5.26	2200	1179.01	1207.54	1207.54	0.000005	0.43	0.02

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
5.15	2200	1204	1207.42	1207.52	0.001649	2.58	0.34
5.03	2200	1204	1206.01	1206.15	0.002983	3.01	0.44
4.88	2200	1200	1204.84	1204.88	0.000208	1.5	0.13
4.74	2200	1188	1204.77	1204.78	0.000048	0.34	0.02
4.59	2200	1192	1204.71	1204.71	0.000236	0.54	0.05
4.47	2200	1200	1204.34	1204.42	0.002281	2.19	0.36
4.31	2200	1199.24	1200.65	1201	0.020282	4.77	1
4.27	2200	1192	1197.26	1197.62	0.008383	4.79	0.72
4.22	2200	1178.19	1196.35	1196.35	0.00001	0.66	0.04
4.15	2200	1184	1196.33	1196.35	0.000084	1.11	0.09
4.09	2200	1188	1196.29	1196.31	0.000137	1.09	0.11
4.04	2200	1184	1196.28	1196.28	0.00002	0.51	0.04
3.89	2200	1174.66	1196.27	1196.28	0.000001	0.3	0.01
3.76	2200	1188	1196.24	1196.27	0.000293	1.31	0.15
3.64	2200	1192	1195.3	1195.86	0.009471	6	0.8
3.5	2200	1186.84	1191.82	1191.88	0.000475	1.9	0.2
3.48	Bridge						
3.46	2200	1184	1191.77	1191.79	0.000094	1.07	0.09
3.35	2200	1188	1191.54	1191.66	0.001249	2.74	0.31
3.23	2200	1184.27	1191.15	1191.18	0.000223	1.5	0.14
3.1	2200	1174.02	1191.09	1191.09	0.00001	0.54	0.03
2.98	2200	1180	1191.08	1191.08	0.000016	0.63	0.04
2.87	2200	1175.62	1191.07	1191.07	0.000012	0.65	0.04
2.78	2200	1188	1190.93	1191.05	0.002909	2.83	0.43
2.71	2200	1188	1190.18	1190.28	0.001853	2.54	0.35
2.65	2200	1187.99	1188.85	1189.1	0.012588	4.02	0.8
2.59	2200	1184	1186.69	1186.86	0.002433	3.31	0.41
2.53	2200	1180	1184.7	1185.53	0.008812	7.32	0.82
2.47	2200	1178.61	1183.39	1183.67	0.001973	4.24	0.41
2.42	2200	1176	1183.19	1183.29	0.000482	2.6	0.21
2.41	2200	1176	1183.19	1183.27	0.000353	2.34	0.18
2.4	2200	1176	1183.18	1183.26	0.000286	2.27	0.17
2.38	2200	1175.59	1183.15	1183.21	0.000255	1.91	0.15
2.33	2200	1180	1182.8	1183.05	0.002782	4.02	0.46
2.31	Bridge						
2.29	2200	1170.86	1180.46	1180.47	0.00003	0.78	0.06
2.21	2200	1176	1180.04	1180.35	0.003393	4.45	0.5
2.13	2200	1176	1178.27	1178.6	0.005598	4.65	0.62
2.12	2200	1176	1177.37	1177.97	0.017088	6.25	1.01
2.1	2200	1158.27	1163.19	1163.43	0.002249	3.91	0.42
2.07	2200	1156	1163.08	1163.18	0.000539	2.44	0.22
2.04	2200	1156.31	1163.06	1163.09	0.00024	1.42	0.14
2.02	2200	1158.36	1163.05	1163.07	0.000124	1.12	0.1
1.95	2200	1157.05	1162.96	1163	0.000373	1.61	0.17
1.89	2200	1152.71	1162.56	1162.74	0.014518	3.44	0.44
1.86	2200	1148	1161.65	1161.66	0.000027	0.81	0.05

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.83	2200	1148	1161.6	1161.65	0.000265	1.65	0.15
1.8	2200	1160	1161.05	1161.52	0.017688	5.49	0.99
1.76	2200	1152.5	1159.28	1159.32	0.000247	1.56	0.15
1.65	2200	1154.51	1159.07	1159.12	0.000611	1.83	0.21
1.52	2200	1144	1158.89	1158.89	0.000001	0.24	0.01
1.39	2200	1147.32	1158.88	1158.89	0.000013	0.45	0.03
1.3	2200	1152	1158.8	1158.87	0.00046	2.09	0.2
1.22	2200	1156	1158.44	1158.55	0.002427	2.67	0.39
1.12	2200	1152	1157.82	1157.83	0.000056	0.92	0.07
1	2200	1152	1157.77	1157.79	0.000104	1	0.09
0.89	2200	1156	1157.43	1157.65	0.005829	3.78	0.59
0.78	2200	1152	1155.49	1155.56	0.000928	2.18	0.26
0.65	2200	1151.5	1155.16	1155.18	0.000175	1.05	0.12
0.51	2200	1152	1154.92	1154.97	0.00062	1.79	0.21
0.36	2200	1151.05	1154.35	1154.41	0.000839	1.95	0.24
0.23	2200	1150.96	1153.68	1153.74	0.001233	2.01	0.28
0.11	2200	1148	1153.21	1153.24	0.000305	1.44	0.15
0	2200	1148	1153.09	1153.1	0.000124	0.97	0.1

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

Exhibit D.2 Hydraulic Results, Baseline Condition (Model 11) for the 10-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	60000	1288	1299.07	1299.87	0.001845	7.15	0.45
13.55	60000	1288	1298.47	1299.09	0.001161	6.34	0.37
13.44	60000	1284	1297.75	1298.39	0.001181	6.42	0.37
13.31	60000	1281.3	1296.9	1297.58	0.001289	6.62	0.39
13.19	60000	1284	1295.58	1296.49	0.002178	7.67	0.49
13.07	60000	1276	1294.62	1295.32	0.001352	6.74	0.4
12.97	60000	1280	1293.09	1294.33	0.003102	8.91	0.58
12.87	60000	1276	1291.83	1292.98	0.001552	8.6	0.44
12.77	60000	1276	1290.92	1292.08	0.001886	8.64	0.48
12.67	60000	1276	1290.43	1291.14	0.001234	6.76	0.38
12.55	60000	1276	1289.7	1290.42	0.001113	6.8	0.37
12.44	60000	1276	1288.55	1289.54	0.002044	8	0.48
12.33	60000	1272	1287.95	1288.61	0.000914	6.48	0.34
12.22	60000	1272	1287.23	1287.95	0.001427	6.8	0.4
12.1	60000	1272	1286.13	1286.9	0.002032	7.05	0.47
12.06	60000	1268	1285.59	1286.38	0.002035	7.11	0.47
11.99	60000	1268	1284.02	1285.29	0.00435	9.03	0.66
11.88	60000	1267.94	1282.01	1283.1	0.003204	8.4	0.58
11.78	60000	1268	1281	1281.69	0.001652	6.67	0.43
11.62	60000	1264	1280.01	1280.49	0.00101	5.57	0.34
11.49	60000	1263.04	1278.82	1279.64	0.001589	7.24	0.43
11.41	60000	1260	1277.47	1278.72	0.002823	8.95	0.56
11.32	60000	1260	1276.08	1277.41	0.002989	9.24	0.58
11.25	60000	1256	1275.34	1276.34	0.001921	8	0.47
11.17	60000	1256	1274.63	1275.57	0.001694	7.77	0.45
11.14	60000	1256	1274.09	1275.1	0.005206	8.07	0.46
11.1	60000	1256	1273.75	1274.35	0.000778	6.21	0.31
11.05	60000	1256	1273.74	1274.16	0.000427	5.18	0.24
11	60000	1254.01	1273.71	1274.02	0.000257	4.5	0.19
10.95	60000	1252	1273.73	1273.94	0.000154	3.69	0.15
10.9	60000	1250.83	1273.69	1273.91	0.000153	3.75	0.15
10.86	60000	1248	1273.65	1273.87	0.000147	3.78	0.15
10.81	60000	1248	1273.64	1273.83	0.000104	3.47	0.13
10.78	60000	1248	1273.62	1273.81	0.000105	3.51	0.13
10.73	60000	1248	1273.57	1273.78	0.000115	3.67	0.13
10.67	60000	1248	1273.43	1273.73	0.000192	4.36	0.17
10.61	60000	1244.2	1273.38	1273.66	0.000168	4.32	0.16
10.56	60000	1244	1273.34	1273.62	0.000157	4.27	0.16
10.52	60000	1234.97	1273.39	1273.57	0.000079	3.4	0.11
10.46	60000	1240	1273.29	1273.53	0.000145	3.97	0.15
10.41	60000	1247.67	1273.29	1273.48	0.000106	3.49	0.13
10.36	60000	1253	1272.76	1273.39	0.000855	6.35	0.33
10.26	60000	1252	1272.63	1273	0.000369	4.84	0.22
10.18	60000	1256	1271.58	1272.64	0.002169	8.29	0.5

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	60000	1256	1270.09	1271.33	0.002115	8.95	0.5
9.96	60000	1254.13	1269.17	1270.22	0.001603	8.41	0.45
9.87	60000	1254.92	1268.64	1269.48	0.001402	7.6	0.41
9.8	60000	1252	1268.26	1269	0.001146	7.33	0.38
9.73	60000	1252	1268	1268.56	0.001005	6.45	0.35
9.67	60000	1250.78	1267.89	1268.27	0.000532	5.53	0.27
9.64	60000	1252	1267.87	1268.19	0.000471	5.03	0.25
9.61	60000	1248.2	1267.86	1268.12	0.000316	4.53	0.21
9.59	60000	1244.4	1267.86	1268.07	0.000243	4.15	0.18
9.55	60000	1251.37	1267.75	1268.01	0.000306	4.38	0.2
9.49	60000	1248	1267.46	1267.86	0.000398	5.25	0.23
9.44	60000	1247.05	1266.98	1267.72	0.00062	7.12	0.3
9.39	60000	1236	1265.02	1267.28	0.002419	12.54	0.57
9.33	60000	1244	1265.12	1266.45	0.001492	9.51	0.44
9.26	60000	1247.57	1264.98	1265.86	0.001028	7.75	0.37
9.2	60000	1248	1264.76	1265.51	0.000854	7.13	0.34
9.13	60000	1248	1263.88	1265.07	0.001338	9	0.42
9.04	60000	1248	1260.71	1263.85	0.004819	14.66	0.77
8.98	60000	1244	1260.1	1262.24	0.003565	12.1	0.66
8.92	60000	1239.59	1259.78	1261.14	0.002061	9.62	0.51
8.88	60000	1233.08	1259.78	1260.71	0.001319	7.94	0.41
8.85	60000	1212	1260.02	1260.4	0.000331	5.09	0.22
8.81	60000	1204	1260.12	1260.3	0.000094	3.47	0.12
8.77	60000	1206.87	1260.14	1260.27	0.000054	3.03	0.1
8.74	60000	1220	1259.93	1260.24	0.000079	4.57	0.16
8.68	60000	1244	1256.52	1259.89	0.010266	15.16	1.03
8.63	60000	1216	1256.07	1256.36	0.000243	4.49	0.18
8.6	60000	1196	1256.2	1256.28	0.00003	2.52	0.07
8.57	60000	1198.17	1256.21	1256.27	0.000019	2.09	0.06
8.52	60000	1208	1256.21	1256.26	0.000014	1.89	0.05
8.44	60000	1192	1256.21	1256.26	0.000013	1.71	0.05
8.36	60000	1212	1256.2	1256.25	0.000017	1.83	0.05
8.29	60000	1204	1256.2	1256.24	0.000011	1.62	0.04
8.2	60000	1202.29	1256.19	1256.23	0.000013	1.8	0.05
8.1	60000	1212	1255.99	1256.2	0.000115	3.83	0.13
8.01	60000	1240	1255.65	1256.1	0.000728	5.48	0.3
7.91	60000	1244	1254.07	1255.39	0.003086	9.38	0.59
7.83	60000	1244	1253.17	1254.12	0.002193	7.86	0.49
7.71	60000	1243.41	1250.32	1252.08	0.005694	10.65	0.76
7.63	60000	1240	1248.88	1249.92	0.002605	8.2	0.53
7.55	58000	1239.6	1248.41	1248.97	0.001278	6	0.38
7.47	58000	1239.83	1247.67	1248.34	0.001768	6.56	0.44
7.45	Bridge						
7.44	58000	1238.53	1247.14	1247.75	0.001569	6.29	0.41
7.4	58000	1239.06	1246.66	1247.35	0.002203	6.83	0.48
7.36	58000	1238.07	1246.34	1246.88	0.001757	5.94	0.42
7.32	58000	1240	1245.88	1246.48	0.002259	6.23	0.47

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.28	58000	1236	1244.42	1245.77	0.006977	9.33	0.8
7.24	58000	1235.58	1241.71	1243.61	0.010667	11.05	1
7.17	58000	1197.93	1227.34	1227.39	0.000058	1.81	0.09
7.1	58000	1206.84	1227.32	1227.37	0.000049	1.82	0.08
7.03	58000	1210.44	1227.23	1227.34	0.000112	2.63	0.12
6.99	58000	1200	1227.27	1227.3	0.00002	1.56	0.06
6.91	58000	1198.45	1227.24	1227.29	0.000043	1.82	0.08
6.8	58000	1196	1227.21	1227.27	0.000034	1.89	0.07
6.69	58000	1197.62	1227.11	1227.23	0.000111	2.82	0.12
6.56	58000	1188.55	1227.11	1227.16	0.000028	1.76	0.07
6.5	58000	1192.83	1227.05	1227.14	0.000057	2.38	0.09
6.45	58000	1180	1227.09	1227.11	0.000009	1.1	0.04
6.4	58000	1196	1227.08	1227.11	0.000014	1.39	0.05
6.38	58000	1195.4	1227	1227.1	0.000064	2.37	0.1
6.35	58000	1194.53	1226.71	1227.06	0.000242	4.75	0.19
6.32	58000	1192	1226.71	1227.02	0.000198	4.44	0.17
6.27	58000	1194.49	1226.71	1226.93	0.000185	3.77	0.16
6.22	58000	1203.46	1226	1226.79	0.001193	7.17	0.38
6.18	58000	1192	1226.1	1226.51	0.000556	5.15	0.26
6.14	58000	1196	1226.19	1226.36	0.000133	3.23	0.14
6.09	58000	1200	1226.08	1226.31	0.000222	3.85	0.17
6.05	58000	1204	1225.8	1226.21	0.000465	5.15	0.25
6.01	58000	1204	1225.46	1226.03	0.022449	6.04	0.3
5.99	58000	1200	1224.42	1224.82	0.000688	5.09	0.24
5.97	58000	1198.59	1224.4	1224.75	0.000596	4.74	0.22
5.95	58000	1196	1224.39	1224.66	0.000317	4.17	0.18
5.93	58000	1198.79	1224.37	1224.62	0.000408	4.04	0.18
5.91	58000	1203.31	1224.15	1224.55	0.000789	5.04	0.27
5.88	58000	1209.96	1222.39	1224.16	0.014327	10.69	0.82
5.87	58000	1206.22	1222.18	1223.65	0.004639	9.75	0.69
5.86	58000	1205.11	1222.03	1223.18	0.02146	8.59	0.54
5.85	58000	1208	1221.74	1222.35	0.001035	6.29	0.35
5.84	58000	1204	1221.64	1222.28	0.001043	6.44	0.35
5.82	58000	1204	1221.6	1222.16	0.000861	6.02	0.32
5.8	58000	1204	1221.52	1222.08	0.000816	6	0.32
5.76	58000	1204	1221.11	1221.88	0.00131	7.01	0.39
5.73	58000	1208	1220.21	1221.47	0.002689	9.01	0.55
5.69	58000	1206.01	1220.24	1221	0.001144	6.96	0.37
5.65	58000	1198.67	1220.35	1220.72	0.000365	4.92	0.22
5.6	58000	1194.35	1220.42	1220.59	0.000122	3.35	0.13
5.56	58000	1208	1219.33	1220.45	0.002219	8.49	0.5
5.53	58000	1192	1219.59	1219.99	0.00044	5.01	0.24
5.47	58000	1208	1218.16	1219.65	0.004243	9.82	0.67
5.4	58000	1196	1217.69	1218.39	0.000952	6.73	0.34
5.26	58000	1179.01	1217.44	1217.81	0.000376	4.87	0.22
5.15	58000	1204	1216.53	1217.4	0.001718	7.52	0.44
5.03	58000	1204	1215.49	1216.33	0.001587	7.34	0.43

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
4.88	58000	1200	1213.9	1214.99	0.001784	8.36	0.46
4.74	58000	1188	1213.32	1213.58	0.001377	4.09	0.18
4.59	58000	1192	1212	1212.36	0.001661	4.86	0.27
4.47	58000	1200	1209.71	1210.78	0.003588	8.33	0.6
4.31	58000	1199.24	1206.78	1207.88	0.003422	7.91	0.58
4.27	58000	1192	1206.75	1207.21	0.000923	5.43	0.33
4.22	58000	1178.19	1206.71	1206.97	0.000383	3.95	0.22
4.15	58000	1184	1206.4	1206.79	0.000753	5	0.29
4.09	58000	1188	1206.26	1206.54	0.000594	4.19	0.26
4.04	58000	1184	1206.23	1206.39	0.000213	3.2	0.16
3.89	58000	1174.66	1206.18	1206.26	0.00006	2.28	0.09
3.76	58000	1188	1205.64	1206.14	0.000812	5.66	0.31
3.64	58000	1192	1204.17	1205.28	0.002748	8.48	0.55
3.5	58000	1186.84	1202.99	1203.6	0.001062	6.24	0.36
3.48	Bridge						
3.46	58000	1184	1202.78	1203.27	0.000669	5.6	0.29
3.35	58000	1188	1202.04	1202.71	0.001136	6.6	0.37
3.23	58000	1184.27	1200.65	1201.78	0.001922	8.54	0.48
3.1	58000	1174.02	1200.08	1200.71	0.0007	6.38	0.3
2.98	58000	1180	1199.36	1200.22	0.000894	7.42	0.34
2.87	58000	1175.62	1198.99	1199.6	0.000912	6.25	0.33
2.78	58000	1188	1198.16	1198.95	0.00198	7.18	0.46
2.71	58000	1188	1197.4	1198.28	0.002157	7.54	0.49
2.65	58000	1187.99	1196.24	1197.39	0.002759	8.58	0.55
2.59	58000	1184	1195.64	1196.6	0.002179	7.85	0.49
2.53	58000	1180	1194.94	1195.85	0.002246	7.67	0.5
2.47	58000	1178.61	1194.06	1195.1	0.002472	8.17	0.52
2.42	58000	1176	1193.76	1194.5	0.001429	6.91	0.41
2.41	58000	1176	1193.72	1194.44	0.001358	6.82	0.4
2.4	58000	1176	1193.65	1194.38	0.001383	6.86	0.4
2.38	58000	1175.59	1193.38	1194.17	0.001584	7.13	0.43
2.33	58000	1180	1192.42	1193.6	0.002954	8.71	0.57
2.31	Bridge						
2.29	58000	1170.86	1189.41	1190.01	0.000915	6.19	0.33
2.21	58000	1176	1187.8	1189.15	0.00375	9.32	0.63
2.13	58000	1176	1186.41	1187.69	0.003231	9.1	0.59
2.12	58000	1176	1184.65	1187.21	0.010359	12.85	1
2.1	58000	1158.27	1172.15	1173.78	0.005572	10.23	0.75
2.07	58000	1156	1171.61	1173.01	0.003825	9.47	0.64
2.04	58000	1156.31	1171.5	1172.38	0.001714	7.53	0.45
2.02	58000	1158.36	1171.5	1172.16	0.000989	6.49	0.35
1.95	58000	1157.05	1171.15	1171.77	0.001095	6.31	0.36
1.89	58000	1152.71	1170.57	1171.31	0.00173	6.89	0.44
1.86	58000	1148	1170.36	1171.05	0.001678	6.69	0.43
1.83	58000	1148	1169.48	1170.62	0.003487	8.57	0.6
1.8	58000	1160	1169.24	1170.03	0.00227	7.14	0.49
1.76	58000	1152.5	1169.31	1169.6	0.000486	4.36	0.24

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.65	58000	1154.51	1168.97	1169.29	0.000664	4.49	0.27
1.52	58000	1144	1168.81	1168.96	0.000138	3.14	0.14
1.39	58000	1147.32	1168.63	1168.83	0.000256	3.63	0.18
1.3	58000	1152	1168.19	1168.62	0.000914	5.26	0.32
1.22	58000	1156	1167.89	1168.27	0.00073	4.94	0.29
1.12	58000	1152	1167.55	1167.89	0.000592	4.69	0.27
1	58000	1152	1167.22	1167.55	0.000538	4.61	0.25
0.89	58000	1156	1166.55	1167.1	0.001249	5.95	0.37
0.78	58000	1152	1166.07	1166.46	0.0007	5.06	0.29
0.65	58000	1151.5	1165.78	1166.06	0.000384	4.25	0.22
0.51	58000	1152	1165.41	1165.74	0.000485	4.57	0.24
0.36	58000	1151.05	1165	1165.34	0.000521	4.7	0.25
0.23	58000	1150.96	1164.68	1165	0.000473	4.57	0.24
0.11	58000	1148	1164.29	1164.67	0.000569	4.9	0.26
0	58000	1148	1164.04	1164.36	0.000401	4.54	0.23

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

Exhibit D.3 Hydraulic Results, Baseline Condition (Model 11) for the 100-Year event.

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
13.64	175000	1288	1306.99	1308.6	0.001536	10.17	0.46
13.55	175000	1288	1306.41	1307.88	0.001284	9.76	0.43
13.44	175000	1284	1305.53	1307.09	0.001344	10.01	0.44
13.31	175000	1281.3	1304.54	1306.14	0.001566	10.15	0.46
13.19	175000	1284	1303.47	1305.04	0.001771	10.07	0.48
13.07	175000	1276	1302.66	1303.98	0.001361	9.21	0.43
12.97	175000	1280	1301.64	1303.2	0.001722	10	0.48
12.87	175000	1276	1300.58	1302.17	0.001857	10.12	0.49
12.77	175000	1276	1299.28	1301.17	0.001846	11.03	0.5
12.67	175000	1276	1298.58	1300.26	0.001436	10.41	0.45
12.55	175000	1276	1297.49	1299.31	0.001632	10.83	0.48
12.44	175000	1276	1295.68	1298.09	0.002469	12.47	0.58
12.33	175000	1272	1294.69	1296.82	0.001747	11.72	0.5
12.22	175000	1272	1293.7	1295.7	0.001973	11.35	0.52
12.1	175000	1272	1292.71	1294.37	0.001966	10.34	0.51
12.06	175000	1268	1292.39	1293.83	0.001736	9.65	0.48
11.99	175000	1268	1291.29	1293.05	0.002375	10.64	0.55
11.88	175000	1267.94	1289.94	1291.78	0.002079	10.89	0.52
11.78	175000	1268	1289.45	1290.75	0.001178	9.14	0.41
11.62	175000	1264	1288.86	1289.79	0.000821	7.75	0.34
11.49	175000	1263.04	1287.72	1289.08	0.001288	9.36	0.42
11.41	175000	1260	1287.01	1288.45	0.001614	9.63	0.46
11.32	175000	1260	1286.36	1287.77	0.00134	9.79	0.43
11.25	175000	1256	1285.72	1287.26	0.001162	10.14	0.41
11.17	175000	1256	1285.14	1286.77	0.001151	10.31	0.41
11.14	175000	1256	1284.75	1286.44	0.003492	10.48	0.42
11.1	175000	1256	1284.52	1285.9	0.000814	9.45	0.35
11.05	175000	1256	1284.54	1285.67	0.000583	8.51	0.31
11	175000	1254.01	1284.48	1285.47	0.000448	7.99	0.27
10.95	175000	1252	1284.59	1285.29	0.000298	6.7	0.22
10.9	175000	1250.83	1284.48	1285.22	0.000311	6.89	0.23
10.86	175000	1248	1284.35	1285.14	0.000314	7.11	0.23
10.81	175000	1248	1284.33	1285.05	0.000261	6.82	0.21
10.78	175000	1248	1284.25	1284.99	0.000279	6.92	0.22
10.73	175000	1248	1284.1	1284.92	0.000293	7.28	0.23
10.67	175000	1248	1283.7	1284.78	0.000435	8.34	0.27
10.61	175000	1244.2	1283.5	1284.63	0.000425	8.54	0.27
10.56	175000	1244	1283.38	1284.53	0.000421	8.61	0.27
10.52	175000	1234.97	1283.58	1284.33	0.000237	7.03	0.21
10.46	175000	1240	1283.5	1284.24	0.000298	7.16	0.23
10.41	175000	1247.67	1283.47	1284.16	0.000251	6.75	0.21
10.36	175000	1253	1282.68	1283.99	0.000839	9.37	0.36
10.26	175000	1252	1282.5	1283.56	0.000567	8.29	0.3
10.18	175000	1256	1281.26	1283.11	0.001536	10.93	0.47

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
10.06	175000	1256	1281.03	1282.17	0.000851	9.18	0.36
9.96	175000	1254.13	1280.47	1281.69	0.000823	9.51	0.36
9.87	175000	1254.92	1280.2	1281.31	0.000712	8.89	0.33
9.8	175000	1252	1280.23	1280.98	0.000485	7.63	0.28
9.73	175000	1252	1280.31	1280.74	0.000306	5.97	0.22
9.67	175000	1250.78	1280.24	1280.65	0.000259	5.95	0.21
9.64	175000	1252	1280.25	1280.6	0.000227	5.48	0.19
9.61	175000	1248.2	1280.24	1280.57	0.000196	5.35	0.18
9.59	175000	1244.4	1280.24	1280.53	0.000169	5.08	0.17
9.55	175000	1251.37	1280.09	1280.48	0.000224	5.66	0.19
9.49	175000	1248	1279.58	1280.34	0.000397	7.64	0.26
9.44	175000	1247.05	1278.5	1280.14	0.000834	11.17	0.37
9.39	175000	1236	1275.23	1279.52	0.002914	18.65	0.67
9.33	175000	1244	1275.83	1278.37	0.001565	13.97	0.5
9.26	175000	1247.57	1276	1277.64	0.00099	11.17	0.4
9.2	175000	1248	1275.87	1277.26	0.000854	10.26	0.37
9.13	175000	1248	1274.43	1276.75	0.001442	13.29	0.48
9.04	175000	1248	1267.84	1275.11	0.006714	23.41	0.98
8.98	175000	1244	1267.26	1271.89	0.004426	18.75	0.79
8.92	175000	1239.59	1267.32	1270.3	0.002619	15.04	0.62
8.88	175000	1233.08	1267.58	1269.63	0.001712	12.46	0.5
8.85	175000	1212	1268.05	1269.14	0.000656	9.1	0.32
8.81	175000	1204	1268.28	1268.91	0.000261	6.87	0.21
8.77	175000	1206.87	1268.31	1268.83	0.000181	6.23	0.18
8.74	175000	1220	1267.6	1268.72	0.000478	9.21	0.28
8.68	175000	1244	1262.56	1268.01	0.008526	20.36	1.04
8.63	175000	1216	1263.83	1264.71	0.000535	8.17	0.29
8.6	175000	1196	1264.17	1264.5	0.000108	5.27	0.14
8.57	175000	1198.17	1264.21	1264.46	0.000069	4.53	0.11
8.52	175000	1208	1264.22	1264.43	0.000055	4.11	0.1
8.44	175000	1192	1264.22	1264.4	0.000049	3.7	0.1
8.36	175000	1212	1264.17	1264.37	0.000059	3.9	0.11
8.29	175000	1204	1264.17	1264.34	0.00004	3.56	0.09
8.2	175000	1202.29	1264.11	1264.32	0.000049	3.98	0.1
8.1	175000	1212	1263.48	1264.22	0.00032	7.58	0.23
8.01	175000	1240	1263.05	1264	0.000848	8.4	0.35
7.91	175000	1244	1260.18	1263.1	0.00342	14.39	0.68
7.83	175000	1244	1259.5	1261.58	0.002331	12	0.56
7.71	175000	1243.41	1256.06	1259.5	0.004908	15.21	0.79
7.63	175000	1240	1254.89	1257.36	0.002947	12.73	0.62
7.55	172000	1239.6	1254.61	1256.12	0.001644	9.87	0.47
7.47	172000	1239.83	1253.59	1255.32	0.002057	10.53	0.52
7.45	Bridge						
7.44	172000	1238.53	1252.44	1254.22	0.002239	10.72	0.54
7.4	172000	1239.06	1251.6	1253.62	0.003015	11.71	0.61
7.36	172000	1238.07	1251.58	1252.7	0.001677	8.7	0.46
7.32	172000	1240	1251.08	1252.33	0.001961	9.09	0.49

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

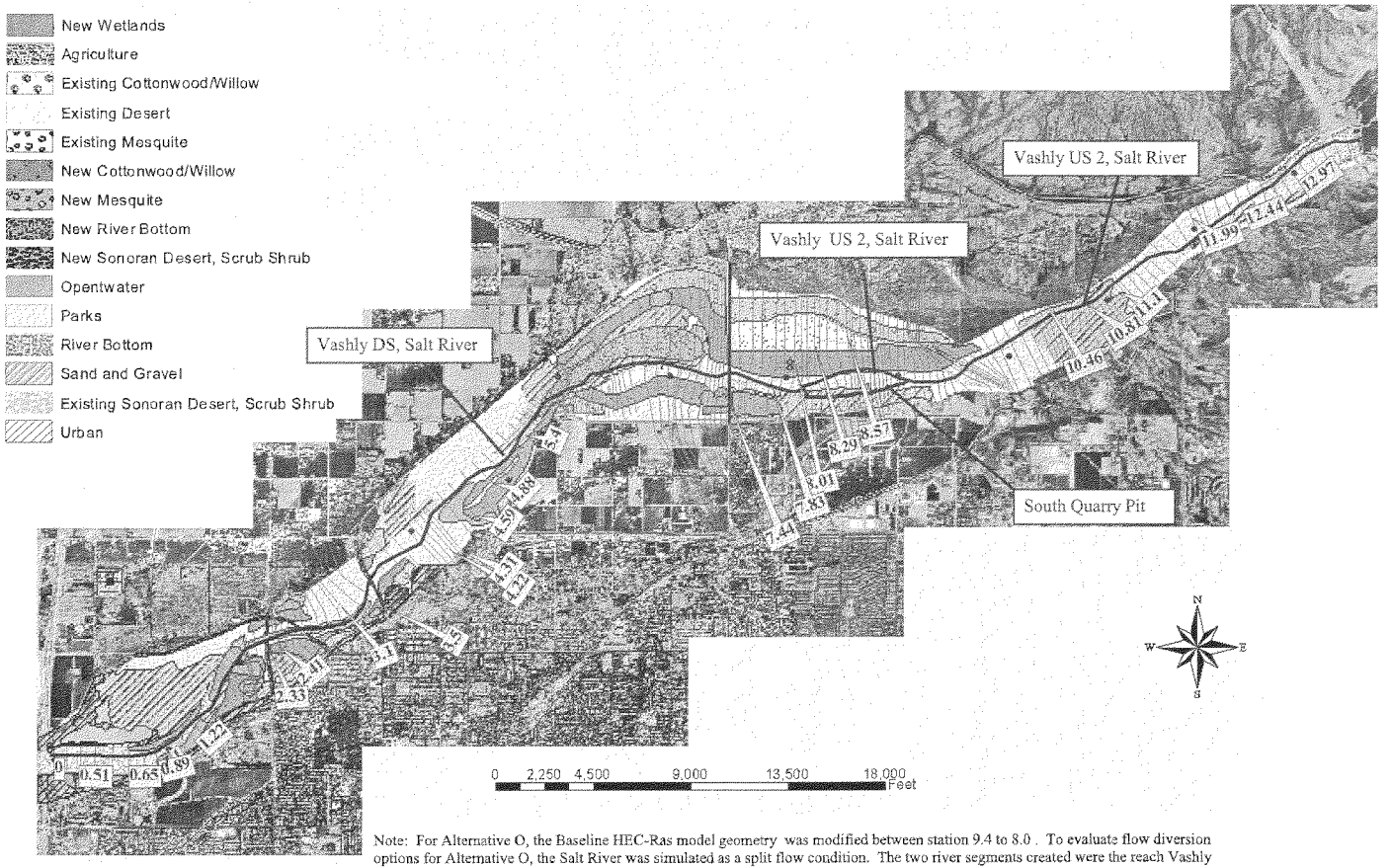
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
7.28	172000	1236	1248.59	1251.59	0.0063	13.89	0.85
7.24	172000	1235.58	1245.75	1249.65	0.008952	15.85	1
7.17	172000	1197.93	1237.34	1237.48	0.00008	3.03	0.11
7.1	172000	1206.84	1237.29	1237.45	0.000084	3.23	0.12
7.03	172000	1210.44	1237.08	1237.39	0.00019	4.51	0.17
6.99	172000	1200	1237.16	1237.32	0.000058	3.21	0.1
6.91	172000	1198.45	1237.11	1237.29	0.000083	3.36	0.12
6.8	172000	1196	1237.02	1237.24	0.000085	3.78	0.12
6.69	172000	1197.62	1236.73	1237.15	0.000212	5.18	0.18
6.56	172000	1188.55	1236.78	1236.98	0.000075	3.61	0.11
6.5	172000	1192.83	1236.59	1236.94	0.000148	4.74	0.16
6.45	172000	1180	1236.75	1236.84	0.000027	2.4	0.07
6.4	172000	1196	1236.68	1236.82	0.000044	3.01	0.09
6.38	172000	1195.4	1236.38	1236.79	0.000166	4.89	0.16
6.35	172000	1194.53	1235.22	1236.64	0.000662	9.61	0.33
6.32	172000	1192	1235.25	1236.52	0.000562	9.09	0.31
6.27	172000	1194.49	1235.43	1236.24	0.000413	7.26	0.26
6.22	172000	1203.46	1235.37	1236.1	0.000459	6.91	0.26
6.18	172000	1192	1235.27	1236.01	0.000466	7	0.27
6.14	172000	1196	1235.31	1235.87	0.000276	6.09	0.21
6.09	172000	1200	1235.03	1235.77	0.000404	7.01	0.25
6.05	172000	1204	1234.67	1235.63	0.000625	7.84	0.31
6.01	172000	1204	1234.11	1235.37	0.031706	8.99	0.38
5.99	172000	1200	1232.7	1233.62	0.001225	7.69	0.33
5.97	172000	1198.59	1232.58	1233.5	0.001172	7.74	0.32
5.95	172000	1196	1232.59	1233.31	0.000672	6.79	0.27
5.93	172000	1198.79	1232.63	1233.22	0.000647	6.2	0.24
5.91	172000	1203.31	1232.49	1233.13	0.000792	6.47	0.27
5.88	172000	1209.96	1231.94	1232.95	0.001083	8.19	0.38
5.87	172000	1206.22	1231.68	1232.87	0.001201	8.76	0.4
5.86	172000	1205.11	1231.13	1232.72	0.011654	10.12	0.44
5.85	172000	1208	1230.87	1232.29	0.001107	9.56	0.4
5.84	172000	1204	1230.67	1232.21	0.001193	9.95	0.41
5.82	172000	1204	1230.62	1232.07	0.001032	9.66	0.39
5.8	172000	1204	1230.48	1231.96	0.001032	9.78	0.39
5.76	172000	1204	1229.87	1231.71	0.001427	10.88	0.45
5.73	172000	1208	1228.53	1231.25	0.002438	13.24	0.58
5.69	172000	1206.01	1228.67	1230.73	0.001516	11.5	0.47
5.65	172000	1198.67	1229.07	1230.22	0.000725	8.6	0.33
5.6	172000	1194.35	1229.22	1229.94	0.000319	6.8	0.23
5.56	172000	1208	1227.22	1229.65	0.002438	12.51	0.58
5.53	172000	1192	1227.75	1228.99	0.000873	8.93	0.36
5.47	172000	1208	1225.87	1228.48	0.002876	13	0.62
5.4	172000	1196	1225.43	1227.4	0.001625	11.43	0.48
5.26	172000	1179.01	1225.08	1226.3	0.000776	9.07	0.34
5.15	172000	1204	1223.48	1225.57	0.002035	11.85	0.53
5.03	172000	1204	1222.13	1224.24	0.002089	11.92	0.54

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
4.88	172000	1200	1219.45	1222.22	0.00313	13.65	0.72
4.74	172000	1188	1219.23	1220.23	0.000817	8.23	0.34
4.59	172000	1192	1218.48	1219.53	0.000941	8.39	0.36
4.47	172000	1200	1216.91	1218.6	0.00207	10.67	0.52
4.31	172000	1199.24	1215.5	1217.04	0.001573	9.85	0.46
4.27	172000	1192	1215.66	1216.61	0.000775	7.88	0.33
4.22	172000	1178.19	1215.69	1216.35	0.000453	6.41	0.26
4.15	172000	1184	1215.32	1216.16	0.000657	7.34	0.31
4.09	172000	1188	1215.33	1215.9	0.000453	5.98	0.26
4.04	172000	1184	1215.36	1215.74	0.000268	4.86	0.2
3.89	172000	1174.66	1215.26	1215.55	0.000139	4.37	0.15
3.76	172000	1188	1214.26	1215.31	0.000894	8.23	0.36
3.64	172000	1192	1213.14	1214.54	0.001648	9.51	0.46
3.5	172000	1186.84	1212.46	1213.4	0.000775	7.77	0.33
3.48	Bridge						
3.46	172000	1184	1212.26	1213.07	0.000606	7.23	0.3
3.35	172000	1188	1210.69	1212.33	0.001317	10.28	0.44
3.23	172000	1184.27	1209	1211.27	0.002074	12.09	0.54
3.1	172000	1174.02	1208.16	1209.87	0.001412	10.5	0.45
2.98	172000	1180	1207.72	1209.05	0.000943	9.28	0.37
2.87	172000	1175.62	1206.51	1208.32	0.001429	10.79	0.45
2.78	172000	1188	1205.87	1207.51	0.001621	10.28	0.47
2.71	172000	1188	1205.08	1206.93	0.001831	10.92	0.5
2.65	172000	1187.99	1203.55	1206.09	0.002605	12.78	0.59
2.59	172000	1184	1203.11	1205.28	0.002134	11.82	0.54
2.53	172000	1180	1202.61	1204.54	0.001889	11.17	0.51
2.47	172000	1178.61	1201.6	1203.86	0.002259	12.06	0.55
2.42	172000	1176	1201.35	1203.24	0.00167	11.02	0.48
2.41	172000	1176	1201.3	1203.17	0.001627	10.96	0.48
2.4	172000	1176	1201.23	1203.1	0.001642	10.97	0.48
2.38	172000	1175.59	1200.93	1202.85	0.001828	11.11	0.5
2.33	172000	1180	1199.53	1202.15	0.002793	12.98	0.61
2.31	Bridge						
2.29	172000	1170.86	1196.83	1198.6	0.001424	10.68	0.45
2.21	172000	1176	1194.29	1197.34	0.003603	14.03	0.69
2.13	172000	1176	1192.78	1195.85	0.003607	14.06	0.69
2.12	172000	1176	1190.15	1195.29	0.008219	18.19	1
2.1	172000	1158.27	1180.87	1183.13	0.002325	12.06	0.56
2.07	172000	1156	1180.58	1182.78	0.00207	11.91	0.54
2.04	172000	1156.31	1180.55	1182.37	0.001475	10.8	0.46
2.02	172000	1158.36	1180.48	1182.18	0.001175	10.47	0.42
1.95	172000	1157.05	1180.28	1181.69	0.001045	9.5	0.39
1.89	172000	1152.71	1180.05	1181.28	0.001056	8.89	0.39
1.86	172000	1148	1179.95	1181.12	0.001	8.68	0.38
1.83	172000	1148	1179.57	1180.9	0.001327	9.28	0.42
1.8	172000	1160	1179.6	1180.62	0.000899	8.11	0.36
1.76	172000	1152.5	1179.77	1180.36	0.00041	6.19	0.25

EXHIBIT D – HYDRAULIC RESULTS, BASELINE CONDITION (MODEL 11)

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
1.65	172000	1154.51	1179.61	1180.12	0.000377	5.73	0.24
1.52	172000	1144	1179.42	1179.89	0.000237	5.52	0.19
1.39	172000	1147.32	1179.18	1179.7	0.000297	5.82	0.22
1.3	172000	1152	1178.78	1179.5	0.000532	6.84	0.28
1.22	172000	1156	1178.6	1179.28	0.000474	6.63	0.27
1.12	172000	1152	1178.36	1179.03	0.000436	6.54	0.26
1	172000	1152	1178.1	1178.76	0.000429	6.55	0.25
0.89	172000	1156	1177.63	1178.46	0.000608	7.31	0.3
0.78	172000	1152	1177.39	1178.1	0.000471	6.78	0.27
0.65	172000	1151.5	1177.18	1177.8	0.000352	6.32	0.23
0.51	172000	1152	1176.85	1177.51	0.000395	6.55	0.25
0.36	172000	1151.05	1176.51	1177.2	0.000411	6.67	0.25
0.23	172000	1150.96	1176.24	1176.92	0.000394	6.61	0.25
0.11	172000	1148	1175.9	1176.65	0.000442	6.92	0.26
0	172000	1148	1175.65	1176.39	0.000403	6.92	0.25



Note: For Alternative O, the Baseline HEC-Ras model geometry was modified between station 9.4 to 8.0 . To evaluate flow diversion options for Alternative O, the Salt River was simulated as a split flow condition. The two river segments created were the reach Vashly US 2, Salt River, and the South Quarry Pit segment.

EXHIBIT F – WATER SURFACE PROFILE, ALTERNATIVE O (MODEL 9)

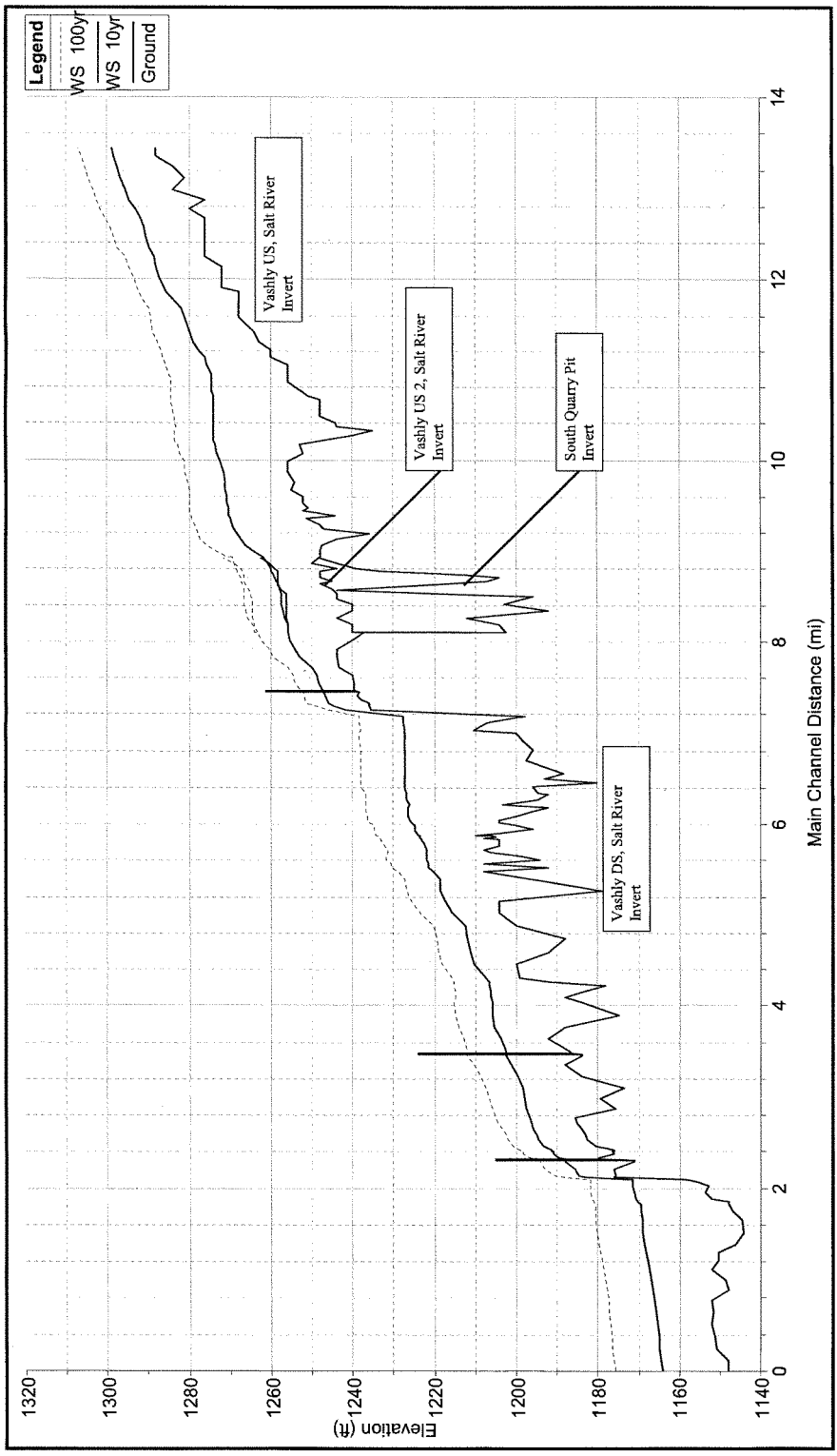


EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

Exhibit G.1 Hydraulic Results, Alternative O (Model 9) for the 3-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
South Quarry Pit		0.83	2172.87	1248	1252.09	1252.17	0.005025	2.3	0.23
South Quarry Pit		0.77	2172.87	1244	1250.22	1250.35	0.006842	2.82	0.27
South Quarry Pit		0.71	2172.87	1239.17	1249.11	1249.15	0.000803	1.61	0.1
South Quarry Pit		0.68	2172.87	1233.05	1249.04	1249.05	0.000209	1.01	0.05
South Quarry Pit		0.64	2172.87	1230.33	1249.03	1249.03	0.00004	0.55	0.03
South Quarry Pit		0.6	2172.87	1230	1249.02	1249.02	0.000015	0.36	0.02
South Quarry Pit		0.57	2172.87	1225.78	1249.02	1249.02	0.00001	0.3	0.01
South Quarry Pit		0.53	2172.87	1230.95	1249.02	1249.02	0.000017	0.36	0.02
South Quarry Pit		0.47	2172.87	1244	1248.84	1248.99	0.015998	3.11	0.37
South Quarry Pit		0.42	2172.87	1224.75	1246.66	1246.66	0.000024	0.42	0.02
South Quarry Pit		0.4	2172.87	1220.72	1246.66	1246.66	0.000011	0.28	0.01
South Quarry Pit		0.37	2172.87	1230.18	1246.66	1246.66	0.000007	0.23	0.01
South Quarry Pit		0.31	2172.87	1221.68	1246.66	1246.66	0.000005	0.2	0.01
South Quarry Pit		0.24	2172.87	1221.31	1246.65	1246.65	0.000003	0.17	0.01
South Quarry Pit		0.15	2172.87	1229.55	1246.65	1246.65	0.000004	0.19	0.01
South Quarry Pit		0.08	2172.87	1221.16	1246.65	1246.65	0.000005	0.19	0.01
South Quarry Pit		0	2172.87	1229.85	1246.65	1246.65	0.000005	0.21	0.01
Salt River	VaShly US	13.64	2200	1288	1290.63	1290.75	0.001711	2.81	0.35
Salt River	VaShly US	13.55	2200	1288	1289.36	1289.5	0.005398	3	0.54
Salt River	VaShly US	13.44	2200	1284	1286.96	1287.14	0.002499	3.35	0.42
Salt River	VaShly US	13.31	2200	1281.3	1286.05	1286.11	0.00055	1.95	0.21
Salt River	VaShly US	13.19	2200	1284	1285.11	1285.4	0.009344	4.31	0.73
Salt River	VaShly US	13.07	2200	1276	1282.21	1282.27	0.000397	1.9	0.18
Salt River	VaShly US	12.97	2200	1280	1281.59	1281.88	0.00578	4.32	0.61
Salt River	VaShly US	12.87	2200	1276	1279.95	1280.01	0.000549	2.02	0.21
Salt River	VaShly US	12.77	2200	1276	1279.56	1279.64	0.000955	2.32	0.27
Salt River	VaShly US	12.67	2200	1276	1279.18	1279.23	0.000602	1.92	0.21
Salt River	VaShly US	12.55	2200	1276	1278.82	1278.88	0.000563	1.91	0.21
Salt River	VaShly US	12.44	2200	1276	1278.32	1278.42	0.001214	2.51	0.3
Salt River	VaShly US	12.33	2200	1272	1277.91	1277.94	0.000405	1.41	0.17
Salt River	VaShly US	12.22	2200	1272	1277.29	1277.51	0.002722	3.8	0.45
Salt River	VaShly US	12.1	2200	1272	1274.32	1274.94	0.008089	6.32	0.76
Salt River	VaShly US	12.06	2200	1268	1273.28	1273.53	0.002117	4.08	0.41
Salt River	VaShly US	11.99	2200	1268	1272.16	1272.51	0.003691	4.73	0.53
Salt River	VaShly US	11.88	2200	1267.94	1271.07	1271.16	0.000815	2.5	0.26
Salt River	VaShly US	11.78	2200	1268	1270.44	1270.57	0.001683	2.92	0.35
Salt River	VaShly US	11.62	2200	1264	1268.47	1268.62	0.003617	3.17	0.47
Salt River	VaShly US	11.49	2200	1263.04	1265.31	1265.61	0.005975	4.4	0.62
Salt River	VaShly US	11.41	2200	1260	1263.83	1264	0.001337	3.32	0.33
Salt River	VaShly US	11.32	2200	1260	1263.39	1263.49	0.000834	2.6	0.26
Salt River	VaShly US	11.25	2200	1256	1263.16	1263.22	0.000463	2.02	0.2
Salt River	VaShly US	11.17	2200	1256	1262.8	1262.92	0.001548	2.78	0.33

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US	11.14	2200	1256	1261.95	1262.37	0.018196	5.19	0.66
Salt River	VaShly US	11.1	2200	1256	1260.1	1260.2	0.001685	2.6	0.34
Salt River	VaShly US	11.05	2200	1256	1259.95	1259.97	0.000162	1.27	0.12
Salt River	VaShly US	11	2200	1254.01	1259.93	1259.93	0.000043	0.73	0.06
Salt River	VaShly US	10.95	2200	1252	1259.92	1259.93	0.000008	0.44	0.03
Salt River	VaShly US	10.9	2200	1250.83	1259.92	1259.93	0.000007	0.42	0.03
Salt River	VaShly US	10.86	2200	1248	1259.92	1259.92	0.000004	0.38	0.02
Salt River	VaShly US	10.81	2200	1248	1259.92	1259.92	0.000002	0.3	0.02
Salt River	VaShly US	10.78	2200	1248	1259.92	1259.92	0.000002	0.3	0.02
Salt River	VaShly US	10.73	2200	1248	1259.92	1259.92	0.000002	0.31	0.02
Salt River	VaShly US	10.67	2200	1248	1259.92	1259.92	0.000006	0.43	0.03
Salt River	VaShly US	10.61	2200	1244.2	1259.92	1259.92	0.000003	0.37	0.02
Salt River	VaShly US	10.56	2200	1244	1259.92	1259.92	0.000003	0.35	0.02
Salt River	VaShly US	10.52	2200	1234.97	1259.92	1259.92	0.000001	0.23	0.01
Salt River	VaShly US	10.46	2200	1240	1259.91	1259.92	0.000003	0.35	0.02
Salt River	VaShly US	10.41	2200	1247.67	1259.91	1259.92	0.000002	0.33	0.02
Salt River	VaShly US	10.36	2200	1253	1259.81	1259.91	0.000785	2.52	0.25
Salt River	VaShly US	10.26	2200	1252	1259.66	1259.67	0.00003	0.8	0.06
Salt River	VaShly US	10.18	2200	1256	1259.52	1259.63	0.001022	2.74	0.29
Salt River	VaShly US	10.06	2200	1256	1258.82	1258.94	0.001304	2.75	0.31
Salt River	VaShly US	9.96	2200	1254.13	1258.33	1258.39	0.00056	2.01	0.21
Salt River	VaShly US	9.87	2200	1254.92	1257.83	1257.97	0.002516	2.95	0.37
Salt River	VaShly US	9.8	2200	1252	1256.99	1257.09	0.00225	2.54	0.29
Salt River	VaShly US	9.73	2200	1252	1256.18	1256.24	0.002074	2.02	0.19
Salt River	VaShly US	9.67	2200	1250.78	1255.51	1255.58	0.001943	1.99	0.19
Salt River	VaShly US	9.64	2200	1252	1255.1	1255.21	0.005247	2.69	0.3
Salt River	VaShly US	9.61	2200	1248.2	1254.75	1254.78	0.0008	1.39	0.12
Salt River	VaShly US	9.59	2200	1244.4	1254.67	1254.69	0.000495	1.14	0.1
Salt River	VaShly US	9.55	2200	1251.37	1254.44	1254.51	0.00343	2.14	0.24
Salt River	VaShly US	9.49	2200	1248	1253.6	1253.64	0.001611	1.65	0.17
Salt River	VaShly US	9.44	2200	1247.05	1253.4	1253.41	0.000289	1.03	0.08
Salt River	VaShly US	9.39	2200	1236	1253.29	1253.33	0.000285	1.42	0.08
Salt River	VaShly US	9.33	2200	1244	1253.2	1253.23	0.000429	1.37	0.1
Salt River	VaShly US	9.26	2200	1247.57	1252.99	1253.02	0.000788	1.44	0.12
Salt River	VaShly US	9.2	2200	1248	1252.69	1252.72	0.001048	1.5	0.14
Salt River	VaShly US	9.13	2200	1248	1252.12	1252.18	0.002291	1.87	0.2
Salt River	VaShly US 2	9.04	27.13	1248	1252.17	1252.18	0.002578	0.39	0.17
Salt River	VaShly US 2	8.98	27.13	1250.19	1250.8	1250.83	0.013193	1.29	0.41
Salt River	VaShly US 2	8.92	27.13	1244	1248.81	1248.81	0.000003	0.05	0.01
Salt River	VaShly US 2	8.88	27.13	1248	1248.81	1248.81	0.00057	0.42	0.1
Salt River	VaShly US 2	8.85	27.13	1248	1248.68	1248.69	0.000963	0.58	0.13
Salt River	VaShly US 2	8.81	27.13	1248	1248.45	1248.45	0.001275	0.49	0.13
Salt River	VaShly US 2	8.77	27.13	1245.26	1248.32	1248.32	0.000012	0.11	0.02
Salt River	VaShly US 2	8.74	27.13	1248	1248.3	1248.32	0.011151	1.04	0.37

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US 2	8.68	27.13	1245.3	1246.66	1246.66	0.00006	0.3	0.06
Salt River	VaShly US 2	8.63	27.13	1244	1246.65	1246.65	0.000013	0.15	0.02
Salt River	VaShly US 2	8.6	27.13	1244	1246.65	1246.65	0.000003	0.09	0.01
Salt River	VaShly US 2	8.57	27.13	1244	1246.65	1246.65	0.000001	0.06	0.01
Salt River	VaShly US 2	8.52	27.13	1240	1246.65	1246.65	0	0.01	0
Salt River	VaShly US 2	8.44	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly US 2	8.36	27.13	1244	1246.65	1246.65	0	0.05	0.01
Salt River	VaShly US 2	8.29	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly US 2	8.2	27.13	1240	1246.65	1246.65	0	0.02	0
Salt River	VaShly DS	8.1	2200	1237.27	1246.65	1246.65	0.000004	0.34	0.02
Salt River	VaShly DS	8.01	2200	1240	1246.63	1246.64	0.000057	0.85	0.07
Salt River	VaShly DS	7.91	2200	1244	1246.45	1246.58	0.002235	2.82	0.38
Salt River	VaShly DS	7.83	2200	1244	1245.8	1245.85	0.000955	1.81	0.25
Salt River	VaShly DS	7.71	2200	1243.41	1244.58	1244.78	0.009177	3.6	0.7
Salt River	VaShly DS	7.63	2200	1240	1242.12	1242.19	0.001674	2.14	0.32
Salt River	VaShly DS	7.55	2200	1239.6	1241.7	1241.73	0.00049	1.3	0.18
Salt River	VaShly DS	7.47	2200	1239.83	1241.39	1241.44	0.00126	1.76	0.28
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	2200	1238.53	1241.21	1241.24	0.000555	1.25	0.19
Salt River	VaShly DS	7.4	2200	1239.06	1241.06	1241.09	0.000883	1.51	0.23
Salt River	VaShly DS	7.36	2200	1238.07	1240.93	1240.95	0.000511	1.24	0.18
Salt River	VaShly DS	7.32	2200	1240	1240.65	1240.75	0.007151	2.52	0.58
Salt River	VaShly DS	7.28	2200	1236	1239.19	1239.49	0.006186	4.38	0.63
Salt River	VaShly DS	7.24	2200	1235.58	1236.78	1237.14	0.019729	4.8	1
Salt River	VaShly DS	7.17	2200	1197.93	1214.45	1214.45	0.000009	0.37	0.03
Salt River	VaShly DS	7.1	2200	1206.84	1214.45	1214.45	0.000015	0.36	0.04
Salt River	VaShly DS	7.03	2200	1210.44	1214.43	1214.44	0.000071	0.65	0.07
Salt River	VaShly DS	6.99	2200	1200	1214.43	1214.43	0	0.12	0.01
Salt River	VaShly DS	6.91	2200	1198.45	1214.43	1214.43	0.000001	0.19	0.01
Salt River	VaShly DS	6.8	2200	1196	1214.43	1214.43	0.000001	0.17	0.01
Salt River	VaShly DS	6.69	2200	1197.62	1214.42	1214.43	0.000022	0.48	0.04
Salt River	VaShly DS	6.56	2200	1188.55	1214.42	1214.42	0.000001	0.15	0.01
Salt River	VaShly DS	6.5	2200	1192.83	1214.42	1214.42	0.000001	0.22	0.01
Salt River	VaShly DS	6.45	2200	1180	1214.42	1214.42	0	0.08	0
Salt River	VaShly DS	6.4	2200	1196	1214.42	1214.42	0	0.1	0
Salt River	VaShly DS	6.38	2200	1195.4	1214.42	1214.42	0.000001	0.21	0.01
Salt River	VaShly DS	6.35	2200	1194.53	1214.41	1214.42	0.000003	0.4	0.02
Salt River	VaShly DS	6.32	2200	1192	1214.41	1214.42	0.000002	0.35	0.02
Salt River	VaShly DS	6.27	2200	1194.49	1214.41	1214.42	0.000002	0.35	0.02
Salt River	VaShly DS	6.22	2200	1203.46	1214.39	1214.41	0.000044	1.14	0.07
Salt River	VaShly DS	6.18	2200	1192	1214.39	1214.4	0.000033	1.04	0.06
Salt River	VaShly DS	6.14	2200	1196	1214.39	1214.4	0.000002	0.32	0.02
Salt River	VaShly DS	6.09	2200	1200	1214.39	1214.4	0.000006	0.46	0.03
Salt River	VaShly DS	6.05	2200	1204	1214.39	1214.39	0.000017	0.61	0.04

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	6.01	2200	1204	1214.38	1214.39	0.000558	0.69	0.04
Salt River	VaShly DS	5.99	2200	1200	1214.35	1214.36	0.000013	0.5	0.03
Salt River	VaShly DS	5.97	2200	1198.59	1214.35	1214.36	0.000006	0.39	0.02
Salt River	VaShly DS	5.95	2200	1196	1214.35	1214.35	0.000004	0.32	0.02
Salt River	VaShly DS	5.93	2200	1198.79	1214.35	1214.35	0.000004	0.31	0.02
Salt River	VaShly DS	5.91	2200	1203.31	1214.35	1214.35	0.000046	0.6	0.04
Salt River	VaShly DS	5.88	2200	1209.96	1213.97	1214.3	0.011879	4.67	0.56
Salt River	VaShly DS	5.87	2200	1206.22	1213.89	1213.94	0.0009	1.79	0.17
Salt River	VaShly DS	5.86	2200	1205.11	1213.87	1213.9	0.000317	1.33	0.11
Salt River	VaShly DS	5.85	2200	1208	1213.85	1213.88	0.000354	1.43	0.11
Salt River	VaShly DS	5.84	2200	1204	1213.77	1213.84	0.000951	2.12	0.18
Salt River	VaShly DS	5.82	2200	1204	1213.7	1213.76	0.000669	2.02	0.18
Salt River	VaShly DS	5.8	2200	1204	1213.67	1213.7	0.000221	1.33	0.11
Salt River	VaShly DS	5.76	2200	1204	1213.6	1213.65	0.000375	1.77	0.18
Salt River	VaShly DS	5.73	2200	1208	1212.95	1213.46	0.017365	5.7	0.99
Salt River	VaShly DS	5.69	2200	1206.01	1210.58	1210.63	0.000403	1.88	0.18
Salt River	VaShly DS	5.65	2200	1198.67	1210.57	1210.57	0.000007	0.51	0.03
Salt River	VaShly DS	5.6	2200	1194.35	1210.57	1210.57	0.000002	0.34	0.02
Salt River	VaShly DS	5.56	2200	1208	1210.42	1210.55	0.002267	2.96	0.39
Salt River	VaShly DS	5.53	2200	1192	1210.3	1210.3	0.000005	0.46	0.02
Salt River	VaShly DS	5.47	2200	1208	1209.84	1210.26	0.009722	5.19	0.78
Salt River	VaShly DS	5.4	2200	1196	1208.18	1208.2	0.000076	0.96	0.08
Salt River	VaShly DS	5.26	2200	1179.01	1208.16	1208.16	0.000008	0.4	0.02
Salt River	VaShly DS	5.15	2200	1204	1208.09	1208.15	0.001899	1.86	0.23
Salt River	VaShly DS	5.03	2200	1204	1206.31	1206.4	0.004695	2.5	0.34
Salt River	VaShly DS	4.88	2200	1200	1204.39	1204.43	0.000301	1.7	0.16
Salt River	VaShly DS	4.74	2200	1188	1204.3	1204.3	0.000007	0.37	0.02
Salt River	VaShly DS	4.59	2200	1192	1204.29	1204.29	0.000031	0.6	0.05
Salt River	VaShly DS	4.47	2200	1200	1204.13	1204.24	0.002081	2.68	0.49
Salt River	VaShly DS	4.31	2200	1199.24	1200.87	1201.07	0.023119	3.64	0.67
Salt River	VaShly DS	4.27	2200	1192	1197.25	1197.61	0.008405	4.83	0.73
Salt River	VaShly DS	4.22	2200	1178.19	1196.33	1196.34	0.00001	0.67	0.04
Salt River	VaShly DS	4.15	2200	1184	1196.31	1196.33	0.000084	1.11	0.09
Salt River	VaShly DS	4.09	2200	1188	1196.28	1196.3	0.000138	1.09	0.11
Salt River	VaShly DS	4.04	2200	1184	1196.27	1196.27	0.00002	0.51	0.04
Salt River	VaShly DS	3.89	2200	1174.66	1196.26	1196.26	0.000001	0.24	0.01
Salt River	VaShly DS	3.76	2200	1188	1196.23	1196.26	0.000298	1.32	0.15
Salt River	VaShly DS	3.64	2200	1192	1195.21	1195.83	0.010864	6.31	0.85
Salt River	VaShly DS	3.5	2200	1186.84	1191.14	1191.23	0.000972	2.44	0.27
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	2200	1184	1191.06	1191.09	0.000148	1.28	0.11
Salt River	VaShly DS	3.35	2200	1188	1190.62	1190.89	0.007405	4.16	0.52
Salt River	VaShly DS	3.23	2200	1183.78	1188.15	1188.22	0.001044	2.16	0.21
Salt River	VaShly DS	3.1	2200	1173.54	1187.81	1187.82	0.000048	0.85	0.05

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	2.98	2200	1179.21	1187.79	1187.79	0.00003	0.66	0.04
Salt River	VaShly DS	2.87	2200	1175.62	1187.77	1187.78	0.000015	0.68	0.04
Salt River	VaShly DS	2.78	2200	1185.67	1187.63	1187.75	0.002222	2.81	0.38
Salt River	VaShly DS	2.71	2200	1185.2	1186.85	1186.97	0.002665	2.76	0.41
Salt River	VaShly DS	2.65	2200	1184.02	1185.99	1186.1	0.002148	2.75	0.38
Salt River	VaShly DS	2.59	2200	1183.07	1185.41	1185.53	0.001711	2.86	0.35
Salt River	VaShly DS	2.53	2200	1182.76	1184.6	1184.78	0.003249	3.44	0.47
Salt River	VaShly DS	2.47	2200	1180.75	1183.13	1183.22	0.009582	2.48	0.3
Salt River	VaShly DS	2.42	2200	1175.84	1181.93	1181.94	0.000026	0.71	0.05
Salt River	VaShly DS	2.41	2200	1175.97	1181.93	1181.94	0.000043	0.85	0.06
Salt River	VaShly DS	2.4	2200	1176.34	1181.92	1181.94	0.000062	0.98	0.08
Salt River	VaShly DS	2.38	2200	1176.14	1181.92	1181.93	0.000043	0.84	0.06
Salt River	VaShly DS	2.33	2200	1179.92	1181.76	1181.9	0.002681	2.94	0.42
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	2200	1170.86	1178.65	1178.66	0.00007	1.02	0.08
Salt River	VaShly DS	2.21	2200	1176	1178.54	1178.6	0.000773	2.03	0.24
Salt River	VaShly DS	2.13	2200	1175.43	1177.82	1178.06	0.003773	3.93	0.51
Salt River	VaShly DS	2.12	2200	1175.83	1177.11	1177.59	0.017858	5.54	0.99
Salt River	VaShly DS	2.1	2200	1158.27	1161.79	1162.52	0.02594	7.11	0.97
Salt River	VaShly DS	2.07	2200	1155.35	1157.6	1157.88	0.004316	4.22	0.54
Salt River	VaShly DS	2.04	2200	1153.78	1157.14	1157.26	0.00245	2.78	0.31
Salt River	VaShly DS	2.02	2200	1152.83	1157	1157.05	0.000731	1.91	0.18
Salt River	VaShly DS	1.95	2200	1153.57	1156.49	1156.62	0.002774	2.94	0.33
Salt River	VaShly DS	1.89	2200	1152.14	1155.93	1156	0.000826	2.1	0.19
Salt River	VaShly DS	1.86	2200	1148	1155.91	1155.92	0.000077	0.96	0.07
Salt River	VaShly DS	1.83	2200	1148	1155.87	1155.9	0.000256	1.43	0.11
Salt River	VaShly DS	1.8	2200	1147.44	1155.86	1155.87	0.000051	0.82	0.05
Salt River	VaShly DS	1.76	2200	1146.98	1155.85	1155.86	0.000026	0.82	0.05
Salt River	VaShly DS	1.65	2200	1144.47	1155.84	1155.85	0.000012	0.48	0.03
Salt River	VaShly DS	1.52	2200	1144	1155.84	1155.84	0.000005	0.3	0.02
Salt River	VaShly DS	1.39	2200	1146.14	1155.83	1155.83	0.00006	0.61	0.05
Salt River	VaShly DS	1.3	2200	1150.23	1155.78	1155.79	0.000102	0.96	0.08
Salt River	VaShly DS	1.22	2200	1150.27	1155.73	1155.75	0.00012	1.03	0.09
Salt River	VaShly DS	1.12	2200	1152	1155.65	1155.67	0.000168	1.14	0.11
Salt River	VaShly DS	1	2200	1148.57	1155.6	1155.61	0.000021	0.61	0.04
Salt River	VaShly DS	0.89	2200	1148	1155.59	1155.6	0.000023	0.7	0.05
Salt River	VaShly DS	0.78	2200	1152	1155.49	1155.56	0.000928	2.18	0.26
Salt River	VaShly DS	0.65	2200	1151.5	1155.16	1155.18	0.000175	1.05	0.12
Salt River	VaShly DS	0.51	2200	1152	1154.92	1154.97	0.00062	1.79	0.21
Salt River	VaShly DS	0.36	2200	1151.05	1154.35	1154.41	0.000839	1.95	0.24
Salt River	VaShly DS	0.23	2200	1150.96	1153.68	1153.74	0.001233	2.01	0.28
Salt River	VaShly DS	0.11	2200	1148	1153.21	1153.24	0.000305	1.44	0.15
Salt River	VaShly DS	0	2200	1148	1153.09	1153.1	0.000124	0.97	0.1

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

Exhibit G.2 Hydraulic Results, Alternative O (Model 9) for the 10-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
South Quarry Pit		0.83	24591.44	1248	1262.48	1263.04	0.005108	6.05	0.29
South Quarry Pit		0.77	24591.44	1244	1260.45	1261.18	0.006856	7.03	0.33
South Quarry Pit		0.71	24591.44	1239.17	1258.97	1259.47	0.003786	6.09	0.26
South Quarry Pit		0.68	24591.44	1233.05	1258.53	1258.89	0.002455	4.96	0.21
South Quarry Pit		0.64	24591.44	1230.33	1258.37	1258.55	0.00086	3.5	0.13
South Quarry Pit		0.6	24591.44	1230	1258.3	1258.39	0.000373	2.41	0.09
South Quarry Pit		0.57	24591.44	1225.78	1258.25	1258.32	0.000277	2.1	0.07
South Quarry Pit		0.53	24591.44	1230.95	1258.16	1258.25	0.000448	2.46	0.09
South Quarry Pit		0.47	24591.44	1244	1257.47	1257.96	0.00961	5.63	0.36
South Quarry Pit		0.42	24591.44	1224.75	1256.26	1256.38	0.000712	2.72	0.11
South Quarry Pit		0.4	24591.44	1220.72	1256.25	1256.3	0.000275	1.82	0.07
South Quarry Pit		0.37	24591.44	1230.18	1256.22	1256.26	0.000174	1.58	0.06
South Quarry Pit		0.31	24591.44	1221.68	1256.18	1256.21	0.000129	1.4	0.05
South Quarry Pit		0.24	24591.44	1221.31	1256.14	1256.16	0.000096	1.24	0.04
South Quarry Pit		0.15	24591.44	1229.55	1256.09	1256.12	0.00011	1.3	0.05
South Quarry Pit		0.08	24591.44	1221.16	1256.05	1256.08	0.00012	1.35	0.05
South Quarry Pit		0	24591.44	1229.85	1255.98	1256.02	0.000144	1.55	0.05
Salt River	VaShly US	13.64	60000	1288	1299.07	1299.87	0.001845	7.15	0.45
Salt River	VaShly US	13.55	60000	1288	1298.47	1299.09	0.001161	6.34	0.37
Salt River	VaShly US	13.44	60000	1284	1297.75	1298.39	0.001181	6.42	0.37
Salt River	VaShly US	13.31	60000	1281.3	1296.9	1297.58	0.001289	6.62	0.39
Salt River	VaShly US	13.19	60000	1284	1295.58	1296.49	0.002178	7.67	0.49
Salt River	VaShly US	13.07	60000	1276	1294.62	1295.32	0.001352	6.74	0.4
Salt River	VaShly US	12.97	60000	1280	1293.09	1294.33	0.003101	8.91	0.58
Salt River	VaShly US	12.87	60000	1276	1291.83	1292.98	0.001552	8.6	0.44
Salt River	VaShly US	12.77	60000	1276	1290.92	1292.08	0.001886	8.64	0.48
Salt River	VaShly US	12.67	60000	1276	1290.43	1291.14	0.001234	6.76	0.38
Salt River	VaShly US	12.55	60000	1276	1289.7	1290.42	0.001113	6.8	0.37
Salt River	VaShly US	12.44	60000	1276	1288.55	1289.54	0.002044	8	0.48
Salt River	VaShly US	12.33	60000	1272	1287.95	1288.61	0.000913	6.48	0.34
Salt River	VaShly US	12.22	60000	1272	1287.23	1287.95	0.001426	6.8	0.4
Salt River	VaShly US	12.1	60000	1272	1286.13	1286.9	0.002031	7.05	0.47
Salt River	VaShly US	12.06	60000	1268	1285.6	1286.38	0.002034	7.11	0.47
Salt River	VaShly US	11.99	60000	1268	1284.03	1285.29	0.004339	9.02	0.66
Salt River	VaShly US	11.88	60000	1267.94	1282.02	1283.11	0.003173	8.38	0.58
Salt River	VaShly US	11.78	60000	1268	1281.03	1281.72	0.001629	6.64	0.42
Salt River	VaShly US	11.62	60000	1264	1280.06	1280.54	0.00099	5.53	0.34
Salt River	VaShly US	11.49	60000	1263.04	1278.9	1279.7	0.001555	7.18	0.42
Salt River	VaShly US	11.41	60000	1260	1277.6	1278.81	0.002722	8.81	0.55
Salt River	VaShly US	11.32	60000	1260	1276.34	1277.58	0.002741	8.95	0.55
Salt River	VaShly US	11.25	60000	1256	1275.68	1276.6	0.001716	7.72	0.45
Salt River	VaShly US	11.17	60000	1256	1275.06	1275.92	0.001467	7.42	0.42

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
Salt River	VaShly US	11.14	60000	1256	1274.6	1275.51	0.004454	7.66	0.43
Salt River	VaShly US	11.1	60000	1256	1274.32	1274.87	0.00067	5.93	0.29
Salt River	VaShly US	11.05	60000	1256	1274.32	1274.7	0.000377	4.98	0.23
Salt River	VaShly US	11	60000	1254.01	1274.29	1274.58	0.000231	4.35	0.18
Salt River	VaShly US	10.95	60000	1252	1274.31	1274.51	0.00014	3.58	0.14
Salt River	VaShly US	10.9	60000	1250.83	1274.27	1274.48	0.000139	3.64	0.14
Salt River	VaShly US	10.86	60000	1248	1274.23	1274.44	0.000134	3.67	0.14
Salt River	VaShly US	10.81	60000	1248	1274.23	1274.41	0.000096	3.38	0.12
Salt River	VaShly US	10.78	60000	1248	1274.2	1274.39	0.000097	3.42	0.12
Salt River	VaShly US	10.73	60000	1248	1274.16	1274.36	0.000106	3.58	0.13
Salt River	VaShly US	10.67	60000	1248	1274.03	1274.31	0.000175	4.23	0.16
Salt River	VaShly US	10.61	60000	1244.2	1273.98	1274.25	0.000154	4.21	0.16
Salt River	VaShly US	10.56	60000	1244	1273.95	1274.22	0.000145	4.16	0.15
Salt River	VaShly US	10.52	60000	1234.97	1273.99	1274.16	0.000073	3.33	0.11
Salt River	VaShly US	10.46	60000	1240	1273.9	1274.13	0.000132	3.84	0.14
Salt River	VaShly US	10.41	60000	1247.67	1273.91	1274.08	0.000097	3.39	0.12
Salt River	VaShly US	10.36	60000	1253	1273.45	1274	0.000704	5.97	0.3
Salt River	VaShly US	10.26	60000	1252	1273.34	1273.67	0.000317	4.61	0.21
Salt River	VaShly US	10.18	60000	1256	1272.52	1273.39	0.001603	7.45	0.43
Salt River	VaShly US	10.06	60000	1256	1271.79	1272.53	0.001098	7.12	0.37
Salt River	VaShly US	9.96	60000	1254.13	1271.29	1271.96	0.000854	6.78	0.33
Salt River	VaShly US	9.87	60000	1254.92	1271.02	1271.52	0.000842	5.91	0.29
Salt River	VaShly US	9.8	60000	1252	1270.76	1271.17	0.001028	5.51	0.26
Salt River	VaShly US	9.73	60000	1252	1270.64	1270.77	0.000837	3.19	0.15
Salt River	VaShly US	9.67	60000	1250.78	1270.47	1270.57	0.000521	2.87	0.13
Salt River	VaShly US	9.64	60000	1252	1270.3	1270.48	0.001007	3.86	0.17
Salt River	VaShly US	9.61	60000	1248.2	1270.22	1270.36	0.000673	3.4	0.14
Salt River	VaShly US	9.59	60000	1244.4	1270.17	1270.27	0.000464	2.93	0.12
Salt River	VaShly US	9.55	60000	1251.37	1270.01	1270.15	0.000752	3.03	0.15
Salt River	VaShly US	9.49	60000	1248	1269.66	1269.84	0.001011	3.43	0.17
Salt River	VaShly US	9.44	60000	1247.05	1269.28	1269.55	0.001426	4.19	0.2
Salt River	VaShly US	9.39	60000	1236	1268.4	1268.92	0.003474	5.76	0.3
Salt River	VaShly US	9.33	60000	1244	1267.41	1267.93	0.003502	5.8	0.31
Salt River	VaShly US	9.26	60000	1247.57	1266.06	1266.61	0.003674	5.95	0.31
Salt River	VaShly US	9.2	60000	1248	1264.54	1265.22	0.004754	6.59	0.36
Salt River	VaShly US	9.13	60000	1248	1262.22	1263.16	0.006087	8.29	0.41
Salt River	VaShly US 2	9.04	33408.56	1248	1262.03	1263.03	0.005012	8.04	0.45
Salt River	VaShly US 2	8.98	33408.56	1250.19	1260.78	1261.36	0.004798	6.11	0.43
Salt River	VaShly US 2	8.92	33408.56	1244	1260.2	1260.37	0.000901	3.27	0.18
Salt River	VaShly US 2	8.88	33408.56	1248	1259.96	1260.17	0.001319	3.72	0.23
Salt River	VaShly US 2	8.85	33408.56	1248	1259.65	1259.89	0.002122	3.95	0.27
Salt River	VaShly US 2	8.81	33408.56	1248	1259.11	1259.42	0.002277	4.45	0.29
Salt River	VaShly US 2	8.77	33408.56	1245.26	1258.71	1258.98	0.001921	4.15	0.27
Salt River	VaShly US 2	8.74	33408.56	1248	1258.26	1258.55	0.002787	4.34	0.31

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
Salt River	VaShly US 2	8.68	33408.56	1245.3	1257.81	1258.05	0.000518	3.89	0.24
Salt River	VaShly US 2	8.63	33408.56	1244	1257.58	1257.87	0.000779	4.32	0.28
Salt River	VaShly US 2	8.6	33408.56	1244	1257.5	1257.76	0.000726	4.13	0.26
Salt River	VaShly US 2	8.57	33408.56	1244	1257.42	1257.65	0.000547	3.9	0.25
Salt River	VaShly US 2	8.52	33408.56	1240	1257.41	1257.5	0.000178	2.36	0.13
Salt River	VaShly US 2	8.44	33408.56	1240	1257.21	1257.4	0.000342	3.47	0.2
Salt River	VaShly US 2	8.36	33408.56	1244	1256.65	1257.1	0.002868	5.37	0.36
Salt River	VaShly US 2	8.29	33408.56	1240	1255.95	1256.39	0.00084	5.31	0.31
Salt River	VaShly US 2	8.2	33408.56	1240	1255.73	1256.03	0.000606	4.37	0.25
Salt River	VaShly DS	8.1	58000	1237.27	1255.8	1256	0.0002	3.57	0.17
Salt River	VaShly DS	8.01	58000	1240	1255.35	1255.83	0.000872	5.56	0.32
Salt River	VaShly DS	7.91	58000	1244	1254.16	1255.12	0.002369	8.06	0.5
Salt River	VaShly DS	7.83	58000	1244	1253.15	1254.07	0.002377	7.7	0.48
Salt River	VaShly DS	7.71	58000	1243.41	1250.22	1251.92	0.005624	10.47	0.76
Salt River	VaShly DS	7.63	58000	1240	1248.81	1249.8	0.002511	8	0.52
Salt River	VaShly DS	7.55	58000	1239.6	1248.3	1248.88	0.001356	6.09	0.39
Salt River	VaShly DS	7.47	58000	1239.83	1247.51	1248.21	0.001968	6.71	0.45
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	58000	1238.53	1247.07	1247.69	0.001757	6.35	0.42
Salt River	VaShly DS	7.4	58000	1239.06	1246.64	1247.3	0.002041	6.52	0.46
Salt River	VaShly DS	7.36	58000	1238.07	1246.35	1246.89	0.001685	5.94	0.42
Salt River	VaShly DS	7.32	58000	1240	1245.91	1246.5	0.002222	6.2	0.47
Salt River	VaShly DS	7.28	58000	1236	1244.51	1245.8	0.006911	9.13	0.77
Salt River	VaShly DS	7.24	58000	1235.58	1241.71	1243.61	0.011253	11.05	1
Salt River	VaShly DS	7.17	58000	1197.93	1227.55	1227.6	0.000055	1.78	0.09
Salt River	VaShly DS	7.1	58000	1206.84	1227.53	1227.58	0.000047	1.8	0.08
Salt River	VaShly DS	7.03	58000	1210.44	1227.44	1227.55	0.000107	2.59	0.12
Salt River	VaShly DS	6.99	58000	1200	1227.48	1227.52	0.00002	1.55	0.06
Salt River	VaShly DS	6.91	58000	1198.45	1227.45	1227.5	0.000042	1.8	0.08
Salt River	VaShly DS	6.8	58000	1196	1227.43	1227.48	0.000033	1.87	0.07
Salt River	VaShly DS	6.69	58000	1197.62	1227.33	1227.45	0.000106	2.78	0.12
Salt River	VaShly DS	6.56	58000	1188.55	1227.33	1227.38	0.000027	1.74	0.06
Salt River	VaShly DS	6.5	58000	1192.83	1227.28	1227.36	0.000056	2.36	0.09
Salt River	VaShly DS	6.45	58000	1180	1227.31	1227.33	0.000008	1.1	0.04
Salt River	VaShly DS	6.4	58000	1196	1227.3	1227.33	0.000013	1.37	0.05
Salt River	VaShly DS	6.38	58000	1195.4	1227.22	1227.32	0.000062	2.35	0.09
Salt River	VaShly DS	6.35	58000	1194.53	1226.93	1227.28	0.000234	4.69	0.19
Salt River	VaShly DS	6.32	58000	1192	1226.94	1227.24	0.000192	4.39	0.17
Salt River	VaShly DS	6.27	58000	1194.49	1226.94	1227.16	0.000177	3.72	0.16
Salt River	VaShly DS	6.22	58000	1203.46	1226.26	1227.03	0.001117	7	0.37
Salt River	VaShly DS	6.18	58000	1192	1226.36	1226.76	0.000517	5.04	0.26
Salt River	VaShly DS	6.14	58000	1196	1226.46	1226.61	0.000127	3.19	0.13
Salt River	VaShly DS	6.09	58000	1200	1226.35	1226.57	0.00021	3.8	0.17
Salt River	VaShly DS	6.05	58000	1204	1226.08	1226.48	0.000435	5.05	0.24

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Cl
Salt River	VaShly DS	6.01	58000	1204	1225.77	1226.31	0.020786	5.9	0.29
Salt River	VaShly DS	5.99	58000	1200	1224.81	1225.19	0.000634	4.96	0.23
Salt River	VaShly DS	5.97	58000	1198.59	1224.79	1225.12	0.00041	4.62	0.21
Salt River	VaShly DS	5.95	58000	1196	1224.79	1225.05	0.000296	4.07	0.18
Salt River	VaShly DS	5.93	58000	1198.79	1224.78	1225.02	0.000374	3.94	0.18
Salt River	VaShly DS	5.91	58000	1203.31	1224.57	1224.94	0.001229	4.85	0.25
Salt River	VaShly DS	5.88	58000	1209.96	1223.87	1224.58	0.005431	6.76	0.48
Salt River	VaShly DS	5.87	58000	1206.22	1223.73	1224.34	0.00391	6.25	0.4
Salt River	VaShly DS	5.86	58000	1205.11	1223.51	1224.12	0.00487	6.27	0.36
Salt River	VaShly DS	5.85	58000	1208	1223.41	1223.86	0.002561	5.39	0.28
Salt River	VaShly DS	5.84	58000	1204	1223.19	1223.68	0.002797	5.61	0.29
Salt River	VaShly DS	5.82	58000	1204	1223	1223.44	0.001603	5.32	0.27
Salt River	VaShly DS	5.8	58000	1204	1222.83	1223.28	0.001643	5.36	0.27
Salt River	VaShly DS	5.76	58000	1204	1222.45	1223.04	0.000865	6.17	0.33
Salt River	VaShly DS	5.73	58000	1208	1221.92	1222.79	0.001455	7.46	0.42
Salt River	VaShly DS	5.69	58000	1206.01	1221.96	1222.52	0.000708	6.01	0.3
Salt River	VaShly DS	5.65	58000	1198.67	1222.03	1222.34	0.000258	4.43	0.19
Salt River	VaShly DS	5.6	58000	1194.35	1222.09	1222.24	0.000132	3.08	0.12
Salt River	VaShly DS	5.56	58000	1208	1221.41	1222.13	0.001986	6.79	0.38
Salt River	VaShly DS	5.53	58000	1192	1221.44	1221.74	0.000879	4.39	0.2
Salt River	VaShly DS	5.47	58000	1208	1220.43	1221.24	0.008791	7.26	0.44
Salt River	VaShly DS	5.4	58000	1196	1218.7	1219.29	0.000727	6.19	0.3
Salt River	VaShly DS	5.26	58000	1179.01	1218.43	1218.73	0.000576	4.47	0.2
Salt River	VaShly DS	5.15	58000	1204	1217.51	1218.16	0.002534	6.57	0.37
Salt River	VaShly DS	5.03	58000	1204	1215.53	1216.3	0.003309	7.13	0.42
Salt River	VaShly DS	4.88	58000	1200	1212.3	1213.77	0.003005	9.78	0.59
Salt River	VaShly DS	4.74	58000	1188	1211.85	1212.17	0.000411	4.51	0.21
Salt River	VaShly DS	4.59	58000	1192	1211.31	1211.72	0.000828	5.13	0.29
Salt River	VaShly DS	4.47	58000	1200	1210.47	1210.92	0.002007	5.88	0.4
Salt River	VaShly DS	4.31	58000	1199.24	1207.27	1208.19	0.008414	7.95	0.56
Salt River	VaShly DS	4.27	58000	1192	1206.55	1207.03	0.000991	5.56	0.34
Salt River	VaShly DS	4.22	58000	1178.19	1206.51	1206.78	0.000408	4.02	0.22
Salt River	VaShly DS	4.15	58000	1184	1206.17	1206.58	0.000818	5.13	0.31
Salt River	VaShly DS	4.09	58000	1188	1206.01	1206.31	0.000654	4.31	0.27
Salt River	VaShly DS	4.04	58000	1184	1205.98	1206.15	0.000227	3.28	0.17
Salt River	VaShly DS	3.89	58000	1174.66	1205.93	1206.01	0.00006	2.31	0.1
Salt River	VaShly DS	3.76	58000	1188	1205.36	1205.89	0.000889	5.82	0.33
Salt River	VaShly DS	3.64	58000	1192	1203.68	1204.94	0.002998	9.04	0.57
Salt River	VaShly DS	3.5	58000	1186.84	1202.49	1203.17	0.001257	6.62	0.38
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	58000	1184	1202.34	1202.83	0.000801	5.62	0.32
Salt River	VaShly DS	3.35	58000	1188	1201.41	1202.16	0.001754	6.92	0.39
Salt River	VaShly DS	3.23	58000	1183.78	1199.62	1200.78	0.002796	8.64	0.48
Salt River	VaShly DS	3.1	58000	1173.54	1198.46	1199.24	0.00126	7.09	0.34

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Ch
Salt River	VaShly DS	2.98	58000	1179.21	1197.83	1198.55	0.00099	6.79	0.3
Salt River	VaShly DS	2.87	58000	1175.62	1197.39	1198.01	0.000703	6.34	0.34
Salt River	VaShly DS	2.78	58000	1185.67	1196.87	1197.52	0.001528	6.48	0.4
Salt River	VaShly DS	2.71	58000	1185.2	1196.46	1197.05	0.001295	6.16	0.36
Salt River	VaShly DS	2.65	58000	1184.02	1195.73	1196.51	0.001672	7.08	0.41
Salt River	VaShly DS	2.59	58000	1183.07	1195	1195.94	0.002095	7.79	0.48
Salt River	VaShly DS	2.53	58000	1182.76	1194.43	1195.25	0.001859	7.25	0.46
Salt River	VaShly DS	2.47	58000	1180.75	1193.28	1194.19	0.015537	7.66	0.47
Salt River	VaShly DS	2.42	58000	1175.84	1191.41	1191.95	0.000814	5.89	0.32
Salt River	VaShly DS	2.41	58000	1175.97	1191.27	1191.9	0.001053	6.39	0.36
Salt River	VaShly DS	2.4	58000	1176.34	1191.08	1191.84	0.001418	7	0.41
Salt River	VaShly DS	2.38	58000	1176.14	1190.91	1191.64	0.001292	6.83	0.39
Salt River	VaShly DS	2.33	58000	1179.92	1189.83	1191.16	0.003502	9.27	0.61
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	58000	1170.86	1188.04	1188.79	0.0013	6.91	0.39
Salt River	VaShly DS	2.21	58000	1176	1185.7	1187.8	0.004356	11.62	0.7
Salt River	VaShly DS	2.13	58000	1175.43	1184.59	1185.98	0.003421	9.46	0.61
Salt River	VaShly DS	2.12	58000	1175.83	1183.01	1185.3	0.006805	12.15	0.85
Salt River	VaShly DS	2.1	58000	1158.27	1171.52	1173.14	0.008015	10.52	0.81
Salt River	VaShly DS	2.07	58000	1155.35	1171.35	1172.21	0.001932	7.59	0.47
Salt River	VaShly DS	2.04	58000	1153.78	1171.33	1171.86	0.001132	5.91	0.32
Salt River	VaShly DS	2.02	58000	1152.83	1171.29	1171.72	0.000795	5.31	0.26
Salt River	VaShly DS	1.95	58000	1153.57	1171	1171.42	0.000848	5.15	0.27
Salt River	VaShly DS	1.89	58000	1152.14	1170.57	1171	0.002245	5.28	0.29
Salt River	VaShly DS	1.86	58000	1148	1170.19	1170.64	0.002775	5.41	0.31
Salt River	VaShly DS	1.83	58000	1148	1169.48	1170.12	0.003036	6.44	0.39
Salt River	VaShly DS	1.8	58000	1147.44	1169.33	1169.65	0.001447	4.55	0.25
Salt River	VaShly DS	1.76	58000	1146.98	1169.2	1169.41	0.000636	3.64	0.18
Salt River	VaShly DS	1.65	58000	1144.47	1168.99	1169.14	0.000255	3.18	0.16
Salt River	VaShly DS	1.52	58000	1144	1168.83	1168.97	0.000226	3.03	0.13
Salt River	VaShly DS	1.39	58000	1146.14	1168.59	1168.75	0.000538	3.23	0.15
Salt River	VaShly DS	1.3	58000	1150.23	1168.23	1168.45	0.000699	3.84	0.2
Salt River	VaShly DS	1.22	58000	1150.27	1167.93	1168.15	0.000761	3.82	0.2
Salt River	VaShly DS	1.12	58000	1152	1167.38	1167.67	0.000998	4.31	0.23
Salt River	VaShly DS	1	58000	1148.57	1166.91	1167.14	0.000695	3.87	0.2
Salt River	VaShly DS	0.89	58000	1148	1166.51	1166.81	0.000462	4.41	0.24
Salt River	VaShly DS	0.78	58000	1152	1166.07	1166.46	0.0007	5.06	0.29
Salt River	VaShly DS	0.65	58000	1151.5	1165.78	1166.06	0.000384	4.25	0.22
Salt River	VaShly DS	0.51	58000	1152	1165.41	1165.74	0.000485	4.57	0.24
Salt River	VaShly DS	0.36	58000	1151.05	1165	1165.34	0.000521	4.7	0.25
Salt River	VaShly DS	0.23	58000	1150.96	1164.68	1165	0.000473	4.57	0.24
Salt River	VaShly DS	0.11	58000	1148	1164.29	1164.67	0.000569	4.9	0.26
Salt River	VaShly DS	0	58000	1148	1164.04	1164.36	0.000401	4.54	0.23

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

Exhibit G.3 Hydraulic Results, Alternative O (Model 9) for the 100-Year event.

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
South Quarry Pit		0.83	60810.77	1248	1271.65	1272.83	0.005442	8.8	0.33
South Quarry Pit		0.77	60810.77	1244	1269.18	1270.78	0.00764	10.31	0.38
South Quarry Pit		0.71	60810.77	1239.17	1267.58	1268.71	0.004918	9.07	0.31
South Quarry Pit		0.68	60810.77	1233.05	1267.01	1267.9	0.003673	7.83	0.27
South Quarry Pit		0.64	60810.77	1230.33	1266.8	1267.32	0.001708	6.04	0.19
South Quarry Pit		0.6	60810.77	1230	1266.72	1266.98	0.000781	4.24	0.13
South Quarry Pit		0.57	60810.77	1225.78	1266.61	1266.83	0.000637	3.84	0.12
South Quarry Pit		0.53	60810.77	1230.95	1266.37	1266.67	0.000969	4.43	0.14
South Quarry Pit		0.47	60810.77	1244	1265.46	1266.16	0.005339	6.72	0.3
South Quarry Pit		0.42	60810.77	1224.75	1264.78	1265.1	0.001273	4.56	0.16
South Quarry Pit		0.4	60810.77	1220.72	1264.78	1264.94	0.000548	3.21	0.1
South Quarry Pit		0.37	60810.77	1230.18	1264.73	1264.85	0.000377	2.86	0.09
South Quarry Pit		0.31	60810.77	1221.68	1264.65	1264.75	0.000294	2.56	0.08
South Quarry Pit		0.24	60810.77	1221.31	1264.56	1264.64	0.000228	2.3	0.07
South Quarry Pit		0.15	60810.77	1229.55	1264.45	1264.54	0.000251	2.38	0.07
South Quarry Pit		0.08	60810.77	1221.16	1264.34	1264.44	0.000279	2.5	0.08
South Quarry Pit		0	60810.77	1229.85	1264.17	1264.3	0.000352	2.91	0.09
Salt River	VaShly US	13.64	175000	1288	1306.99	1308.6	0.001536	10.17	0.46
Salt River	VaShly US	13.55	175000	1288	1306.41	1307.88	0.001284	9.76	0.43
Salt River	VaShly US	13.44	175000	1284	1305.53	1307.09	0.001344	10.01	0.44
Salt River	VaShly US	13.31	175000	1281.3	1304.54	1306.14	0.001566	10.15	0.46
Salt River	VaShly US	13.19	175000	1284	1303.47	1305.04	0.001771	10.07	0.48
Salt River	VaShly US	13.07	175000	1276	1302.66	1303.98	0.001361	9.21	0.43
Salt River	VaShly US	12.97	175000	1280	1301.64	1303.2	0.001722	10	0.48
Salt River	VaShly US	12.87	175000	1276	1300.58	1302.17	0.001857	10.12	0.49
Salt River	VaShly US	12.77	175000	1276	1299.28	1301.17	0.001846	11.03	0.5
Salt River	VaShly US	12.67	175000	1276	1298.57	1300.26	0.001437	10.41	0.45
Salt River	VaShly US	12.55	175000	1276	1297.48	1299.31	0.001632	10.83	0.48
Salt River	VaShly US	12.44	175000	1276	1295.68	1298.09	0.00247	12.48	0.58
Salt River	VaShly US	12.33	175000	1272	1294.69	1296.82	0.001748	11.72	0.5
Salt River	VaShly US	12.22	175000	1272	1293.69	1295.69	0.001975	11.35	0.52
Salt River	VaShly US	12.1	175000	1272	1292.7	1294.36	0.001969	10.34	0.51
Salt River	VaShly US	12.06	175000	1268	1292.38	1293.83	0.001738	9.65	0.48
Salt River	VaShly US	11.99	175000	1268	1291.28	1293.04	0.002381	10.65	0.55
Salt River	VaShly US	11.88	175000	1267.94	1289.92	1291.77	0.002087	10.9	0.52
Salt River	VaShly US	11.78	175000	1268	1289.44	1290.73	0.001182	9.15	0.41
Salt River	VaShly US	11.62	175000	1264	1288.84	1289.77	0.000824	7.75	0.34
Salt River	VaShly US	11.49	175000	1263.04	1287.7	1289.06	0.001294	9.37	0.42
Salt River	VaShly US	11.41	175000	1260	1286.98	1288.43	0.001625	9.65	0.46
Salt River	VaShly US	11.32	175000	1260	1286.33	1287.74	0.001351	9.81	0.43
Salt River	VaShly US	11.25	175000	1256	1285.68	1287.22	0.001171	10.17	0.41
Salt River	VaShly US	11.17	175000	1256	1285.1	1286.73	0.00116	10.34	0.41

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US	11.14	175000	1256	1284.71	1286.41	0.003522	10.51	0.42
Salt River	VaShly US	11.1	175000	1256	1284.47	1285.86	0.00082	9.47	0.36
Salt River	VaShly US	11.05	175000	1256	1284.5	1285.63	0.000587	8.53	0.31
Salt River	VaShly US	11	175000	1254.01	1284.43	1285.43	0.00045	8.01	0.27
Salt River	VaShly US	10.95	175000	1252	1284.54	1285.24	0.0003	6.72	0.22
Salt River	VaShly US	10.9	175000	1250.83	1284.43	1285.17	0.000313	6.9	0.23
Salt River	VaShly US	10.86	175000	1248	1284.3	1285.09	0.000316	7.12	0.23
Salt River	VaShly US	10.81	175000	1248	1284.28	1285	0.000263	6.83	0.21
Salt River	VaShly US	10.78	175000	1248	1284.2	1284.94	0.00028	6.93	0.22
Salt River	VaShly US	10.73	175000	1248	1284.05	1284.87	0.000294	7.29	0.23
Salt River	VaShly US	10.67	175000	1248	1283.65	1284.73	0.000437	8.36	0.27
Salt River	VaShly US	10.61	175000	1244.2	1283.45	1284.58	0.000427	8.56	0.27
Salt River	VaShly US	10.56	175000	1244	1283.32	1284.48	0.000423	8.63	0.27
Salt River	VaShly US	10.52	175000	1234.97	1283.53	1284.28	0.000238	7.04	0.21
Salt River	VaShly US	10.46	175000	1240	1283.45	1284.19	0.0003	7.17	0.23
Salt River	VaShly US	10.41	175000	1247.67	1283.41	1284.1	0.000253	6.76	0.21
Salt River	VaShly US	10.36	175000	1253	1282.61	1283.94	0.000848	9.4	0.36
Salt River	VaShly US	10.26	175000	1252	1282.43	1283.5	0.000572	8.31	0.3
Salt River	VaShly US	10.18	175000	1256	1281.17	1283.05	0.001562	10.98	0.47
Salt River	VaShly US	10.06	175000	1256	1280.94	1282.09	0.000867	9.24	0.36
Salt River	VaShly US	9.96	175000	1254.13	1280.37	1281.6	0.00084	9.57	0.36
Salt River	VaShly US	9.87	175000	1254.92	1280.04	1281.16	0.000957	8.97	0.34
Salt River	VaShly US	9.8	175000	1252	1279.92	1280.7	0.001046	7.77	0.28
Salt River	VaShly US	9.73	175000	1252	1279.96	1280.22	0.000776	4.39	0.16
Salt River	VaShly US	9.67	175000	1250.78	1279.85	1280	0.000455	3.64	0.13
Salt River	VaShly US	9.64	175000	1252	1279.74	1279.93	0.000649	4.27	0.15
Salt River	VaShly US	9.61	175000	1248.2	1279.67	1279.85	0.00057	4.2	0.14
Salt River	VaShly US	9.59	175000	1244.4	1279.47	1279.75	0.000701	4.75	0.16
Salt River	VaShly US	9.55	175000	1251.37	1279.43	1279.59	0.000536	3.66	0.14
Salt River	VaShly US	9.49	175000	1248	1278.77	1279.3	0.001414	5.8	0.22
Salt River	VaShly US	9.44	175000	1247.05	1278.01	1278.85	0.002303	7.38	0.28
Salt River	VaShly US	9.39	175000	1236	1277.74	1278.18	0.001734	6.11	0.24
Salt River	VaShly US	9.33	175000	1244	1277.23	1277.69	0.001742	6.17	0.24
Salt River	VaShly US	9.26	175000	1247.57	1275.53	1276.76	0.003703	9.01	0.35
Salt River	VaShly US	9.2	175000	1248	1273.63	1275.28	0.005142	10.34	0.41
Salt River	VaShly US	9.13	175000	1248	1270.82	1272.96	0.007066	12.36	0.48
Salt River	VaShly US 2	9.04	111189.2	1248	1269.33	1272.82	0.008424	15.08	0.64
Salt River	VaShly US 2	8.98	111189.2	1250.19	1269.04	1270.2	0.003813	8.67	0.4
Salt River	VaShly US 2	8.92	111189.2	1244	1268.76	1269.24	0.001172	5.63	0.23
Salt River	VaShly US 2	8.88	111189.2	1248	1268.47	1269	0.001425	5.91	0.26
Salt River	VaShly US 2	8.85	111189.2	1248	1268.28	1268.73	0.001508	5.4	0.25
Salt River	VaShly US 2	8.81	111189.2	1248	1267.63	1268.34	0.001909	6.78	0.3
Salt River	VaShly US 2	8.77	111189.2	1245.26	1267.34	1267.95	0.001618	6.25	0.28
Salt River	VaShly US 2	8.74	111189.2	1248	1267.09	1267.62	0.001716	5.84	0.27

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly US 2	8.68	111189.2	1245.3	1266.73	1267.29	0.000482	6.02	0.26
Salt River	VaShly US 2	8.63	111189.2	1244	1266.48	1267.13	0.000601	6.46	0.28
Salt River	VaShly US 2	8.6	111189.2	1244	1266.42	1267.04	0.000626	6.36	0.27
Salt River	VaShly US 2	8.57	111189.2	1244	1266.42	1266.92	0.000454	5.67	0.25
Salt River	VaShly US 2	8.52	111189.2	1240	1266.5	1266.75	0.000216	4.02	0.16
Salt River	VaShly US 2	8.44	111189.2	1240	1266.11	1266.61	0.000407	5.68	0.24
Salt River	VaShly US 2	8.36	111189.2	1244	1265.64	1266.29	0.002595	6.48	0.31
Salt River	VaShly US 2	8.29	111189.2	1240	1264.4	1265.19	0.003124	7.12	0.35
Salt River	VaShly US 2	8.2	111189.2	1240	1263.44	1264.26	0.001103	7.48	0.32
Salt River	VaShly DS	8.1	172000	1237.27	1263.5	1264.24	0.000425	6.91	0.26
Salt River	VaShly DS	8.01	172000	1240	1262.55	1263.91	0.001149	9.34	0.4
Salt River	VaShly DS	7.91	172000	1244	1260.56	1262.96	0.002772	12.61	0.59
Salt River	VaShly DS	7.83	172000	1244	1259.53	1261.7	0.002635	12	0.56
Salt River	VaShly DS	7.71	172000	1243.41	1255.85	1259.42	0.005117	15.4	0.8
Salt River	VaShly DS	7.63	172000	1240	1254.55	1257.18	0.003209	13.06	0.65
Salt River	VaShly DS	7.55	172000	1239.6	1254.22	1255.82	0.001847	10.16	0.49
Salt River	VaShly DS	7.47	172000	1239.83	1253.04	1254.92	0.002585	11.01	0.55
Salt River	VaShly DS	7.45	Bridge						
Salt River	VaShly DS	7.44	172000	1238.53	1252.06	1253.96	0.002823	11.06	0.56
Salt River	VaShly DS	7.4	172000	1239.06	1251.66	1253.35	0.002433	10.53	0.55
Salt River	VaShly DS	7.36	172000	1238.07	1251.64	1252.77	0.001655	8.75	0.46
Salt River	VaShly DS	7.32	172000	1240	1251.12	1252.4	0.001981	9.16	0.49
Salt River	VaShly DS	7.28	172000	1236	1248.88	1251.67	0.006182	13.43	0.81
Salt River	VaShly DS	7.24	172000	1235.58	1245.75	1249.65	0.01012	15.85	1
Salt River	VaShly DS	7.17	172000	1197.93	1238.5	1238.63	0.000068	2.89	0.1
Salt River	VaShly DS	7.1	172000	1206.84	1238.45	1238.6	0.000072	3.08	0.11
Salt River	VaShly DS	7.03	172000	1210.44	1238.26	1238.55	0.000159	4.27	0.16
Salt River	VaShly DS	6.99	172000	1200	1238.34	1238.49	0.000055	3.09	0.1
Salt River	VaShly DS	6.91	172000	1198.45	1238.36	1238.44	0.000041	2.43	0.08
Salt River	VaShly DS	6.8	172000	1196	1238.2	1238.4	0.000076	3.63	0.12
Salt River	VaShly DS	6.69	172000	1197.62	1237.95	1238.32	0.000182	4.93	0.17
Salt River	VaShly DS	6.56	172000	1188.55	1237.99	1238.18	0.000066	3.48	0.11
Salt River	VaShly DS	6.5	172000	1192.83	1238.03	1238.13	0.000043	2.63	0.09
Salt River	VaShly DS	6.45	172000	1180	1238.04	1238.12	0.000024	2.32	0.07
Salt River	VaShly DS	6.4	172000	1196	1237.98	1238.11	0.000039	2.9	0.08
Salt River	VaShly DS	6.38	172000	1195.4	1237.7	1238.08	0.000144	4.69	0.15
Salt River	VaShly DS	6.35	172000	1194.53	1236.65	1237.94	0.000567	9.16	0.31
Salt River	VaShly DS	6.32	172000	1192	1236.68	1237.84	0.000485	8.68	0.29
Salt River	VaShly DS	6.27	172000	1194.49	1236.86	1237.59	0.000349	6.89	0.24
Salt River	VaShly DS	6.22	172000	1203.46	1236.82	1237.47	0.000377	6.52	0.24
Salt River	VaShly DS	6.18	172000	1192	1236.75	1237.4	0.000375	6.55	0.24
Salt River	VaShly DS	6.14	172000	1196	1236.78	1237.28	0.000229	5.74	0.19
Salt River	VaShly DS	6.09	172000	1200	1236.53	1237.2	0.000336	6.65	0.23
Salt River	VaShly DS	6.05	172000	1204	1236.26	1237.08	0.000489	7.27	0.27

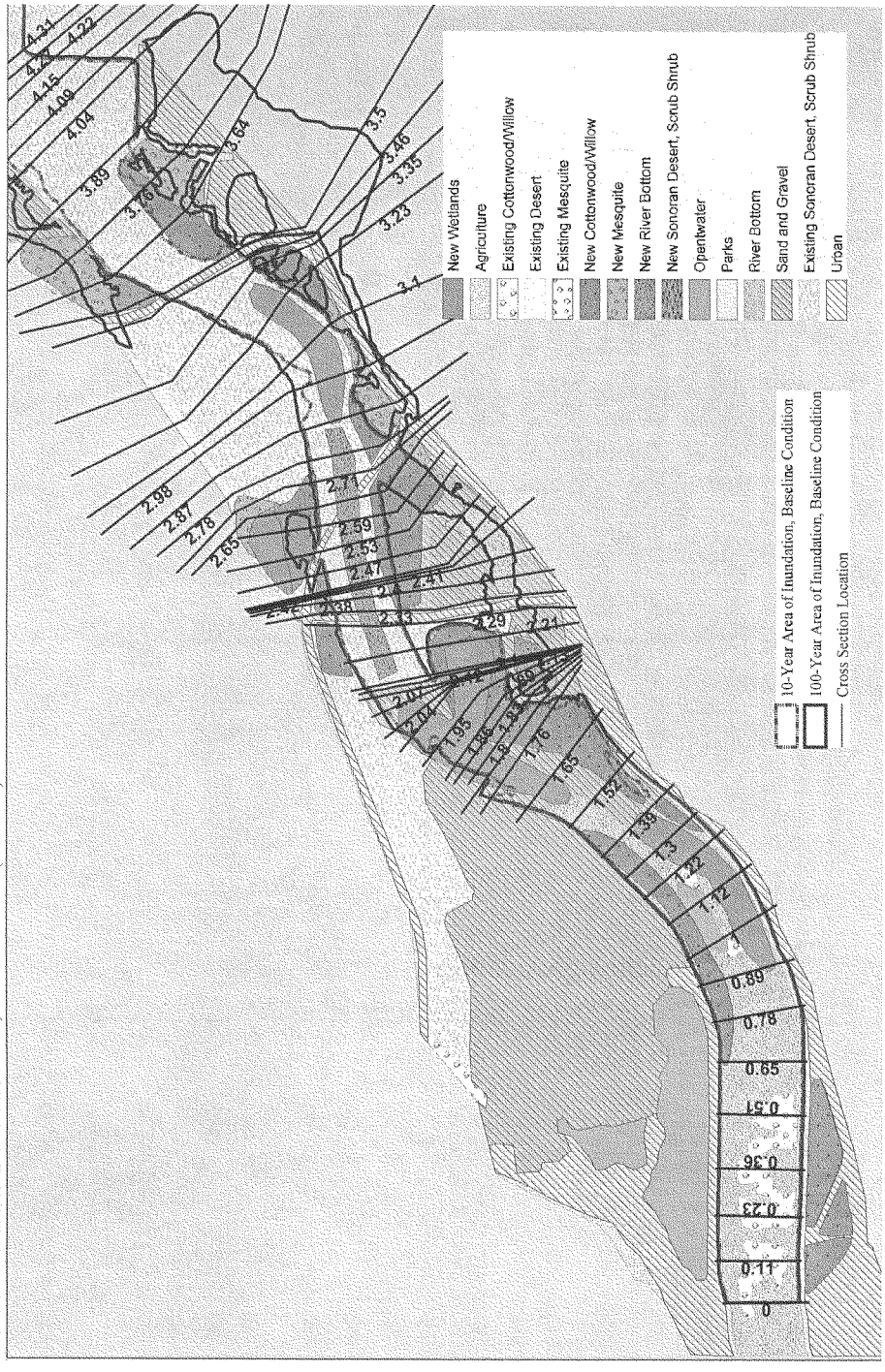
EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	6.01	172000	1204	1235.84	1236.88	0.023402	8.19	0.33
Salt River	VaShly DS	5.99	172000	1200	1234.85	1235.58	0.000831	6.84	0.27
Salt River	VaShly DS	5.97	172000	1198.59	1234.76	1235.5	0.000662	6.9	0.27
Salt River	VaShly DS	5.95	172000	1196	1234.8	1235.37	0.000493	6.1	0.23
Salt River	VaShly DS	5.93	172000	1198.79	1234.83	1235.3	0.000461	5.57	0.21
Salt River	VaShly DS	5.91	172000	1203.31	1234.74	1235.23	0.000802	5.64	0.22
Salt River	VaShly DS	5.88	172000	1209.96	1234.33	1235.05	0.001521	6.85	0.3
Salt River	VaShly DS	5.87	172000	1206.22	1234.05	1234.93	0.001888	7.54	0.32
Salt River	VaShly DS	5.86	172000	1205.11	1233.58	1234.78	0.0039	8.76	0.36
Salt River	VaShly DS	5.85	172000	1208	1233.46	1234.55	0.002762	8.36	0.32
Salt River	VaShly DS	5.84	172000	1204	1233.16	1234.35	0.003081	8.76	0.34
Salt River	VaShly DS	5.82	172000	1204	1232.93	1234.09	0.001926	8.62	0.33
Salt River	VaShly DS	5.8	172000	1204	1232.68	1233.88	0.002052	8.79	0.33
Salt River	VaShly DS	5.76	172000	1204	1232.13	1233.58	0.000967	9.67	0.38
Salt River	VaShly DS	5.73	172000	1208	1231.33	1233.29	0.001479	11.26	0.46
Salt River	VaShly DS	5.69	172000	1206.01	1231.44	1232.96	0.000968	9.89	0.39
Salt River	VaShly DS	5.65	172000	1198.67	1231.67	1232.57	0.000888	7.65	0.28
Salt River	VaShly DS	5.6	172000	1194.35	1231.71	1232.31	0.000337	6.24	0.2
Salt River	VaShly DS	5.56	172000	1208	1230.47	1232.09	0.002464	10.21	0.43
Salt River	VaShly DS	5.53	172000	1192	1230.57	1231.51	0.001589	7.78	0.29
Salt River	VaShly DS	5.47	172000	1208	1228.97	1230.7	0.007394	10.6	0.46
Salt River	VaShly DS	5.4	172000	1196	1227.23	1228.99	0.001266	10.7	0.43
Salt River	VaShly DS	5.26	172000	1179.01	1227.01	1227.89	0.001043	7.87	0.28
Salt River	VaShly DS	5.15	172000	1204	1225.52	1226.96	0.0027	10.05	0.42
Salt River	VaShly DS	5.03	172000	1204	1223.7	1225.11	0.003027	10.07	0.43
Salt River	VaShly DS	4.88	172000	1200	1220.11	1222.53	0.003392	12.82	0.66
Salt River	VaShly DS	4.74	172000	1188	1219.57	1220.55	0.000802	8.1	0.34
Salt River	VaShly DS	4.59	172000	1192	1218.89	1219.82	0.000975	8.01	0.34
Salt River	VaShly DS	4.47	172000	1200	1218.21	1219.01	0.001396	7.9	0.37
Salt River	VaShly DS	4.31	172000	1199.24	1215.62	1217.17	0.004517	10.27	0.48
Salt River	VaShly DS	4.27	172000	1192	1215.45	1216.41	0.000795	7.92	0.34
Salt River	VaShly DS	4.22	172000	1178.19	1215.47	1216.15	0.00047	6.48	0.26
Salt River	VaShly DS	4.15	172000	1184	1215.09	1215.95	0.000687	7.44	0.31
Salt River	VaShly DS	4.09	172000	1188	1215.09	1215.68	0.000475	6.06	0.26
Salt River	VaShly DS	4.04	172000	1184	1215.13	1215.51	0.00028	4.93	0.2
Salt River	VaShly DS	3.89	172000	1174.66	1215.02	1215.32	0.000137	4.44	0.15
Salt River	VaShly DS	3.76	172000	1188	1214	1215.08	0.000922	8.36	0.36
Salt River	VaShly DS	3.64	172000	1192	1212.78	1214.27	0.001795	9.78	0.48
Salt River	VaShly DS	3.5	172000	1186.84	1212.16	1213.13	0.000821	7.91	0.34
Salt River	VaShly DS	3.48	Bridge						
Salt River	VaShly DS	3.46	172000	1184	1212	1212.85	0.000727	7.43	0.31
Salt River	VaShly DS	3.35	172000	1188	1210.53	1212.17	0.001698	10.28	0.43
Salt River	VaShly DS	3.23	172000	1183.78	1208.71	1210.86	0.002519	11.79	0.52
Salt River	VaShly DS	3.1	172000	1173.54	1207.29	1209.16	0.002068	10.97	0.48

EXHIBIT G – HYDRAULIC RESULTS, ALTERNATIVE E (MODEL 9)

River	Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl
Salt River	VaShly DS	2.98	172000	1179.21	1206.8	1208.03	0.001057	8.92	0.35
Salt River	VaShly DS	2.87	172000	1175.62	1205.6	1207.32	0.001176	10.52	0.44
Salt River	VaShly DS	2.78	172000	1185.67	1205.15	1206.55	0.001539	9.5	0.42
Salt River	VaShly DS	2.71	172000	1185.2	1204.64	1206.06	0.001484	9.58	0.41
Salt River	VaShly DS	2.65	172000	1184.02	1203.37	1205.36	0.00228	11.34	0.5
Salt River	VaShly DS	2.59	172000	1183.07	1202.58	1204.71	0.002063	11.71	0.53
Salt River	VaShly DS	2.53	172000	1182.76	1202.17	1203.99	0.001695	10.82	0.49
Salt River	VaShly DS	2.47	172000	1180.75	1200.89	1203	0.015677	11.65	0.53
Salt River	VaShly DS	2.42	172000	1175.84	1199.05	1200.63	0.001235	10.11	0.42
Salt River	VaShly DS	2.41	172000	1175.97	1198.8	1200.56	0.001463	10.66	0.46
Salt River	VaShly DS	2.4	172000	1176.34	1198.49	1200.47	0.001777	11.29	0.5
Salt River	VaShly DS	2.38	172000	1176.14	1198.28	1200.21	0.001755	11.13	0.49
Salt River	VaShly DS	2.33	172000	1179.92	1196.62	1199.59	0.003357	13.83	0.67
Salt River	VaShly DS	2.31	Bridge						
Salt River	VaShly DS	2.29	172000	1170.86	1194.2	1196.57	0.002274	12.37	0.56
Salt River	VaShly DS	2.21	172000	1176	1193.04	1195.54	0.002547	12.68	0.59
Salt River	VaShly DS	2.13	172000	1175.43	1190.68	1194.12	0.004276	14.88	0.74
Salt River	VaShly DS	2.12	172000	1175.83	1188.38	1193.56	0.007589	18.26	1
Salt River	VaShly DS	2.1	172000	1158.27	1181.99	1183.71	0.001871	10.7	0.48
Salt River	VaShly DS	2.07	172000	1155.35	1182	1183.4	0.001088	9.65	0.4
Salt River	VaShly DS	2.04	172000	1153.78	1182.05	1183.13	0.000997	8.41	0.33
Salt River	VaShly DS	2.02	172000	1152.83	1181.88	1183.01	0.000969	8.59	0.31
Salt River	VaShly DS	1.95	172000	1153.57	1181.65	1182.62	0.000916	7.94	0.3
Salt River	VaShly DS	1.89	172000	1152.14	1181.35	1182.18	0.001657	7.33	0.29
Salt River	VaShly DS	1.86	172000	1148	1181.1	1181.93	0.001851	7.34	0.29
Salt River	VaShly DS	1.83	172000	1148	1180.66	1181.59	0.001986	7.77	0.33
Salt River	VaShly DS	1.8	172000	1147.44	1180.62	1181.24	0.001114	6.35	0.25
Salt River	VaShly DS	1.76	172000	1146.98	1180.57	1181.02	0.000596	5.41	0.2
Salt River	VaShly DS	1.65	172000	1144.47	1180.39	1180.73	0.000307	4.7	0.17
Salt River	VaShly DS	1.52	172000	1144	1180.06	1180.49	0.000367	5.27	0.18
Salt River	VaShly DS	1.39	172000	1146.14	1179.72	1180.16	0.000676	5.32	0.19
Salt River	VaShly DS	1.3	172000	1150.23	1179.33	1179.84	0.000641	5.75	0.22
Salt River	VaShly DS	1.22	172000	1150.27	1179.05	1179.56	0.00071	5.74	0.21
Salt River	VaShly DS	1.12	172000	1152	1178.55	1179.14	0.000795	6.18	0.24
Salt River	VaShly DS	1	172000	1148.57	1178.14	1178.68	0.000691	5.91	0.22
Salt River	VaShly DS	0.89	172000	1148	1177.74	1178.36	0.00038	6.34	0.24
Salt River	VaShly DS	0.78	172000	1152	1177.39	1178.1	0.000471	6.78	0.27
Salt River	VaShly DS	0.65	172000	1151.5	1177.18	1177.8	0.000352	6.32	0.23
Salt River	VaShly DS	0.51	172000	1152	1176.85	1177.51	0.000395	6.55	0.25
Salt River	VaShly DS	0.36	172000	1151.05	1176.51	1177.2	0.000411	6.67	0.25
Salt River	VaShly DS	0.23	172000	1150.96	1176.24	1176.92	0.000394	6.61	0.25
Salt River	VaShly DS	0.11	172000	1148	1175.9	1176.65	0.000442	6.92	0.26
Salt River	VaShly DS	0	172000	1148	1175.65	1176.39	0.000403	6.92	0.25

EXHIBIT H– AREA OF INUNDATION MAP, ALTERNATIVE O (MODEL 9)



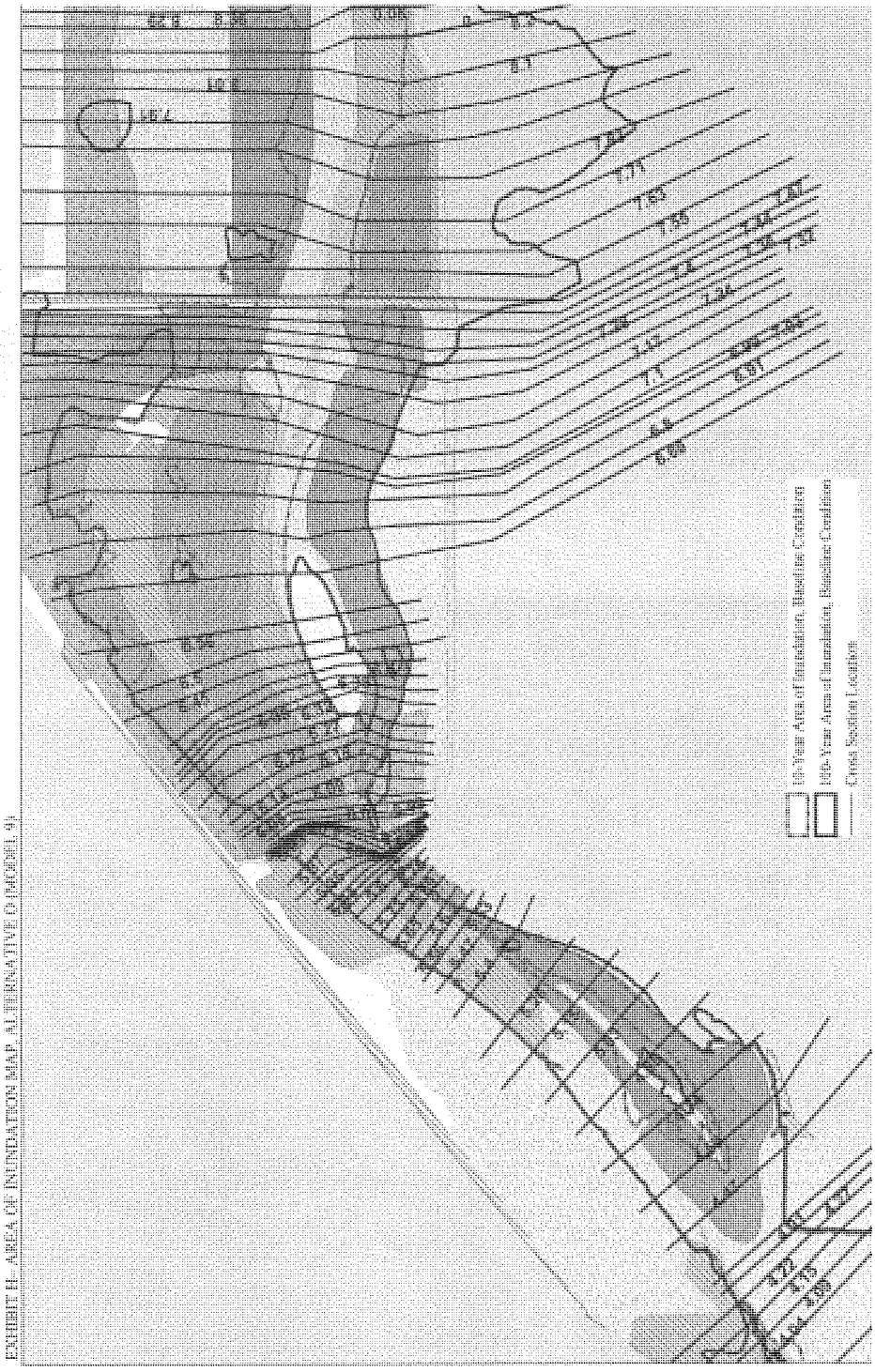


EXHIBIT H - AREA OF INUNDATION MAP ALTERNATIVE D (MODEL 9)
10-Year Area of Inundation, Baseline Condition
100-Year Area of Inundation, Baseline Condition
Cross Section Location

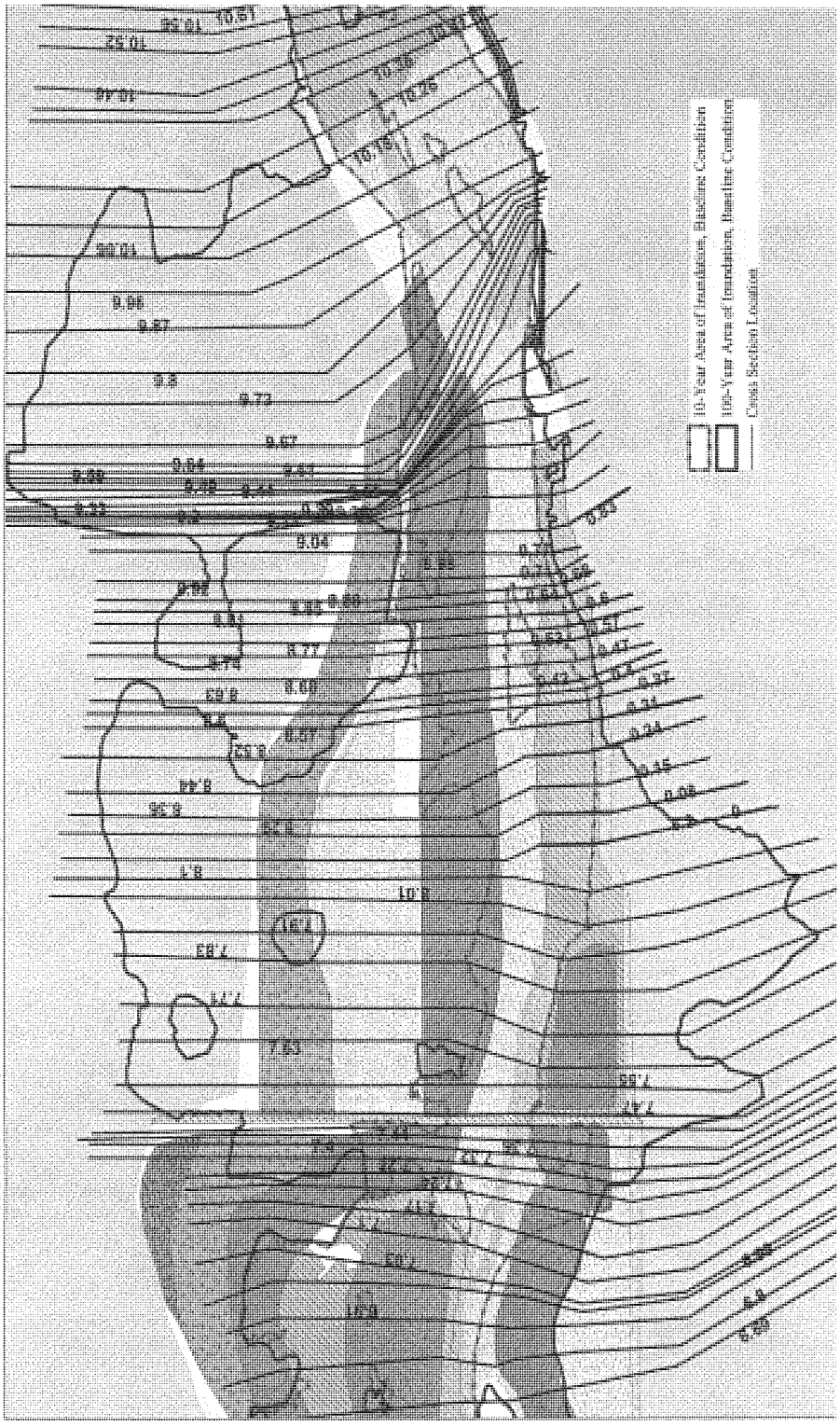


EXHIBIT III - AREA OF INUNDATION MAP, ALTERNATIVE G (MODEL 9)

WATER BUDGET ANALYSIS

TABLE OF CONTENTS

WATER BUDGET ANALYSIS WITH-PROJECT

INTRODUCTION 1
Purpose 1
Description of Study Area 1

PLANT WATER DEMAND 5

PROJECT FEATURES 7
Project Water Supply 7
Pump Stations 7
Water Distribution Channel 7
Water Distribution Pipe 7
Irrigation System 8
Wetland Feature 9

WATER BUDGET ANALYSIS 10
Vegetation Water Demand 10
Monthly Water Demand 10
Water Sources 13
Irrigation System 15

PREFERRED ALTERNATIVE 16

RECOMMENDATIONS 18

REFERENCES 19

EXHIBITS 20

INTRODUCTION

Introduction

Purpose

1. The With Project Water Budget consisted of a preliminary design for the water distribution system and an estimation of the annual and monthly water demand takes into account plant water demand and irrigation losses. Monthly and annual water demand was estimated for cottonwood/willow, mesquite, upper sonoran desert and wetland vegetation types. Results were assessed for vegetation type, sub-areas and water sources. Five water sources were identified for project water: City of Mesa wastewater treatment effluent, stormwater runoff, agriculture tailwater, groundwater and Salt River Project (SRP) water made available by the Salt River Pima Maricopa Indian Community (SRPMIC). Features and results presented in this section are referenced with respect to sub-areas, sub-area locations are shown on Figure B-2.

Description of Study Area

2. The Va Shly'ay Akimel study area is located within Maricopa County in central Arizona. The study area includes the section of the Salt River that begins at Granite Reef Diversion Dam (Granite Reef) on the east side of the study area and extends downstream to the west for a distance of approximately 15 miles to the Pima Freeway (State 101), Figure B-1.

3. The majority of the study area is within the jurisdiction of the Salt River Pima-Maricopa Indian Community (SRPMIC). A portion of the project is within the jurisdiction of the City of Mesa located in the southwest part of the study area.

4. The channel of the Salt River within the study area contains several active and historic sand and gravel mining pits. Salt River Project (SRP) operates the Granite Reef Underground Storage Project (GRUSP) on the Salt River overbank area in the central part of the study area and the City of Mesa operates a recharge project on the west end of the study area.

5. The Salt River was a perennial stream until the construction of upstream dams, with associated reservoirs, regulated the flow. There are four dams on the Salt River and two dams on the Verde River, a tributary to the Salt River. These structures control the flow changed the character of the Salt River within the study area into an ephemeral stream. Granite Reef Dam is a diversion structure, not a water storage or flood control structure. This dam diverts the flow in the Salt River into two major irrigation canals, the Arizona Canal on the northside and the Southern Canal on the southside. Flows only occur through the study area when there are flood releases from the upstream reservoirs. The flood flows vary in duration, quantity and magnitude depending on the nature of the flood releases. Historically, the flood releases over Granite Reef Dam have gone from zero to 200,000 ft^3/s in less than a week. Due to these modifications the Salt River has become a ephemeral river with events occurring on average once every three years.

INTRODUCTION

6. The winter months are typically when large regional storms or series of storms occur. These storms may include an accumulation and subsequent melt of the snow pack in the Salt River and Verde River watersheds and result in the releases of water into the Salt River system that can flow over Granite Reef Dam into the study area. While the river stages may be high for an extended period, the quantity and intensity of accompanying storm precipitation is generally reduced in the lower elevations, including the study area.

7. During the middle to late summer months the monsoon storm pattern is typical. These storms produce intense, short-duration thunderstorms with significant precipitation. During these storms the river stages are low because the storms are localized and because the upstream reservoirs usually have the capacity to store the local runoff from the watershed.

8. For a more detailed discussion on the runoff and surface water refer to Appendix A, Runoff Discussion, the without project water budget analysis (Piésold, 2002a) and interior drainage report (Piésold, 2002b)

9. Depth to the groundwater table varies throughout the study area as a result of the hydrogeologic conditions and dams constructed on the Salt and Verde Rivers. Granite Reef Dam was constructed to divert the Salt River flow into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the project area. Although not intended to be a storage reservoir, some water is retained up stream of the dam at all times. Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP reported that water seeps through the radial gates because the gates do not form a tight seal with the granite bedrock. The result is a continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records.

10. On average the depth to groundwater ranges from 100 feet to 120 feet in the project area. In certain areas, downstream of Granite Reef Dam, near the GRUSP site and at the City of Mesa wastewater treatment facility, the depth to groundwater is much less. This is due to recharge from local surface water sources, seepage from Granite Reef Dam, SRP recharge water and recharge from wastewater effluent, respectively.

Figure B-1. VaShly Akimel Reach Map.

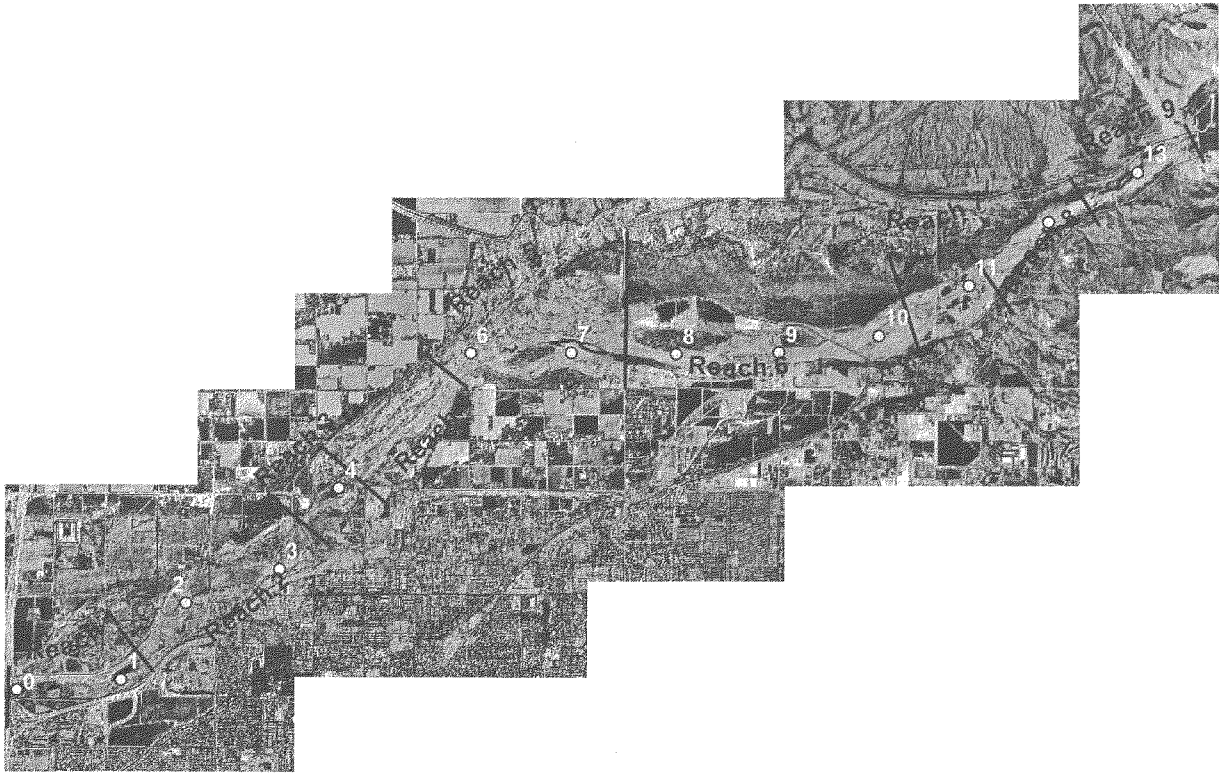
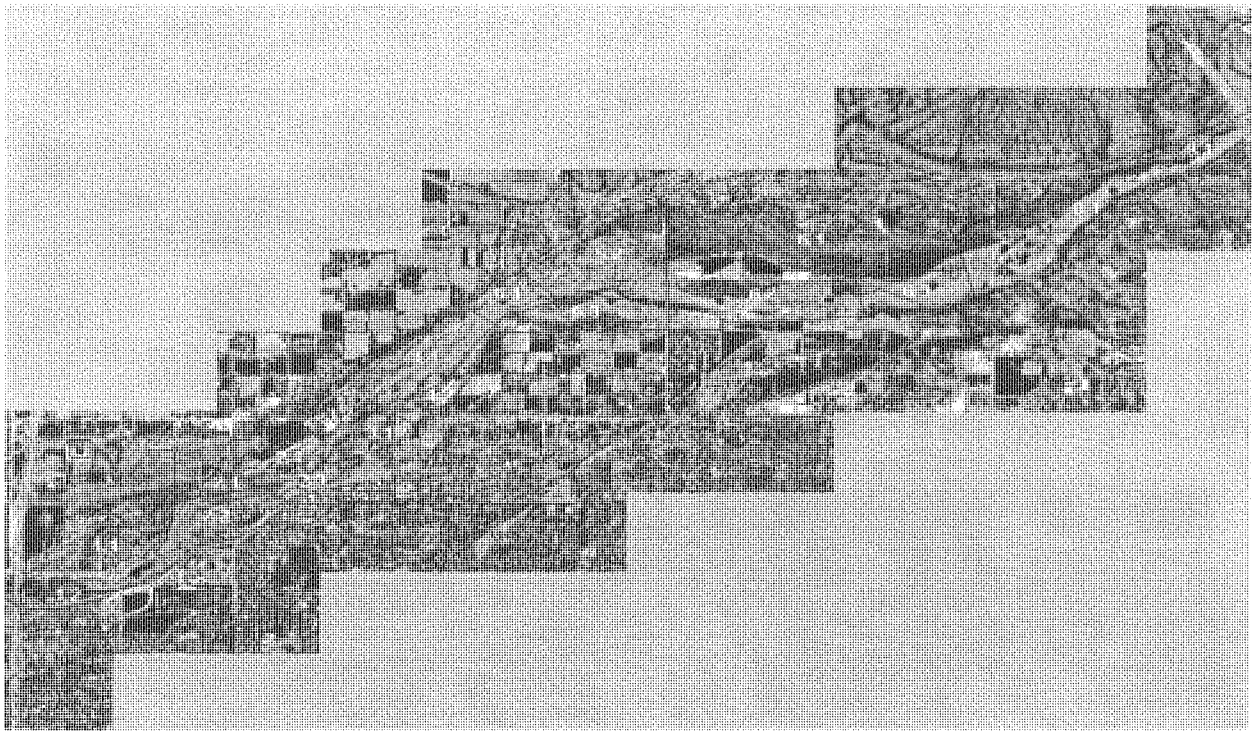


Table B-2. Project sub-area locations and river stations.



Plant Water Demand

Plant Water Demand

11. Various sources were referenced to come up with an appropriate estimate for the water demand for cottonwood/willow, mesquite, upper sonoran desert and wetland vegetation types. It was decided that the annual average evapotranspiration rates presented in the USACE Feasibility Study reports for the Rio Salado and Tres Rios restoration projects best represented the water demand for this project area. Summary of the evapotranspiration rates are shown in Table B-1.

Table B-1. Annual Evapotranspiration Rate.

Source	Va Shly'ay	Paseo*	Tres Rios Del Norte**	Tres Rios***	Rio Salado****	John Moeur*****
Cottonwood/Willow	6.3	6	6.03	6.3	7-8.5	4-8.5
Mesquite	3	1.7	3	1.6	1.6	2-4.5
Sonoran Desert	2	2	4	2	3-4	0.5-2.5
Wetlands	9	12	6.5 (open water)	11.7	7.5-16.5	9-16

*"Paseo de las Iglesias Environmental Restoration Study Tucson, Arizona Draft Groundwater and Water Budget Analysis" (Present Condition), October 2002.
** "Tres Rios Del Norte Draft Groundwater and Water Budget Analysis", 8/20/2002.
***"Tres Rios, Arizona Feasibility Report April 2000";'Greeley & Hansen, 1998. Tres Rios, Arizona Fesibility Study, Salt/Gila Groundwater Analysis. Task-2 Water Budget Analyses and Development, Salt and Gila River Technical Memorandum, February 1998.
**** "Rio Salado Salt River, Arizona Feasibility Report, Technical Appendices", April 1998.
***** John Moeur, personal communciation, USACE, 2002.

12. The monthly evapotranspiration pattern for each of the vegetation types was assumed to be similar to the monthly consumptive use pattern, et, for the Salt River vegetation determined in the Tres Rios project study, Table B-2 (Piesold, 2002a).

Table B-2. Monthly evapotranspiration rate pattern.

Month	et (ft/month)
January	0.185
February	0.185
March	0.185
April	0.37
May	0.37
June	0.555
July	0.555
August	0.555
September	0.185
October	0.185
November	0.185
December	0.185
Annual	3.7

13. Assuming this pattern, the monthly evapotranspiration rate for the different vegetation types, et_i, for month i, corresponds to the normalized monthly

evapotranspiration rate, n_i, Table B-3, where n equals the monthly evapotranspiration rate divided by the annual evapotranspiration rate.

Table B-3. Monthly normalized evapotranspiration rate pattern.

Month	n_i
January	0.05
February	0.05
March	0.05
April	0.1
May	0.1
June	0.15
July	0.15
August	0.15
September	0.05
October	0.05
November	0.05
December	0.05

14. Thus, for a given month i the monthly evapotranspiration rate is,

$$et_i = n_i ET \qquad \text{eq. B-1}$$

15. where ET is the annual evapotranspiration rate, Table B-4.

Table B-4. Monthly vegetation evapotranspiration rate.

	Cottonwood/ Willow	Mesquite	Wetland	Upper Sonoran Desert
Month	et (ft/month)	et (ft/month)	et (ft/month)	et (ft/month)
January	0.3	0.2	0.5	0.1
February	0.3	0.2	0.5	0.1
March	0.3	0.2	0.5	0.1
April	0.6	0.3	0.9	0.2
May	0.6	0.3	0.9	0.2
June	0.9	0.5	1.4	0.3
July	0.9	0.5	1.4	0.3
August	0.9	0.5	1.4	0.3
September	0.3	0.2	0.5	0.1
October	0.3	0.2	0.5	0.1
November	0.3	0.2	0.5	0.1
December	0.3	0.2	0.5	0.1
Annual	6.3	3.0	9.0	2.0

Project Features

Project Features

Project Water Supply

16. The water supply for the project will come from five water sources in varying amounts: City of Mesa wastewater treatment effluent, stormwater runoff, agriculture tailwater, groundwater and SRP water made available by the SRPMIC. The project will require commitments to provide an adequate water supply for at least 50 years.

Pump Station

17. A pumping station will be designed to pump groundwater to support sub-areas 5.2 and 6.1 and to have the capacity to support sub-area 5.1. The estimated pump capacity ranges from 1,500 to 5,000 gal/minute. Alternatives A, D and I do not have a pump station in the design.

18. A landfill located north of the project area, west of Gilbert Road, had groundwater guidelines that restricted raising the local groundwater table to a specified elevation. The pumping station can be used to control water levels near the landfill, offsetting incidental recharge caused by irrigation of vegetated areas.

19. Additional pumps will be needed to pump water from the SRPMIC irrigation channels on the north bank to vegetated areas along the main channel and on the south bank. Pump stations will be located at Alma School Road and Country Club Road.

Water Distribution Channel

20. A distribution channel will be designed to distribute surface water from water source to vegetated area. The distribution channel will be incorporated in Alternatives B, C, E, H and G. The channels will be lined have no water loss due to infiltration. The channel will be 40 feed wide and 3 feet deep. They will be designed to be a perennial source of water for project features.

Water Distribution Pipe

21. A 12-inch pvc pipe will be buried through out the project area to convey water from the pump station, wastewater effluent sources and existing SRPMIC irrigation system to the vegetated areas. Diversion structures will be designed to divert water to the distribution pipe from the SRPMIC system and the City of Mesa wastewater treatment source.

22. Stormwater and irrigation tailwater will be used when available. The diversion structures will be integrated into these sources where applicable. The diversion structures will be designed to divert both project water and excess water to the project area.

Project Features

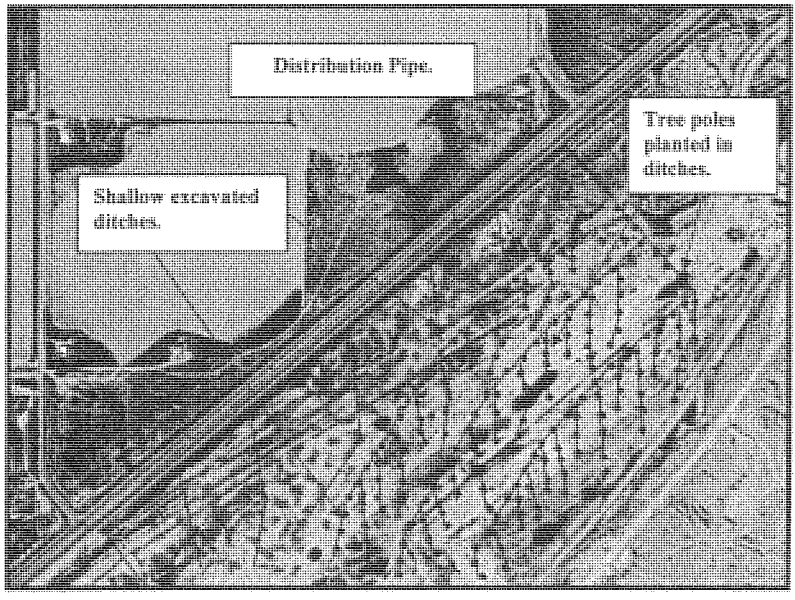
Irrigation Systems

23. Water distributed to the vegetated area will then be used for irrigation purposes using three systems: drip irrigation, flood irrigation and surface braided irrigation (SBIN).

24. Drip irrigation is a common system for irrigation however it is not an advantageous method for encouraging incidental growth and the irrigation of large areas. The drip irrigation system had an assumed irrigation efficiency of 80%.

25. SBIN distributes water through a network of shallow ditches, 6 inches deep and 2-3 ft wide. Channels maybe lined or unlined. Maintenance of these channels may be necessary after larger flow events. Water distribution will need to be manually controlled for the life of the project. The unlined SBIN method had an assumed irrigation efficiency of 50%. Note that the irrigation efficiency for a lined system will be higher than that of an unlined system.

Figure B-4. Surface Braided Irrigation Network (SBIN) Diagram.



26. The flood irrigation method consists of inundating an area by overland flow. This method has a low irrigation efficiency; vegetation water demand divided by total water demand (vegetation water demand plus water losses), but has low maintenance requirements and construction costs. Water distribution will need to be manually controlled for the life of the project. The flood irrigation method had an assumed irrigation efficiency of 20%. The flood irrigation method results can be assumed equal to the unlined SBIN system for the feasibility study.

Project Features

Wetland Feature

27. Many of the alternatives will have wetland features in their design. For the feasibility study it was assumed that engineering of the wetland area will be required to create and maintain these arca. It was assumed that 7 feet will be excavated at the wetland area. A 2 foot clay area will be placed to decrease the permeability at the wetland. A 2 foot gravel layer will be placed on top of the clay layer to prevent damage to the clay layer. Some topsoil may need to be placed on top of the coarse material to allow for the establishment of wetland vegetation.

28. An inlet structure will be designed to protect the wetland substrate from high velocity flows entering the wetland.

Water Budget Analysis

Water Budget Analysis

29. Water budget for the project alternatives were calculated based on the evapotranspiration rate for the vegetation cover type. The drip irrigation and SBIN irrigation systems were also evaluated for irrigation efficiency and water demand. Infiltration losses for the distribution channel and the wetland were not taken into account. Depending on the lining of the channel and the wetland, the infiltration loss can be substantial and will need to be taken into account in the final design.

30. It was assumed that precipitation, agriculture tailwater and stormwater runoff did not to contribute to the irrigation of vegetated area.

Vegetation Water Demand

31. Each Alternative was broken up into their vegetated area and multiplied by the annual evapotranspiration rate to estimate annual alternative vegetation water demand, Table B-5.

Table B-5. Annual alternative vegetation water demand.

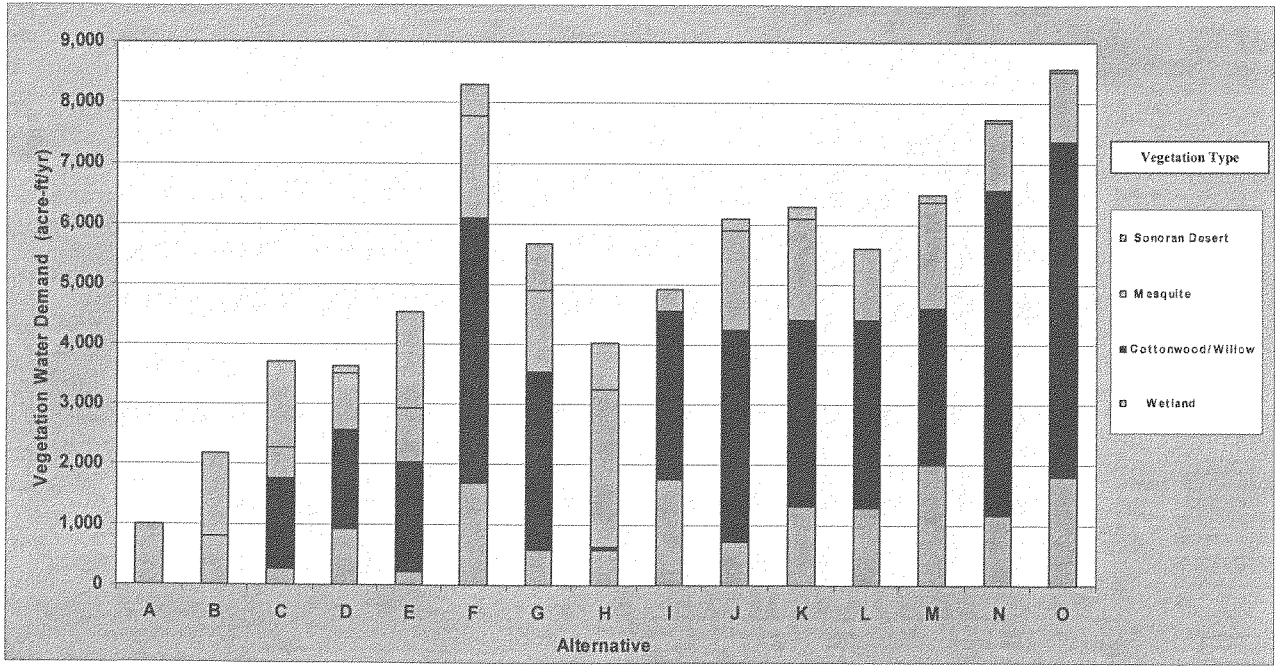
	Wetland	Wetland	Cottonwood/ Willow	Cottonwood/Willow	Mesquite	Mesquite	Sonoran Desert	Sonoran Desert	Total	Total
Alternative	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)	Area (acres)	Water Demand (acre-ft/yr)
A	0	0	0	0	0	0	496	992	496	992
B	0	0	0	0	267	802	685	1,370	952	2,172
C	29	260	238	1,500	166	497	720	1,440	1,152	3,696
D	103	930	259	1,635	313	939	63	126	739	3,629
E	52	229	287	1,808	296	888	808	1,615	1,416	4,540
F	187	1,682	701	4,418	558	1,673	266	531	1,711	8,304
G	64	578	470	2,959	454	1,363	395	790	1,383	5,690
H	64	578	9	55	870	2,609	395	790	1,338	4,032
I	196	1,765	443	2,788	6	18	174	348	819	4,920
J	82	735	556	3,501	556	1,668	92	183	1,285	6,087
K	146	1,318	493	3,103	558	1,675	104	208	1,301	6,304
L	143	1,286	495	3,117	400	1,199	0	0	1,037	5,602
M	222	2,002	412	2,598	587	1,762	63	126	1,285	6,488
N	131	1,178	853	5,371	380	1,139	24	47	1,387	7,736
O	200	1,798	883	5,566	380	1,139	24	47	1,486	8,550

32. The total water demand ranges from 990 acre-ft/yr (Alternative A) to 8,600 acre-ft/yr (Alternative O). Generally, cottonwood/willow vegetation type tends to have the largest annual water demand because of the high evapotranspiration rate, 6.3 ft/yr, and large areas of re-vegetation.

Monthly Water Demand

33. Monthly water demand was estimated for each alternative based on the monthly evaporation distribution presented in Plant Water Demand section, Table B-6.

Figure B-6. Annual alternative vegetation water demand.

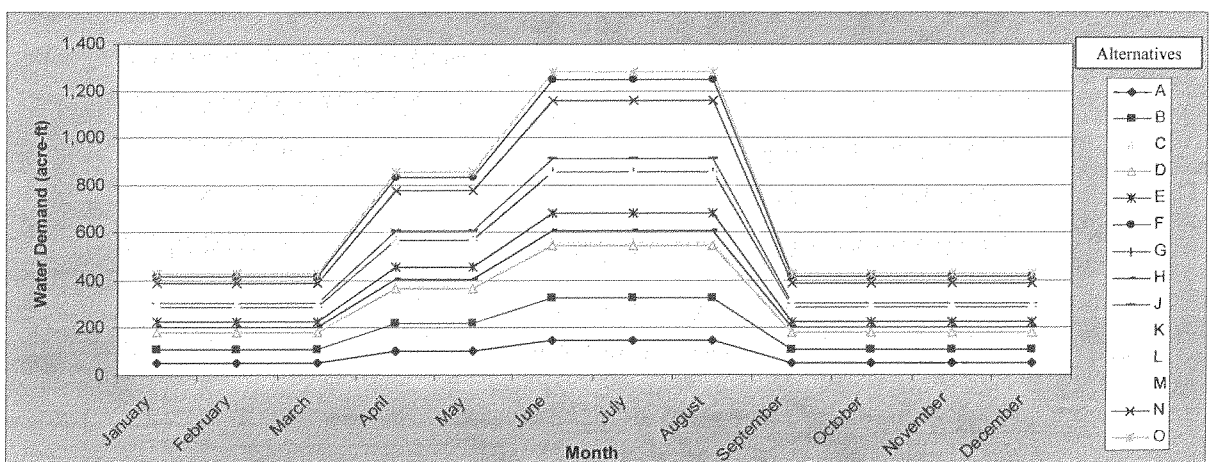


Water Budget Analysis

Table B-6. Monthly alternative water demand.

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Month	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)	Water Demand (acre-ft/month)
January	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
February	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
March	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
April	99	217	370	363	454	830	569	403	492	609	630	560	649	774	855
May	99	217	370	363	454	830	569	403	492	609	630	560	649	774	855
June	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
July	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
August	149	326	554	544	681	1,246	854	605	738	913	946	840	973	1,160	1,282
September	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
October	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
November	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
December	50	109	185	181	227	415	285	202	246	304	315	280	324	387	427
Annual	992	2,172	3,696	3,629	4,540	8,304	5,690	4,032	4,920	6,087	6,304	5,602	6,488	7,736	8,550

Figure B-7. Monthly alternative water demand.



Water Budget Analysis

34. The maximum monthly water demand occurs during the months of June, July and August, the minimum period occurs from September to March, Figure B-7.

Water Sources

35. The water sources used were dependent on the source location, proximity to vegetated area and water availability. The water demand, not including irrigation efficiencies is shown on Table B-7. The water demand for each sub-area analysis is shown on Table B-8.

Table B-7. Alternatives water source water requirement.

	Effluent	Well Water	SRPMIC Surface Water	Total
Alternative	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)	Water Requirment (acre-ft/yr)
A	0	0	992	992
B	0	787	1,385	2,172
C	0	676	3,021	3,696
D	0	887	2,742	3,629
E	242	1,419	2,879	4,540
F	0	1,331	6,973	8,304
G	234	943	4,513	5,690
H	0	782	3,250	4,032
I	0	0	4,920	4,920
J	0	1,249	4,838	6,087
K	0	1,350	4,954	6,304
L	0	1,072	4,530	5,602
M	0	1,228	5,259	6,488
N	174	1,804	5,757	7,736
O	176	2,012	6,361	8,550

36. The largest source of water was SRPMIC surface water. Wastewater will only be used to support vegetation located in sub-area 1.2. The well was designed to support sub-area 5.2 and 50% of sub-area 6.1. Precipitation, stormwater runoff and agriculture tailwater were not accounted for in the water demand estimates.

Table B-8. Sub-area water demand.*

***Refer to Figure B-2 for sub-area locations.**

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sub-area	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)
1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	146	410
1.2	0	0	0	0	242	0	234	0	0	0	0	0	0	174	176
2.1	0	0	0	0	2	91	0	0	76	17	0	0	14	8	53
2.2	0	0	40	0	164	581	327	289	522	279	254	440	534	464	932
2.3	0	46	96	0	96	310	227	173	189	140	140	147	140	150	339
2.4	0	0	0	0	0	316	0	0	66	258	257	413	260	284	195
3.1	0	0	0	0	0	181	207	190	105	124	159	0	147	181	154
3.2	0	0	0	0	0	0	0	0	0	0	147	0	0	0	98
4.1	0	242	486	657	384	950	810	696	494	461	462	0	463	337	0
4.2	0	0	0	705	0	718	274	169	710	652	651	389	694	719	1,033
5.1	83	179	284	341	275	242	282	280	240	126	263	287	209	364	0
5.2	263	699	676	887	876	1,076	943	726	272	994	576	1,007	638	1,169	1,670
5.3	50	50	330	1,040	311	887	614	466	591	997	1,013	1,000	1,053	691	948
6.1	262	326	0	0	450	510	0	0	0	510	510	65	590	595	683
6.2	224	486	1,362	0	1,455	1,670	1,563	898	1,142	960	1,291	1,618	1,164	1,834	1,758
6.3	109	144	422	0	286	771	210	145	514	570	580	236	582	619	99
Total	992	2,172	3,696	3,629	4,540	8,304	5,690	4,032	4,920	6,087	6,304	5,602	6,488	7,736	8,550

Water Budget Analysis

Irrigation System

37. To take into account inefficiencies in the irrigation and distribution system it was assumed that the drip irrigation was 80% efficient and the SBIN system was 50% efficient, Table B-9. Efficiency values were based on engineering judgment.

Table B-9. Annual alternative water demand including irrigation inefficiencies.

	Vegetation	Drip	SBIN
Alternative	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)	Water Demand (acre-ft/yr)
A	992	1,240	1,983
B	2,172	2,715	4,345
C	3,696	4,620	7,393
D	3,629	4,537	7,259
E	4,540	5,675	9,080
F	8,304	10,380	16,607
G	5,690	7,113	11,381
H	4,032	5,040	8,064
I	4,920	6,150	9,840
J	6,087	7,609	12,174
K	6,304	7,880	12,608
L	5,602	7,002	11,204
M	6,488	8,110	12,976
N	7,736	9,669	15,471
O	8,550	10,688	17,100

38. The drip irrigation is more effective for irrigating the vegetation features. However because of the size of the area that will be re-vegetated it may be difficult to install a drip irrigation system. The SBIN has less maintenance requirements than the drip system. In addition to lower maintenance demands, the SBIN system could be more effective to encourage vegetation growth that was not planted as part of the project.

Preferred Alternative

Preferred Alternative

39. Alternative O with the SBIN irrigation system was determined as the preferred alternative. The total water, including the 50% irrigation efficiency, was on average 17,000 acre-ft per year. This assumes that there was no rainfall or surface runoff. Rainfall and surface runoff would normally reduce water demands. But to be conservative it was decided that these sources need to be treated as non-reliable.
40. The sub-area distribution of water was broken down into reach segments (e.g. 1, 2, 3...) which relates to the sub-area (e.g. 1.1, 1.2, 2.1...). The highest demand for water occurs within reaches 5 and 6, Table B-10.

Table B-10. Annual Reach water demand for Alternative O. See Figure B-1 for reach locations.

Reach	Area (acres)	Water Demand (acre-ft)
1	81	1174
2	217	3038
3	59	505
4	145	2066
5	486	5235
6	497	5081
Total	1,486	17099

41. The water sources necessary to support the vegetation are: SRPMIC irrigation water, groundwater from a new well and treated effluent. The largest volume of water comes from the SRPMIC irrigation water. Annual average total demand and maximum monthly demand for each source are shown in Table B-11.

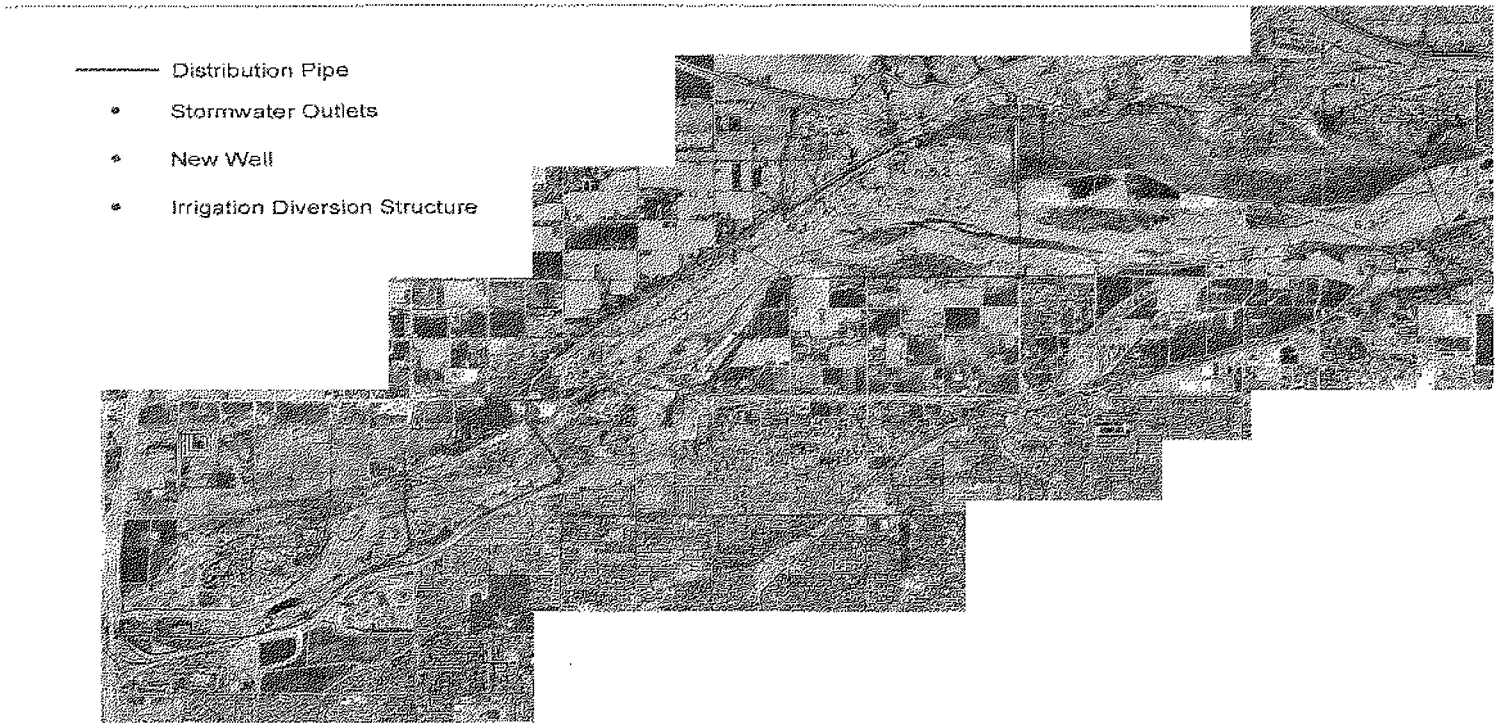
Table B-11. Annual water demand for each source for Alternative O.

	WWTP Demand (acre-ft)	Well Water Demand (acre-ft)	SRPMIC Demand (acre-ft)
Total	353	4,023	12,723
Max Monthly	53	604	1,908

42. The new well was sized for Pump capacity of 10,600 gallons per minute with a depth of 150 ft.

43. The water distribution for Alternative O is shown on Figure B-8. The distribution system consists of one well, diversion structures to divert water from SRPMIC irrigation system to project features, 12" PVC pipe, and irrigation system which sill be a combination of drip and the SBIN methods. Losses throughout the system were taken into account when it was assumed that the irrigation efficiency was 50%

Figure 8-8. Alternative C water distribution system.



RECOMENDATIONS

Recommendations

44. There are some concerns regarding the water budget analysis. First, the water budget was based on long-term steady-state condition. It does not take into account the variability of starting up the project, initial growth of vegetation and eventual maturity of the plants. In addition, water demand assumes that precipitation, stormwater runoff and agriculture tailwater do not contribute to the irrigation of the project vegetation. Another concern is that losses due to infiltration were either taken into account in the irrigation efficiency estimates or assumed negligible, lined water distribution channel. Depending on the final design of the irrigation system and the distribution channel, the losses due to infiltration can greatly increase the overall water budget. It has been estimated that the daily infiltration loss rate can be as much as 1 ft/day or 365 ft/yr, almost 40 times that the annual evapotranspiration rate of wetland vegetation.

45. Alternative O was the preferred alternative. It requires 17,000 acre-ft/yr a majority of the water needed to support the project features comes from the SRPMIC irrigation waters. The largest water demand is found in reaches 5 and 6. In all, the preferred alternative consists of 200 new acres of wetland, 883 new acres of cottonwood/willow, 380 new acres of mesquite, 24 new acres of Sonoran desert, scrub shrub, and 225 new acres of river bottom.

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EXHIBIT B.1 – SUBAREA WATER DEMAND – ALTERNATIVE O

	wetland		Cotton/wood		Mesquit	Sonoran Desert			Total		River Bottom
Area	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)	Water Demand (acre-ft)	Area (acres)
1.1	27	246	26	165	0	0	0	0	53	410	0.0
1.2	0	0	28	176	0	0	0	0	28	176	0
2.1	0	0	8	53	0	0	0	0	8	53	6
2.2	47	427	78	493	4	12	0	0	130	932	17
2.3	24	216	14	88	12	35	0	0	50	339	6
2.4	10	86	15	93	5	15	0	0	30	195	2
3.1	0	0	17	109	15	45	0	0	32	154	0
3.2	0	0	6	36	21	62	0	0	26	98	0
4.1	0	0	0	0	0	0	0	0	0	0	3
4.2	44	395	101	638	0	0	0	0	145	1033	0
5.1	0	0	0	0	0	0	0	0	0	0	55
5.2	32	291	154	969	121	363	24	47	331	1670	135
5.3	15	139	117	740	23	69	0	0	156	948	0
6.1	0	0	23	146	179	538	0	0	202	683	0
6.2	0	0	279	1758	0	0	0	0	279	1758	0
6.3	0	0	16	99	0	0	0	0	16	99	0
Total	200	1802	883	5561	380	1140	24	47	1486	8550	225

EXHIBIT B.2 – MONTHLY WATER SURCE REQUIREMENT ALTERNATIVE O

	WWTP*	Well Water	SRPMIC**	Total
Month	Monthly (acre-ft)	Monthly (acre-ft)	Monthly (acre-ft)	Monthly (acre-ft)
January	18	201	636	855.0
February	18	201	636	855.0
March	18	201	636	855.0
April	35	402	1,272	1,709.9
May	35	402	1,272	1,709.9
June	53	604	1,908	2,564.9
July	53	604	1,908	2,564.9
August	53	604	1,908	2,564.9
September	18	201	636	855.0
October	18	201	636	855.0
November	18	201	636	855.0
December	18	201	636	855.0
Total	353	4,023	12,723	17,099
Maximum	53	604	1,908	2,565

*City of Mesa treatment plant effluent
**Salt River Pima Maricopa Indian Community irrigation water

WATER BUDGET WITHOUT-PROJECT

Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01E Water Budget
Final Report

July 17, 2002

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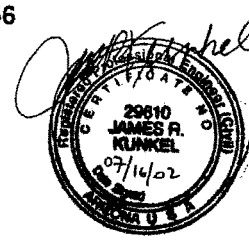

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Project 1889A/0110

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01E Water Budget
Final Report

Table of Contents

List of Tables iv
List of Photos iv
List of Drawings v
1.0 Introduction 1
2.0 Water Uses 2
2.1 Water Demands of Vegetation 2
2.2 Evaporation Losses 3
2.3 Infiltration Losses 4
3.0 Water Sources 5
3.1 In-situ Groundwater 5
3.1.1 Description of Source 5
3.1.2 Quantity Analyses 6
3.1.3 Quality Analyses 10
3.1.4 Water Rights 10
3.1.5 Assessment of In-situ Groundwater 11
3.2 Pumped Groundwater 12
3.2.1 Description of Source 12
3.2.2 Quantity Analyses 12
3.2.3 Quality Analyses 13
3.2.4 Water Rights 13
3.2.5 New Water Well Development 14
3.2.6 Assessment of Source 14
3.3 Salt River Flood Flows 15
3.3.1 Description of Source 15

Table of Contents *(Continued)*

3.3.2 Quantity Analyses 15
3.3.3 Quality Analyses 16
3.3.4 Water Rights 16
3.3.5 Assessment of Source 16
3.4 Storm Water Discharges 17
3.4.1 Description of Source 17
3.4.2 Quantity Analyses 18
3.4.3 Quality Analyses 19
3.4.4 Assessment of Source 19
3.5 Effluent 20
3.5.1 Description of Source 20
3.5.2 Quantity Analyses 20
3.5.3 Quality Analysis 21
3.5.4 Water Rights 21
3.5.5 Assessment of Source 21
3.6 Irrigation Return Flows 22
3.6.1 Description of Source 22
3.6.2 Quantity Analyses 24
3.6.3 Quality Analyses 25
3.6.4 Water Rights 25
3.6.5 Assessment of Source 26
3.7 Canal Drains 26
3.7.1 Description of Source 26
3.7.2 Quantity Analyses 28
3.7.3 Quality Analyses 28
3.7.4 Water Rights 28
3.7.5 Assessment of Source 28
3.8 Sand and Gravel Mining Operations Releases 29
3.8.1 Description of Source 29
3.8.2 Quantity Analyses 29

Table of Contents *(Continued)*

3.8.3 Quality Analyses 29
3.8.4 Water Rights 29
3.8.5 Assessment of Source 30
3.9 Salt River Project and Central Arizona Project Water 30
3.9.1 Description of Source 30
3.9.2 Quality Analyses 31
3.9.3 Water Rights 31
3.9.4 Assessment of Water Source 32
4.0 Evaluation of Water Sources 33
5.0 Recommendations 36
References R-1

List of Tables

Table	Title
2-1	Riparian and Constructed Wetland Vegetation Requirements
3-1	Summary of Historic Salt River Flood Flows
3-2	Storm Drains Average Annual Runoff Volumes
3-3	Canal Drains Average Annual Runoff Volumes
4-1	Water Budget Matrix
4-2	Restored Habitat Water Demands
4-3	Habitat Achievable Under Existing Conditions
4-4	Water Budget Projections

List of Photos

Photo	Title
3-1	Salt River Upstream of Granite Reef Dam
3-2	Seepage Downstream of Granite Reef Dam
3-3	Vegetated Areas Downstream of Granite Reef Dam
3-4	Salt River near Greenfield Road
3-5	Salt River at Alma School Road
3-6	Price Drain
3-7	SRPMIC's Evergreen Canal
3-8	Evergreen Drain Turnout
3-9	Hennessey Drain Turnout
3-10	SRP's Arizona Canal
3-11	SRP's Southern Canal

List of Drawings

Drawing	Title
100	Water Budget Map

Va Shly'ay Akimel Salt River Restoration Project Feasibility Study JAB.01E Water Budget Final Report

1.0 Introduction

The Va Shly'ay Akimel Salt River Restoration Project (SRRP) is located along the Salt River between Granite Reef Diversion Dam (Granite Reef Dam) and the Pima Freeway (Loop SR-101). The success of this project is largely dependent on the water budget[1]. The water budget must identify each potential source, quantify the amount and seasonality of flow, and evaluate the quality of the water. The water budget required for this project, however, is more than just an inventory of water sources. It must also identify and quantify the water demands. Restoration projects involve wetlands and riparian vegetation, which have seasonal water demands that are greater in the summer than in the winter. In fact, the water demands vary by month. It is necessary to evaluate the water budget on a monthly basis because annual information does not contain sufficient detail to allow consideration of these monthly demands.

The Va Shly'ay Akimel project area encompasses the Salt River from Granite Reef Dam downstream to the Pima Freeway. This 15-mile reach has been divided into six smaller reaches for this study. Reach 1 extends from Granite Reef Dam to 2,500 feet downstream of Greenfield Road. Reach 2 continues to Gilbert Road and includes the Granite Reef Underground Storage Project (GRUSP), a 210-acre groundwater recharge project operated by the Salt River Project (SRP). Reach 3 extends from Gilbert Road to Horne Road and includes a large sand and gravel mining operation. Reach 4 continues to Country Club Drive. Reach 5 extends from Country Club Drive to 4,000 feet downstream of Alma School Road, encompasses several sand and gravel mining operations, and lies adjacent to the Old Tri-Cities Landfill. Lastly, Reach 6 continues to the Pima Freeway. This last reach has been confined between effluent recharge ponds on both sides of the river.

[1] The water budget is an accounting of water inflows to and outflows from the restored habitat areas. The model must inventory the potential water sources and water demands; in addition, the model must quantify the amount and timing of water available from each source and water required by each demand.

2.0 Water Uses

Three primary water demands were identified that are associated with a river restoration project. These include consumptive use by wetland vegetation, evaporation from open water bodies, and infiltration into the soil or riverbed. Consumptive use is defined as the water needed to account for plant evapotranspiration, which is the water required by the plant for growth along with the water that may be evaporated from both the plant itself and the soil in the immediate area surrounding the plant. The monthly and annual water demands were quantified for these water uses as a rate of water used per acre of vegetation or open water. When the project alternatives are finalized, the total demands can be projected by multiplying the per-acre demands by the number of acres for each land use category.

2.1 Water Demands of Vegetation

The water demand of vegetation varies depending on the individual and combination of plant species within a habitat unit. In the Tres Rios Project, a similar river restoration project in western Phoenix, the average annual evapotranspiration of river vegetation was projected to equal 3.70 acre-feet per acre. This general rate accounted for a mix of vegetation species that is similar to the expected mix for this project (Greeley and Hansen, 2001). The monthly demand is calculated as a percentage of the annual demand and defines the seasonality of the required water supply. The following values are based on water demand projections for the Tres Rios Project.

Consumptive Use for Salt River Habitat
(Southcentral Arizona)

Month	Percent of Annual Demand (%)	Consumptive Use (acre-feet/acre)
January	5	0.185
February	5	0.185
March	5	0.185
April	10	0.370
May	10	0.370
June	15	0.555
July	15	0.555
August	15	0.555
September	5	0.185
October	5	0.185
November	5	0.185
December	5	0.185
Annual	100	3.70

The root zone depth of vegetation is also an important criterion when assessing the adequacy of water supplies to meet demands. If the roots of plants have access to groundwater, it reduces the irrigation demand. Plants have different water requirements depending on the phase of development, seeding, sapling, and maturity. Table 2-1 (Wass, 2002) presents the root zone depth information for several species common within the Salt River environment. The table also presents the desirable ranges of inundation depth for aquatic plants. These data can be used to assess in-situ groundwater and to calculate irrigation demands during alternative development.

2.2 Evaporation Losses

The SRRP may include open water bodies, constructed wetlands, and marsh areas. In the central Arizona area, the annual evaporation from an open water body averages 72.4 inches or 6.03 feet per year, roughly 6 acre-feet per acre. However, evaporation is seasonal with the greatest evaporation in the summer months (Cooley, 1970). Constructed wetlands and marshes are open water bodies in which the surface area is shared by water and vegetation. The consumptive use of these areas closely approximates the open water body evaporation rate; thus, the evaporation rate can be used to calculate the water demand for the open water body, constructed wetland, or marsh.

Evaporation from Open Water
(Southcentral Arizona)

Month	Evaporation (acre-feet/acre)
January	0.183
February	0.258
March	0.417
April	0.550
May	0.750
June	0.825
July	0.825
August	0.750
September	0.575
October	0.442
November	0.275
December	0.183
Annual	6.03

2.3 Infiltration Losses

Infiltration accounts for the water that seeps or percolates into soil and geologic units that lie beneath the restored habitat areas. In southcentral Arizona, these rates are often significant and result in little or no water available for vegetation growth. The infiltration losses through the bottom of open-water and marsh areas for this study can be projected based on the percolation rates at the local recharge projects. At the GRUSP site, recharge rates have averaged between 1 and 3 feet per day. However, an organic mat typically forms on the bottom and sides of marsh areas; this mat restricts the percolation rate. Research for the Tres Rios Project has shown that the percolation rate in an unlined open water or marsh area is typically 1 to 2 feet per day. For this study, an infiltration rate of 1 foot per day will be assumed; this rate equates to 365 acre-feet of water infiltrated for each acre of open water or marsh areas.

3.0 Water Sources

The success of a habitat restoration project such as the SRRP is largely dependent upon the amount and quality of water that is available to sustain the riparian habitat. A sufficient and reliable supply of suitable water must be developed to support the aquatic, wetland, and upland plant species. Several potential water sources were identified for the SRRP area; two relate to groundwater resources and seven involve surface water. Groundwater can either be utilized by plant roots in place (in-situ), or it can be pumped to the surface and distributed to the restoration project. These represent the two potential groundwater sources identified. The potential surface water sources identified include Salt River flood flows, storm water discharges, effluent, irrigation return flows, canal drains, discharges from sand and gravel mining operations, and SRP or Central Arizona Project (CAP) water. These sources were each evaluated based on the quantity, reliability, and quality of flow available for habitat restoration. In general, the sources were classified into the following four categories.

- **Dependable Source.** A source is dependable if it is available on a continuous basis to meet the water demands of the habitat area and has acceptable water quality. Dependable sources constitute the baseline water supply.

- **Supplemental Source.** A source may be considered supplemental if it is available to augment the dependable baseline source. This could include infrequent and unreliable flows that can be put to beneficial use when they are available but cannot be relied upon as a dependable base flow. The supplemental flow must also have good water quality.

- **Problem Source.** Problem sources must be accounted for but may not be suitable as a water supply for the SRRP. These flows may inhibit the restoration project by potentially damaging restored vegetation or hindering the water quality within the Salt River.

- **Unacceptable Source.** A source is considered unacceptable if it has poor water quality or is not desireable for riparian habitat restoration.

3.1 In-situ Groundwater

3.1.1 Description of Source

In-situ groundwater is defined as groundwater that can be utilized, in place, by riparian vegetation. For this to occur, the groundwater table must be within the root zone depth of the desired plant species. The depth to groundwater as well as the water table fluctuations are important factors for establishing and maintaining riparian habitat.

Historically, the Salt River was a perennial stream and supported riparian and wetland vegetation. However, water storage and diversion projects have depleted the Salt River flows downstream of Granite Reef Dam and, in turn, have decreased the amount of water that gets recharged into the alluvial aquifer. Immediately downstream from Granite Reef Dam, the water table is still sufficiently close to the surface so that riparian vegetation can access this water through its root systems. These vegetated habitat areas in the Salt River suggest that in-situ groundwater may be a potential source of water for the habitat restoration project. Photo 3-1 shows the Salt River upstream of Granite Reef Dam; this area is similar to the historical conditions throughout the Salt River Valley.

Photo 3-1. Salt River Upstream of Granite Reef Dam

3.1.2 Quantity Analyses

The water table is variable throughout the study area and is impacted by both hydrogeologic and anthropogenic factors. One of these anthropogenic factors is Granite Reef Dam. The dam was constructed to divert Salt River water into the Arizona Canal and the Southern Canal. This dam marks the upstream boundary of the SRRP. Although not intended to be a storage reservoir, this dam inadvertently retains some water at all times.

Small flood flows can be released to the Salt River through radial gates while larger flood flows are allowed to pass over the dam crest. SRP has reported that water seeps through the radial gates as they do not form a tight seal with the granite bedrock. The result is a very low

continuous flow of water downstream from the dam. SRP does not monitor the seepage and does not have flow records. Photo 3-2 shows the seepage downstream of Granite Reef Dam.

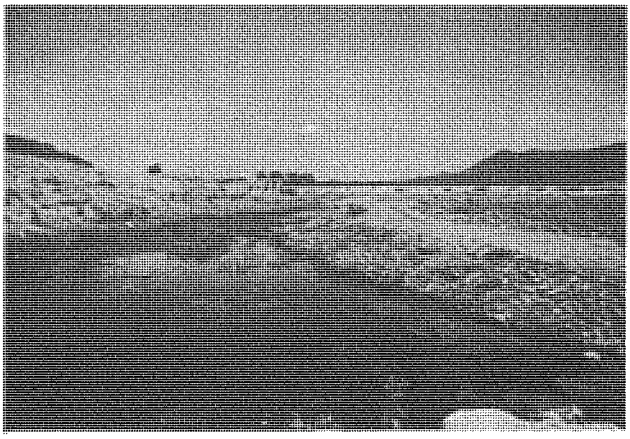

Photo 3-2. Seepage Downstream of Granite Reef Dam

The local geology maintains this seepage as a surface flow. A bedrock shelf overlain by a veneer of sedimentary materials extends downstream from the dam. The seepage is sufficient to saturate these alluvial sediments to maintain a continuous surface flow. This flow has been sufficient to establish and support abundant vegetation. In addition, areas of open water provide riparian and aquatic habitat. This pattern continues for approximately one mile downstream. The existing vegetated areas are shown on the Water Budget Map (Drawing 100). Photo 3-3 shows the vegetated areas that extend for approximately one mile downstream from the dam.

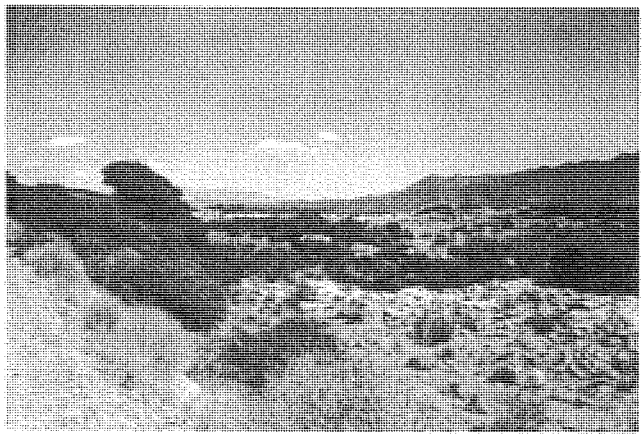

Photo 3-3. Vegetated Areas Downstream of Granite Reef Dam

The depth to the bedrock shelf rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream. As the bedrock depth increases, the surface flow that supports wetland vegetation upstream becomes subsurface water. Regional groundwater pumping has resulted in a general lowering of the water table throughout the area. In addition, dams located on the Verde River and Salt River upstream prevent perennial flow in the river channel and limit natural recharge. The result is that the general groundwater depth beneath the Salt River ranges from 60 to 80 feet below the surface for the majority of the study area (Knight Piésold, 2002a). Photo 3-4 shows the Salt River near Greenfield Road.

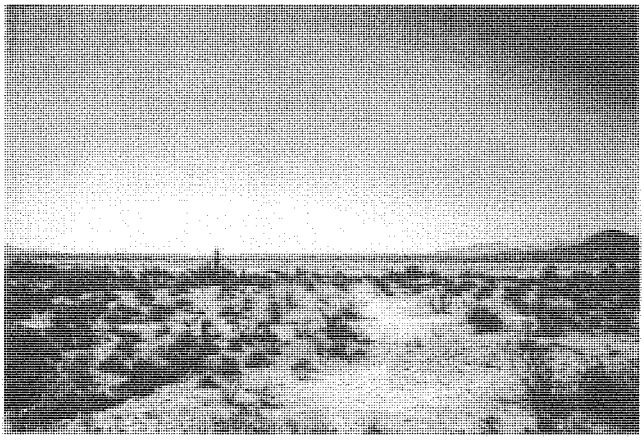

Photo 3-4. Salt River Near Greenfield Road

There are two groundwater recharge projects in the study area that have local impacts on the groundwater table. Toward the downstream end of Reach 2, SRP is recharging water into the upper alluvial aquifer through the GRUSP. SRP is recharging nearly 90,000 acre-feet of water annually. These recharge ponds encompass an area of approximately 216 acres. Their recharge permit allows them to recharge as much as 200,000 acre-feet per year; however, this rate would produce a groundwater mound that could impact other facilities. SRP has to limit the amount of water recharged in order to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87. This results in a water level that is about 50 to 60 feet below the river channel in the immediate GRUSP area. The GRUSP site is shown on the Water Budget Map (Drawing 100).

The second recharge project is located near the downstream end of the project area. At this site, effluent from the Northwest Water Reclamation Plant (NWWRP), which is owned and operated by the City of Mesa (Mesa), is being discharged into a series of recharge ponds where the effluent is allowed to infiltrate into the Salt River sediments. Approximately 5,000 to 6,000 acre-feet of water has been recharged annually into these ponds. The Salt River Pima-Maricopa Indian Community (the Community) owns five ponds on the north side of the river totaling 75 acres; these ponds have received an average of 330 acre-feet of effluent each month since their inception in May 2001. Mesa owns four ponds on the south side of the river totaling 27 acres; these ponds have received an average of 140 acre-feet of effluent each month since

January 2000. The groundwater mound that results from this recharge raises the local water table in this area to within 50 to 60 feet below the river bed. The NWWRP and the percolation ponds are shown on the Water Budget Map (Drawing 100).

3.1.3 Quality Analyses

Long-term irrigation practices and landfills within the Salt River Valley have historically influenced water quality in the upper alluvial aquifer. High salinity, chloride, and nitrate concentrations were occasionally found in the shallow groundwater near irrigated or formerly irrigated areas. Also, some landfills have historically caused elevated levels of volatile halocarbons. More recently, the Community has developed a water quality management plan to protect and enhance surface water and groundwater quality (EcoPlan, 1997; EcoPlan, 1998). Since groundwater quality monitoring began in the 1980s, the water quality has significantly improved. Monitoring results from the first quarter of 2002 indicate that there were no exceedences of the maximum contaminant levels for volatile halocarbons in any of the sampled wells (Kenneth D. Schmidt and Associates, 2002). In addition, the concentrations of many volatile halocarbons were the lowest since monitoring commenced. It should also be noted that there are no superfund sites within the restoration project area. There is, however, an environmental investigation to assess the Old Tri-Cities Landfill located along the north bank of the Salt River near Country Club Road. Data are not yet available from this study. In-situ groundwater is generally suitable for agricultural uses and should be adequate for the habitat restoration project.

3.1.4 Water Rights

In this section and in all the following water rights assessment sections, water rights are discussed in relation to the Community as well as to non-Indian lands. The difference is that water rights established by the State of Arizona do not apply to the Community lands; however, federal water rights and court adjudications do apply. Non-Indian lands are subject to state water rights, federal water rights, and court adjudications.

The Community owns and controls the groundwater beneath their land, and it is not governed by state water rights. The federal government has established this right and has restricted pumping on non-Indian lands to prevent groundwater withdrawals from beneath the Community lands. Groundwater beneath the non-Indian lands is a state resource, and use is regulated via several groundwater rights and pumping permits.

Consumptive use of groundwater by vegetation (in-situ groundwater) is not included in state groundwater right categories. There are no water rights to define or restrict the direct use of groundwater by vegetation for habitat restoration projects in central Arizona. In-situ groundwater, when available, can be used as a part of the SRRP water supply.

The seepage at Granite Reef Dam is surface water and, until it percolates into the ground, could be subject to surface water appropriation rights. If this seepage flow is diverted before it percolates and used as a part of the water supply for the SRRP, it is possible that a downstream water user with rights to Salt River flow could protest. A claim by the downstream water users would be difficult to uphold because all of the seepage percolates into the ground about one mile downstream from the dam and is currently not available for diversion by downstream water users. If this water were used as a part of the SRRP water supply, it probably would be channeled to support vegetation along the north and south river banks just downstream from the dam rather than being diverted and delivered to a location farther downstream. The channelization is not a diversion and may not be subject to water appropriation regulations. In general, the use of the seepage flow to support in-stream vegetation does not appear to be contrary to existing water rights.

3.1.5 Assessment of In-situ Groundwater

In-situ groundwater can provide a reliable source of water for the area immediately downstream from Granite Reef Dam. In this area, seepage from the dam forms a local perched water table near the surface. Currently, wetland plant species are growing along this reach of the river and extend for approximately one mile downstream. This source of water could be used to restore native riparian vegetation in this area. This local supply is considered a dependable water source for Reach 1.

For the remaining reaches of this habitat restoration project, in-situ groundwater will not provide a reliable source of water. The intent of this project is to restore habitat areas for cottonwood, willow, and mesquite trees; these species require that the depth to groundwater be less than approximately 30 feet for survival. The depth to groundwater, however, exceeds 60 feet for most of the remaining area. In-situ groundwater is considered to be an unacceptable source of water for Reaches 2 through 5 of the SRRP.

3.2 Pumped Groundwater

3.2.1 Description of Source

Pumped groundwater is groundwater that lies below the root zone of the desired vegetation and must be pumped to the surface to be utilized. After the water is pumped to the surface, a distribution system must be developed to deliver this water to certain areas of the habitat restoration project.

3.2.2 Quantity Analyses

Groundwater in sufficient quantity to supply water wells is present throughout the majority of the SRRP area. This is demonstrated by the location and number of existing wells. Some of these wells are shown on the Water Budget Map (Drawing 100). The only area where groundwater is not present in sufficient quantity to supply a well is the initial 2 miles of the Salt River downstream from Granite Reef Dam. Bedrock is shallow in that area, and the saturated sediments may not contain sufficient water to maintain well pumping.

Pumped groundwater has been a reliable source of water for many years throughout the Salt River Valley including the SRRP area. These wells range in capacity from relatively small wells that produce 10 to 20 gallons per minute (gpm) to large irrigation wells producing more than 2,000 gpm. Many of the wells within the Community have not been used for many years. Recently, the Community has begun a maintenance program for these wells to ensure that they will be available for use in the future if desired.

Pumped groundwater can be provided using existing wells or new wells. The advantage of using an existing well is that the costs associated with constructing the well have been committed. The constraint is that the location of some wells requires construction of a distribution pipeline and may require a booster pump. The advantage of drilling a new well is that it could be located at a point within the project to minimize distribution pipeline costs. The constraints are the costs associated with constructing a new well and meeting the state regulations if the new well is located on non-Indian lands.

Pumped groundwater is available on a continuous basis and in sufficient quantity could provide a dependable supply of suitable water for the restoration project. The primary implication on using pumped groundwater is the impact that this pumping may have on other nearby groundwater wells.

3.2.3 Quality Analyses

Groundwater quality varies somewhat throughout the upper, middle, and lower alluvial units with the highest quality found in the lower units. As stated above for in-situ groundwater, groundwater from all alluvial units is generally suitable for agricultural purposes and is expected to be adequate for this habitat restoration project.

3.2.4 Water Rights

The Community regulates pumping of groundwater from beneath its land. They control where wells may be drilled and what the groundwater can be used for. The Community could permit the use of water from existing wells or the drilling of new wells to supply the SRRP. However, the Community is restricted in the quantity of groundwater it can pump and the total quantity of water it can use in any year through the Water Rights Settlement Agreement of 1988. This means that the Community can commit pumped groundwater to the SRRP but may need to reduce water use for another purpose.

The use of groundwater from beneath non-Indian land must be permitted by the state. Irrigation Grandfather Rights establish the right to pump and use groundwater for the growing of food and forage crops. These rights were established in 1980 on lands that were irrigated before that time and are tied to the specific parcels of land. The water pumped pursuant to the Irrigation Grandfather Right must be used on the land that was originally decreed for that right. The water cannot be used for irrigation on other lands. The lands within the Salt River channel do not fall into the Irrigation Grandfather Right category. Therefore, groundwater pumped pursuant to an Irrigation Grandfather Right is not a supply available to the SRRP.

The state also created specific permits to allow pumping of groundwater for new uses. These include poor quality groundwater permits, dewatering permits, mining permits, hydrologic testing permits, and general industrial use permits. The state has specific requirements and conditions that must be met for a water user to secure a pumping permit. It does not appear that the SRRP could meet all of the requirements and conditions. Therefore, groundwater permits are not available for this project.

Mesa can pump groundwater pursuant to a Service Area Right. This type of groundwater right is issued to public supply water providers. It allows the water provider to pump the quantity of water needed to meet a given demand, subject to water conservation requirements. The Arizona

Groundwater Code dictates that, except in times of surface water drought, all groundwater pumped by an entity, such as Mesa, with an Assured Water Supply designation must be replenished through the use of long-term storage credits, Irrigation Grandfather Right extinguishment credits, membership in the Central Arizona Groundwater Replenishment District, annual storage and recovery, or depletion of its groundwater allowance. Groundwater pumped under this right for habitat restoration would count toward Mesa's annual pumping total and would entail a depletion of their store of credits, making less water available to meet the needs of other current and future water users. Long-term storage credits and Irrigation Grandfather Right extinguishment credits are potential sources of water for the project but require an agreement between the parties to finance their creation.

3.2.5 New Water Well Development

If new wells are needed to pump groundwater, the Community could allow the wells to be drilled on their land. The wells should be located to produce minimal interference to existing wells. The well siting would involve a hydrogeologic investigation, but state permits are not required.

If new wells are to be drilled on non-Indian land, permits must be obtained from the ADWR. An impact study is required for all wells with a pump capacity of 500 gpm or greater. The study must demonstrate that the new well will not produce an additional 25 feet of drawdown in existing wells after five years of pumping. If the additional drawdown is less than 10 feet, the permit can be issued. If the drawdown is greater than 10 feet but less than 25 feet, the owner of the new well must obtain a release letter from the owner of each impacted well stating that an agreement has been reached to mitigate the drawdown. This can be a time consuming and expensive process.

Drilling new wells to pump groundwater is feasible and should be considered if there are no existing wells available to supply the project.

3.2.6 Assessment of Source

When the physical availability of pumped groundwater is considered, it is a dependable or supplemental water supply. There are no projections that the aquifer will be depleted, and water rights do not prevent its use for the SRRP. However, institutional commitments by the Community, Mesa, or SRP must be made to allow groundwater pumping. These considerations must be resolved before finalizing the design of the pump and delivery system.

3.3 Salt River Flood Flows

3.3.1 Description of Source

The SRRP is downstream from Granite Reef Dam, which is below the confluence of the Salt River and the Verde River. In the past, both rivers were perennial with consistent flow rates. The construction of dams and water storage reservoirs upstream allowed for the development of water resources to supply water for irrigation and urban use in the Phoenix Valley. Most of the time, all of the flow in the Salt River is diverted at Granite Reef Dam into the Arizona Canal and Southern Canal. The riverbed downstream is typically dry. Photo 3-5 shows the Salt River at Alma School Road.

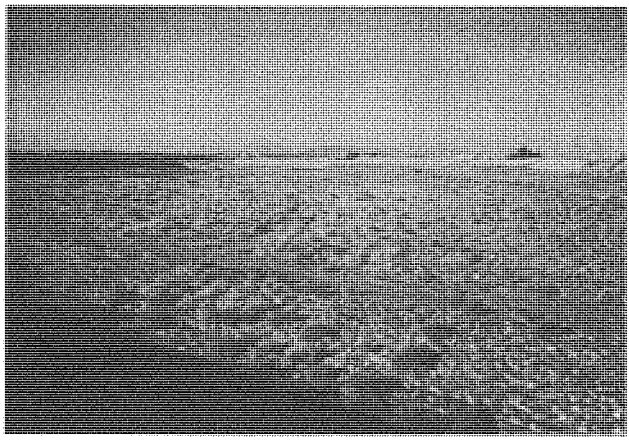

Photo 3-5. Salt River at Alma School Road

The river, however, is still subject to floods because the reservoirs on the Verde River have no dedicated flood capacity, and only one of the four reservoirs on the Salt River has flood capacity. Due to the design of the dams, only limited flows can be released in anticipation of floods. When the water level reaches the spillway at Granite Reef Dam, substantial quantities of water are released, causing the downstream reaches of the Salt River to flood.

3.3.2 Quantity Analyses

The river downstream of Granite Reef Dam can be dry for long periods. For example, the Salt River flooded in 1941 and then was dry until it flooded again in 1966. The next flood occurred in 1973. The periods from 1978 to 1984 and from 1991 to 1995 were wet periods. Since 1995,

there have been no flood releases. Table 3-1 summarizes historic releases at Granite Reef Dam (Tres Rios River Management Plan Water Supply Technical Committee, 1997). This information demonstrates that, in the past, flood flows were more frequent and with less magnitude. Changes in the watershed and construction of additional dams have changed the pattern of flooding. Most of the largest recorded floods have occurred since 1978. Table 3-1 also demonstrates that there is no pattern to the frequency, duration, or magnitude of the flood flows.

3.3.3 Quality Analyses

The Tres Rios River Management Plan Water Quality Technical Committee (1998) reviewed the water quality records for the Salt River and focused on the Granite Reef Dam sampling location. That study found that there were no chemical water quality issues associated with Salt River water. However, during flood periods, sediments represented a water quality problem; the sediment load exceeded the standard established for the designated uses of the river. The problem was not because the sediments represented contamination. There are no known water quality issues that would prevent flood flows from being used as a water source for the SRRP.

3.3.4 Water Rights

Salt River flood water is subject to surface water rights for diversion. A right filed with the state or established by adjudication is required. However, during a flood, all diversion rights are typically fulfilled. Generally, all water demands are diverted into the two canals at Granite Reef Dam; a flood typically represents surplus water. Consequently, in order to encourage its use, SRP does not charge water users a fee to use Salt River flood water.

3.3.5 Assessment of Source

Flood flows do not occur on a regular basis or in predictable quantities; therefore, they do not represent a dependable water source. While the water may be available, it may be difficult to incorporate flood flows into the SRRP water supply. Flood flows do represent a supplemental source because they recharge the groundwater and replicate historic conditions in the river. Aquifer recharge is an indirect use of flood flows. During or shortly after a flood, it is possible that the water table will rise to the point where the vegetation roots can access it. However, when the flood subsides, the water table will return to depths greater than the root zone.

Flood flows have additional benefits to the natural habitat of the river. Small flows will saturate the soils and spread seeds to encourage the seedling germination and development of cottonwood and willow trees. Moderate flood flows will remove some vegetation and maintain open areas in

the river channel. The removal of vegetation is a natural occurrence in river systems. These flows can also redistribute sediments in the channel and help to replace nutrients in the riverbed soils.

Large floods, on the other hand, represent a problem source. The magnitude of these flows can damage restored habitat areas, degrade the reconstructed channels, and deposit excessive amounts of debris throughout the project. The peak flow during the 1980 flood was 200,000 cubic feet per second (cfs), which did extensive damage to the Salt River Valley. Flows of this magnitude are neither predictable nor preventable.

3.4 Storm Water Discharges

3.4.1 Description of Source

Storm water discharges represent runoff from urban and rural areas due to rainfall events. In general, storm water can enter the Salt River through defined outfall points from storm water drainage systems or as overland flow runoff from areas immediately adjacent to the river.

The Community does not currently have an extensive storm water management system to collect and convey storm water runoff to a designated outfall point. In general, roadside ditches and irrigation canals intercept the majority of storm runoff. These features retain most of this runoff, thus eliminating discharges into the Salt River. There are a few areas downgradient of roadside ditches and irrigation canals where runoff will reach the Salt River. However, these areas are relatively small, and little runoff is projected to occur during most storm events.

The only known storm drain in the Community is located near the intersection of Alma School Road and McKellips Road. This 60-inch pipe collects runoff from curb inlets along these roads and may intercept some irrigation return flows from nearby agricultural areas and the Cypress Golf Course. The Alma School Storm Drain is shown on the Water Budget Map.

Within Mesa, there are several storm drains that discharge to the Salt River (Haws, 2002). The most significant of these drains is the Price Drain. This open channel is located adjacent to the Price Road Freeway (Pima Freeway or Loop SR-101) and services a large drainage area. Inflows to this drain include a drainage channel along the Superstition Freeway (U.S. 60) and the drainage tunnel under the Price Road Freeway. Flow records for this drain were obtained from the Flood Control District of Maricopa County (FDCMC). Photo 3-6 shows the Price Drain near

the intersection of the Pima Freeway and the Red Mountain Freeway. The Price Drain is shown on the Water Budget Map.

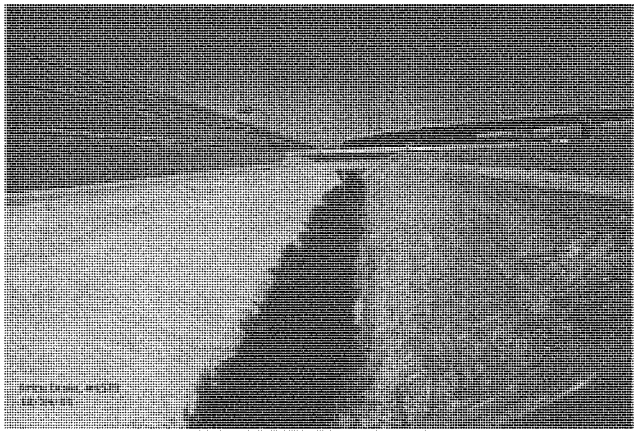

Photo 3-6. Price Drain

Several other smaller storm drains exist along the south bank of the Salt River. Unfortunately, there are no flow records for these drains. There are also several areas adjacent to the river where overland flow runoff discharges directly to the river. These areas are generally undeveloped with the exception of the occasional sand and gravel mining operation.

3.4.2 Quantity Analyses

Knight Piésold conducted a site investigation to verify the location of storm drains that discharge into the Salt River. At the time of this investigation, approximately 1 to 2 cfs was flowing from the Community's storm drain on the north bank of the river near Alma School Road. It was also observed that natural vegetation was growing in the riverbed near this outfall. There are no flow records for this drain, and the exact drainage area that contributes runoff to the drain is not known. According to SRPMIC personnel, water rarely flows from this drain as most runoff from the Community is typically diverted to other water users such as sand and gravel mining operations. However, the presence of plant species indicates that this runoff is sufficient to maintain this vegetation.

Flow records for the Price Drain indicate that the mean flow to the river for the period from February 2001 to April 2002 was approximately 4.4 cfs. The peak flow during this period was 691 cfs. The records also show that there were only 24 days in which the average daily flow was less than 1 cfs, and there were only seven days in which the average day flow was less than 0.5 cfs. In addition, an area of significant size has recently become heavily vegetated immediately downstream of the Price Drain outfall. This vegetation is presumably due to the relatively continuous flow from that drain. Based on these facts, it is apparent that this drain receives flows from sources other than storm water runoff. It is possible that this drain collects lawn irrigation return flows from residential areas as well as return flows from other water users within the tributary area.

To quantify the average monthly and annual volumes of runoff from ungaged storm drains, the approach used in the Rio Salado project (USACE, 1998) was used to estimate the average annual volume of runoff. To estimate the average monthly volume of runoff, the annual amount was distributed according to the monthly rainfall distribution in the Phoenix area (Schmidli, 1996). This approach is described in detail in the Draft Report for the Interior Drainage Analyses (Knight Piésold, 2002b). Table 3-2 provides the monthly and annual runoff amounts estimated for these drains.

3.4.3 Quality Analyses

Storm water discharges from urbanized metropolitan areas are generally of poor quality. The quality varies depending on the land uses within the tributary area, the magnitude and duration of the storm event, and the length of time between consecutive storm events. Sediment and chemical pollutants tend to accumulate between storms and are washed from the streets, parking lots, ditches, or other features during the proceeding event; this occurrence is termed the "first flush." The quality of the "first flush" water is generally poor. As the runoff continues, the water quality improves. Mesa has reported that the base flow from the Price Drain may not have this first flush water quality problem.

3.4.4 Assessment of Source

Rainfall events are infrequent in the Phoenix area, so storm water runoff would generally not be considered as a dependable water source for a habitat restoration project. However, the Price Drain may be a dependable water supply. This drain has produced a consistent base flow, which can be incorporated into the restoration project. In addition, the Alma School Drain has produced

sufficient flow to support a small area of wetland plant species; unfortunately, there are no records to further evaluate this flow.

The remaining storm drains represent two categories of water supply – problem and supplemental. The first flush runoff generally has poor water quality and may not be suitable to nourish restored vegetation. Additionally, the peak flow rates emanating from these drains during major storm events may damage the habitat areas. These flows are both problem sources. After the first flush, the water quality generally improves. This runoff could be a supplemental source.

3.5 Effluent

3.5.1 Description of Source

Treated effluent represents a drought-tolerant water supply. During water shortage periods, most water conservation measures control the external use of water such as lawn watering, car washing, and landscape irrigation. These uses do not contribute to wastewater flow, so the amount of wastewater will only be reduced slightly during most drought periods.

3.5.2 Quantity Analyses

Mesa owns and operates the NWWRP located near the downstream end of the project area (Haws, 2002). The NWWRP currently produces about 8.5 to 9.0 million gallons per day (mgd) of effluent; however, the plant is currently being expanded to a design capacity of 18 mgd. This expansion is expected to be completed in late summer of 2002. In the future, the inflow to the NWWRP could grow to approximately 30 mgd. Currently, the effluent from the plant can be discharged to three locations:

- Four City-owned percolation ponds on the south side of the river (south ponds)
- Five Community-owned percolation ponds on the north side of the river (north ponds)
- Directly to the Salt River, just north of the plant site

In the future, a fourth receiving source will be a 36-inch reclaimed water line that is being constructed in conjunction with the Red Mountain Freeway (Loop SR-202). This reclaimed water line will provide landscape water for the freeway and potentially other uses as well as eventually deliver water to the Roosevelt Water Conservation District (RWCD) canal system east of Val Vista Drive. It is anticipated that this reclaimed water line will be active beginning in summer 2003.

Historically, the plant has discharged approximately 5,000 to 6,000 acre-feet of water into the percolation ponds. The five Community-owned ponds, totaling 75 acres, have received an average of 330 acre-feet of effluent each month since their inception in May 2001. The four Mesa-owned ponds, totaling 27 acres, have received an average of 140 acre-feet of effluent each month since January 2000. Effluent has also been discharged directly into the river; however, no releases have been made to the river since the Community-owned ponds have been in operation.

3.5.3 Quality Analysis

The quality of the effluent from the NWWRP meets aquifer recharge standards, surface water quality standards, and NPDES requirements. Having met all three of these authoritative standards, the quality of effluent is suitable for the restoration project.

3.5.4 Water Rights

The producer of effluent retains ownership until it is discharged and no longer under the control of the producer. If effluent is discharged to a river channel, a downstream water user can file for an appropriation to divert the water just like any other surface water source. The water user may be granted the surface water right to divert the effluent; however, this right does not guarantee that the effluent producer will continue to discharge to the river channel. The producer still has control as to where the effluent is discharged.

Normally, when effluent is discharged to the river, the producer loses control and hence the right to the effluent. However, if the receiving water channel is designated to be a part of the conveyance system, the producer can maintain the right to the flow. This could occur if Mesa discharged effluent to a receiving channel in the Salt River with the intent to transport the flow to the restoration project.

When Mesa discharges the effluent to the recharge ponds, they retain control of the effluent and maintain the right to this water. Once the effluent is recharged, Mesa's right to this effluent is protected pursuant to groundwater recharge legislation statutes.

3.5.5 Assessment of Source

Effluent from the NWWRP could be a dependable or supplemental supply for portions of the SRRP. The water source is drought-tolerant and can meet water quality standards for restoration. However, Mesa, which controls the right to the effluent flow, must make an institutional decision to commit water to the project. Currently, Mesa owes a substantial water debt to the RWCD.

Once the reclaimed water line to the RWCD canal line is in place, Mesa intends to use the majority of the effluent from the NWWRP to fulfill this debt. Mesa receives long-term storage credits from this delivery as well as from water recharged through the percolation ponds. Therefore, use of reclaimed water for habitat restoration would mean a depletion of the long-term storage credits that Mesa uses to comply with Assured Water Supply requirements and to meet current and future demands.

The direct use of effluent could be used in the western and central portions of the project area where gravity flow and the reclaimed water distribution system can be used to deliver the effluent. It may not be cost-effective, however, to deliver effluent to the eastern portions of the project near Granite Reef Dam. However, indirect use of effluent could be achieved throughout the study area by using recovery wells to pump groundwater accounted for as recharge credits.

3.6 Irrigation Return Flows

3.6.1 Description of Source

The SRRP lies adjacent to irrigated agricultural lands so that the potential exists to use irrigation return flows as a water source for the ecosystem and habitat restoration. Irrigation return flows constitute the water delivered to the agricultural areas that is not consumed by crops, evaporated, or infiltrated into the soils. These flows can occur under two scenarios.

The first scenario, termed tailwater, occurs when surplus irrigation water is applied to the fields but is not used by the crops. Irrigation in the project area is typically accomplished through a flood irrigation technique where sufficient water is applied at the top of the field to force water through the furrows to the other end. In some areas, sumps have been constructed to collect the excess water and pump it back to the top of the field or divert it to another water user. In other areas, the excess water drains from the fields and is either intercepted by irrigation canals, storm water ditches, other diversion structures, or discharged directly into the Salt River.

The second scenario occurs when surplus irrigation water is delivered to the canals but is not applied to the fields. This excess water then either remains in the canal where it evaporates or infiltrates, is diverted to other users, or is discharged into the Salt River. This scenario can occur if a rainfall event occurs after irrigation water is delivered to a lateral canal; the soils in the irrigated areas may be saturated by rainfall so that the canal water is no longer needed. In other

cases, the irrigation canals may intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks.

The existing agricultural lands adjacent to the study area are located primarily within the Community. These agricultural lands are divided into three distinct areas: (1) land north of the Arizona Canal, (2) land south of the Arizona Canal and north of the Salt River, and (3) land south of the Salt River.

The areas north of the Salt River receive irrigation water primarily from SRP's Arizona Canal. There are also several groundwater wells located within this area that have historically been used for irrigation. These wells, however, have not been utilized for many years. Recently, the Community has begun a maintenance program for these wells to ensure that they will be available for use in the future if desired. For the areas north of the Arizona Canal, daily orders are pumped from a diversion point approximately one-half mile upstream of the Evergreen turnout and delivered through turnouts along Stapley Drive.

South of the Arizona Canal, daily orders are released through an electronically-controlled gate into the Community's Evergreen Canal, which is located about 7 miles west of Granite Reef Dam. From the Evergreen Canal, irrigation water is then diverted or pumped into lateral canals between the Pima Freeway and Horne Road. These lateral canals are shown on the Water Budget Map. Photo 3-7 shows the Community's Evergreen Canal. There are six defined outfall points that discharge excess irrigation water into the Salt River from this area. Two of these are located between Hayden Road and the Pima Freeway; these outfalls are outside of the study area. The remaining four locations are shown on the Water Budget Map.

Photo 3-7. SRPMIC's Evergreen Canal

The areas within Mesa that were historically irrigated have since been urbanized. In addition, there are no agricultural areas south of the river upstream of the RWCD canal. The area south of the Salt River, referred to as the Lehi District, receives water from SRP's Southern Canal at a diversion point approximately 8 miles downstream of Granite Reef Dam. There are three canals throughout the Lehi area; each of these canals ultimately discharge into the Salt River. The location of these three canal and their outfall points are shown on the Water Budget Map.

The RWCD and SRP irrigate agricultural areas located in eastern Mesa, Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no irrigation return flows from these areas.

3.6.2 Quantity Analyses

Under the current configuration, the Community supplies approximately 60,000 acre-feet of irrigation water to agricultural users annually.

Approximately 14,000 acre-feet of this water are delivered to the areas north of the Arizona Canal. The canal intercepts all runoff from this area so that irrigation return flows from this area are not a potential source of water for the restoration project.

The remaining 46,000 acre-feet are delivered to farms, the Cypress Golf Course, and individual homeowners for lawn irrigation. The table below identifies water delivered to these entities.

SRPMIC Irrigation Water Use with Potential to Reach the Salt River (South of the Arizona Canal)

Water User	Annual Water Use (acre-feet)		
	1999	2000	2001
Associated Farms	18,511	27,009	27,061
Rogers Farms	9,130	17,731	16,645
Taylor Farms	13,786	0	0
Juan Montiel Farm	57	170	142
Lehi Farm	2,249	1,952	1,892
Cypress Golf Course	177	164	109
Homeowners Lawn Irrigation	125	91	31
Total Irrigation	44,035	47,117	45,880

The amount of irrigation return flow generating from these water users is not currently monitored and is difficult to quantify. SRPMIC personnel have suggested that approximately 10 percent of the water delivered to the farms may become irrigation return flow.

3.6.3 Quality Analyses

The quality of the irrigation return flows can meet the needs of the SRRP in most cases. The water is Salt River water and, as demonstrated in previous sections of this report, the quality is acceptable. In some locations, irrigation drainage water can be saline, but that problem usually occurs far downstream in the western portions of the SRP service area.

Localized water quality problems could occur if surface runoff drainage enters the irrigation drain canals and transports contaminants from surrounding areas into the drain canals. A review of the aerial photographs indicates there are no concentrated animal feeding operations in the area that could contribute contaminated runoff into the drainage canal system.

3.6.4 Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.6.5 Assessment of Source

Irrigation return flows may provide a supplemental source of water for the habitat restoration. However, nearly all irrigation return flow from within the Community are currently diverted to other water users, so this water is not available without an institutional decision to allocate this water to the project by the Community. In addition, several factors prohibit irrigation return flows from being a reliable source. Typically, only the amount of water necessary for irrigation is delivered to the fields, which minimizes the tailwater amount. Additionally, storm events that produce significant runoff are rare so that surplus canal water is not available on a regular basis. The irrigation flows that do occur, however, only take place during the irrigation season. When the flows are available, they could be incorporated to supplement the water supply for the SRRP. Since all irrigation within the study area takes place within the western portion of the Community, irrigation return flows would only be available to Reaches 4, 5, and 6.

3.7 Canal Drains

3.7.1 Description of Source

Canal drains are typically constructed along the major canals in the area to provide a means to discharge water from the canal other than the designated delivery turnouts. During storm events, the canals intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Additionally, the major canals occasionally convey more water than is needed by the downstream water users; in this case, the excess water can be released through the canal drains. Three significant canal drains were identified within the study area, namely the Evergreen Drain, Hennessey Drain, and Tempe Drain. Each of these canal drains is operated by the SRP. These drains are shown on the Water Budget Map. Photo 3-8 and Photo 3-9 show the turnouts to the Evergreen Drain and Hennessey Drain, respectively.

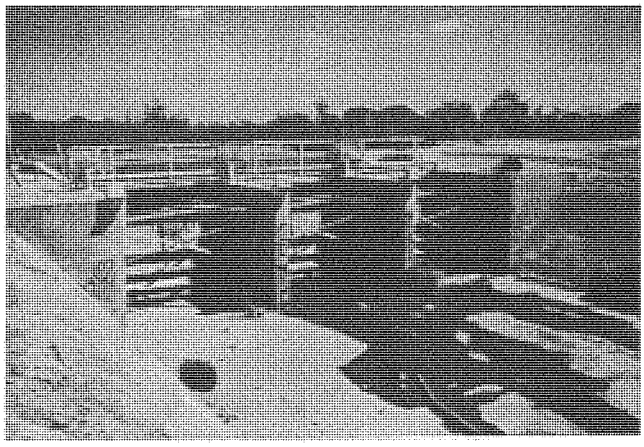

Photo 3-8. Evergreen Drain Turnout

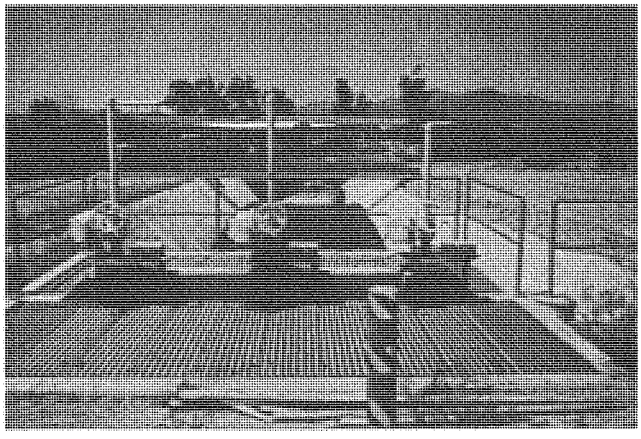

Photo 3-9. Hennessey Drain Turnout

There are also several lateral canals that could ultimately drain into the Salt River. These canals, however, are generally relatively small and rarely have a surplus of water. There are no flow records available for these canals. Given the size and infrequent water surplus of these canals, they are not considered to be a potential water source for the habitat restoration project. These lateral canals are shown on the Water Budget Map.

The RWCD diverts water from the Southern Canal at a pumping station located approximately 5.0 miles downstream of Granite Reef Dam. Irrigation water is pumped from the Southern Canal into the Roosevelt Canal, which then flows toward the southeast. The areas irrigated by the RWCD irrigation water are located in eastern Mesa, eastern Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no canal drains that return water to the Salt River.

3.7.2 Quantity Analyses

Flow records for the SRP drains were evaluated for the period from January 1992 through December 2001. These records indicate that, for the Evergreen Drain, the average monthly volume of flow for this period ranged from 10.9 acre-feet in May to 74.5 acre-feet in September with an average annual total of 566.5 acre-feet. For the Hennessey Drain, the average monthly volume of flow ranged from 2,264.3 acre-feet in April to 4,937.4 acre-feet in August with an average annual total of 45,930.7 acre-feet. It should be noted that the flow records for the Hennessey Drain do not include the water delivered to the GRUSP project. For the Tempe Drain, the average monthly volume of flow ranged from 8.0 acre-feet in December to 2,607.2 acre-feet in January with an average annual total of 10,880.2 acre-feet. In addition, ponded water exists in the Salt River channel in the vicinity of the Tempe Drain outfall; this may indicate that the Tempe Drain may provide sufficient water to establish some restored habitat. Table 3-3 summarizes the average monthly and annual volumes of flow for these drains for the period of record evaluated.

3.7.3 Quality Analyses

The water discharged from canal drains is generally high quality and suitable for the habitat restoration project.

3.7.4 Water Rights

Irrigation return flows discharged to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.7.5 Assessment of Source

Canal drains may provide a supplemental source of water for the restoration project. The amount of water released through these drains is relatively consistent from month to month; however, releases typically only occur for a few days each month. These releases are controlled by the

SRP and are not expected to be reliable. Canal drains are typically only utilized when a surplus of water exists in the major canals. When these releases do occur, however, they could be used to supplement the habitat restoration water supply.

3.8 Sand and Gravel Mining Operations Releases

3.8.1 Description of Source

There were four mining operations identified within the project study area; these operations use water to process aggregate materials. Three of these mining operations are operated by Salt River Sand and Rock (SRSR), and one is operated by United Metro Materials Corp. The SRSR Dobson Plant is located north of the river between the Pima Freeway (Loop SR-101) and Dobson Road. The SRSR Beeline Plant is located south of the Beeline Highway (U.S. 87) between Horne Road and Gilbert Road. The SRSR Higley Plant is located north of the Southern Canal between Greenfield Road and Higley Road, and the United Metro operation is located south of the Beeline Highway on the east side of Country Club Drive. To our knowledge, some of these operations discharge a negligible amount of water to the Salt River.

3.8.2 Quantity Analyses

The Community provides water to Salt River Sand and Rock for use in their Dobson Plant. The Community has provided approximately 450 acre-feet, 800 acre-feet, and 1,200 acre-feet of water to this plant during 1999, 2000, and 2001, respectively. This water is used for processing aggregates and stored in holding ponds when not in use. To our knowledge, a negligible amount of water is being discharged into the Salt River.

3.8.3 Quality Analyses

The quality of water discharged from sand and gravel mining operations is dependant partially on the original water supply. The most significant water quality impairment due to these mining operations is sediment.

3.8.4 Water Rights

Discharges from sand and gravel mining operations released to the river become available for use by other water users. If this water is diverted and directed into the SRRP, it could be utilized to support the wetland and riparian habitat.

3.8.5 Assessment of Source

Discharges from sand and gravel mining operations are not considered to be a potential water source for the restoration project. To our knowledge, there are no operations that currently discharge excess water into the Salt River.

3.9 Salt River Project and Central Arizona Project Water

3.9.1 Description of Source

SRP delivers water to the Community lands as well as non-Indian lands. SRP canals are subject to a two- to four-week dry-up period every year to allow for maintenance activities. The Arizona Canal and Southern Canal have separate dry-up periods. Photo 3-10 and Photo 3-11 show the Arizona Canal and Southern Canal, respectively.

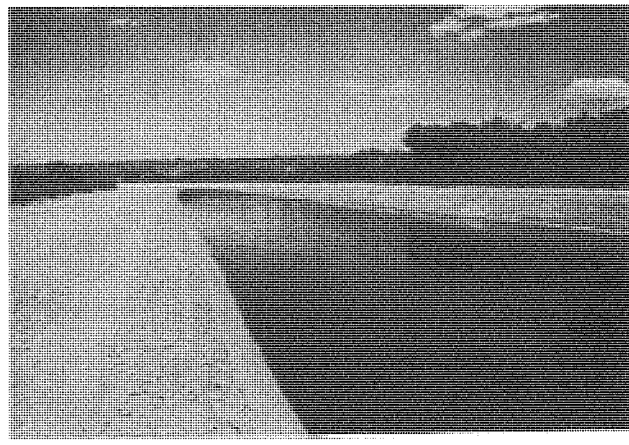

Photo 3-10. SRP's Arizona Canal

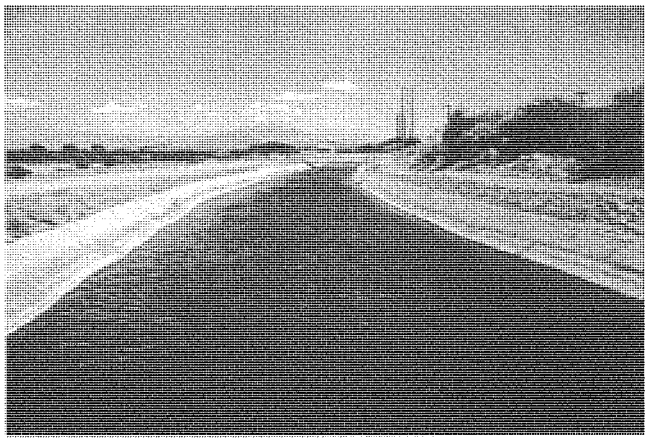

Photo 3-11. SRP's Southern Canal

CAP water is diverted from the Colorado River and transported across Arizona. The CAP system crosses the Salt River immediately downstream of Granite Reef Dam, and there are turnouts that allow CAP water to be diverted into the SRP system. The CAP canal is not subject to periodic dry-up periods, but because the SRP system is needed to transport to the project area, the SRP dry up can impact the delivery.

3.9.2 Quality Analyses

The quality of both SRP and CAP water is suitable for use in the SRRP. Quality is not a constraint.

3.9.3 Water Rights

SRP is a delivery organization. The water rights associated with lands within the SRP area are tied to the land. These water rights were established by the Kent Decree and relate to normal flow of surface water and stored water. SRP lands also have pumped rights gained when the landowner funded well development. Lands in the Salt River do not have SRP rights, and SRP could not provide water to these lands. SRP delivers water to the Community, and the rights for this water were also established by the Kent Decree. There may be more flexibility to allow use of Community water on lands within the river.

Rights to CAP water are established by allocations made by the Secretary of the Interior. The Community has a contract with the federal government for CAP water. Mesa has a subcontract with the Central Arizona Water Conservation District and the Bureau of Reclamation for delivery of CAP water.

3.9.4 Assessment of Water Source

SRP water delivered to non-Indian lands should not be considered as a potential water source. CAP water delivered to Mesa could be considered a water source. However, Mesa would need to commit a portion of its allocated water to the project. Use of Mesa's CAP subcontract water for habitat restoration would mean a depletion of the water Mesa uses to comply with Assured Water Supply requirements and to meet current and future demands. This is an institutional issue rather than a water supply issue. It may also be possible to develop an agreement between the parties whereby excess CAP water is purchased and transported through the SRP/CAP interconnection facility for delivery to the SRRP. However, excess CAP water supplies are not projected to be available in the very long term.

There is a potential to use water delivered by SRP to the Community and the Community's CAP allocation to supply the SRRP. These are institutional decisions that must be made by the Community rather than a water supply issue. If committed to the project, this water could be diverted at Granite Reef Dam or via a pump station to supply the eastern portion of the project area. Deliveries to the central and western portion of the project could use the Community's irrigation water delivery system.

If SRP or CAP water is committed to the project, it will be a dependable supply for most of the year. However, a supplemental supply may be needed to augment the flow during the SRP dry-up periods. The need for a supplemental supply can be defined when the habitat alternatives are developed and the vegetation mix is proposed. The water demand of the vegetation may be very low when the dry up occurs, and the demand for supplemental water may be small or eliminated.

4.0 Evaluation of Water Sources

Each of the potential water sources has been evaluated based on the quantity and seasonality of flow, water quality, water rights, and institutional considerations. A few dependable and supplemental sources of water are available to supply the SRRP. For some of these, there is sufficient information to quantify the potential supply; however, others will require further monitoring to verify the quantity and seasonality of flow. In addition, the Community, Mesa, SRP, or CAP could make other water sources available upon institutional commitments. These entities will need to decide if, how much, and when they will commit water to the SRRP. Table 4-1 presents a summary of the analyses.

The habitat restoration alternatives for this project have not yet been developed; however, an estimate of the potential water demands can still be made. For the purposes of this evaluation, the water demands have been estimated for three types of habitat restoration: (1) unlined open water-marsh areas, (2) lined open water-marsh areas, and (3) cottonwood-willow-mesquite areas.

Unlined open water-marsh areas will have two principal water demands – infiltration and evaporation. The infiltration losses through the bottom of the open water-marsh area can be projected based on the local percolation rates. GRUSP has recharge rates that average between 1 and 3 feet per day. However, an organic mat typically forms on the bottom and sides of wetland areas that will restrict percolation. Research for the Tres Rios Project has shown that the percolation in an unlined open water-marsh can be 1 to 2 feet per day. Assuming a 1-foot-per-day percolation rate, a total of 365 feet (or acre-feet per acre) will infiltrate each year. With an annual evaporation rate of 6.033 feet per year and an annual precipitation rate of 0.638 feet per year, the net evaporation demands is 5.40 feet per year. Therefore, the total water demand of unlined open water-marsh areas will be 370.40 feet per year. This amount is equivalent to a continuous flow of 0.51 cfs per acre (0.33 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for unlined open water-marsh habitat areas.

Lined open water-marsh areas can be designed to reduce and possibly eliminate infiltration. This technique drastically reduces the amount of infiltration and decreases the net water demand. If infiltration is eliminated, the lined open water-marsh areas will only have one water demand – evaporation. Thus, considering precipitation, the net water demand for lined open water-marsh areas will be 5.40 feet per year or 0.0075 cfs per acre (0.0048 mgd per acre). Evaporation rates are greatest during the summer months of June and July when the demand is 0.825 feet per

month. Coincidentally, June, with 0.011 feet, boasts one of the lowest monthly precipitation amounts. During June, a net water demand of 0.81 feet per month results in a peak flow demand of 0.0137 cfs per acre (0.0088 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for lined open water-marsh habitat areas.

The cottonwood-willow-mesquite areas are projected to have a consumptive use of 3.70 feet per year (or acre-feet per acre each year) with no infiltration losses. Considering precipitation, this results in a net water demand of 3.06 feet per year. This amount is equivalent to a continuous flow of 0.0042 cfs per acre (0.0027 mgd per acre). Consumptive use values are greatest during June, July, and August when the demand is 0.555 feet per month. June experiences the least amount of precipitation, creating the largest net water demand. During June, a net water demand of 0.54 feet per year results in a peak flow demand of 0.0091 cfs per acre (0.0059 mgd per acre). Table 4-2 shows the monthly water demands, per acre, for cottonwood-willow-mesquite habitat areas.

From this water budget analysis, the only dependable water sources that are currently available include the Price Drain, the Alma School Drain, and seepage at Granite Reef Dam. The seepage at Granite Reef Dam is already supplying water to wetland areas similar to those proposed to be restored. Using only the flows from the Price Drain and Alma School Drain, the amount of habitat areas that could be restored were computed on a monthly basis; these results are shown in Table 4-3. The areas that these flows can support vary for each month, so the month with the lowest supply to demand ratio governs the amount of habitat area that can realistically be restored. During June, approximately 156 acres of lined open water-marsh areas or 233 acres of cottonwood-willow-mesquite areas could be restored. During other months, this water supply could fulfill the water demand for larger habitat areas; however, the peak water demands in June limit the acreage that this water supply can support without an additional water source. Table 4-3 shows the monthly water budget using only the Price Drain and Alma School Drain for water supply.

For the purposes of this evaluation, the Tres Rios Project can be used for comparison. The SRRP is approximately 15 miles long whereas the Tres Rios Project is approximately 9 miles long. However, it can be used to develop approximate water demands. Tres Rios contains approximately 440 acres of open water-marsh and approximately 2,400 acres of restored vegetation. If similar habitat restoration alternatives are proposed for this project, approximately

730 acres of open water-marsh and 4,000 acres of cottonwood-willow-mesquite areas would be restored. The water demand for lined open water-marsh areas would then be 3,938 acre-feet per year; this corresponds to a continuous rate of 5.44 cfs (3.52 mgd). The water demand for 4,000 acres of cottonwood-willow-mesquite would be 12,247 acre-feet per year; this corresponds to a continuous rate of 16.92 cfs (10.93 mgd). A total water demand of 16,185 acre-feet, equivalent to a continuous rate of 22.36 cfs (14.45 mgd), would be required to replicate the habitat areas similar to those for Tres Rios Project. During June, the peak water demand for both habitat types would be 46.57 cfs (30.10 mdg). Table 4-4 shows the monthly water demands for habitat areas similar to those for the Tres Rios Project.

An additional water supply is required to meet the water demands for restored vegetation patterns similar to those for the Tres Rios Project. The monthly and annual amounts needed are shown on Figure 4-4. During the peak month of June, an additional 43.27 cfs (27.97 mgd) is required. During the winter months, the additional supply required would be much less; for example, an additional 4.09 cfs (2.65 mgd) would be required in December.

To make up this deficit, a dependable source of water must be committed to the restoration project. Pumped groundwater, effluent, and SRP or CAP water could each feasibly supply all or a portion of this additional amount; however, an institutional commitment must be made by the owners of these water sources. If pumped groundwater is used to supply this deficit, utilizing existing wells or installing new wells will be necessary. Assuming an average well production of 1,200 gpm, 16 wells would be required during the peak month of June; fewer wells would be required at other times. The NWWRP, with its existing capacity, does not have sufficient effluent to meet the peak month demands; however, effluent could be used in conjunction with another source. If SRP or CAP water is used as a water source, this water would not be available for use by the Community or Mesa to meet other demands. For comparison, the long-term residential water use is approximately 140 gallons per person per day. A projected demand of 27.97 mgd is equivalent to the water supply for about 200,000 people.

This analysis demonstrates that limited water is currently available to supply the SRRP; these sources are dependable but are not of sufficient quantity to fulfill to total project needs. An additional source or combination of sources must be sought to provide adequate water for the restored habitat. This additional supply could feasibly come from pumped groundwater, effluent, SRP, or CAP sources given that the appropriate entities that control this water make a commitment to the project.

5.0 Recommendations

Knight Piésold has developed several recommendations related to the water budget.

1. Monitor the discharge from the Alma School Drain located on the north bank of the Salt River along Alma School Road to verify the quantity of water available and if the supply is fairly continuous over the year. Given the presence of wetland vegetation at the outlet, this drain could likely be a dependable water source.

2. Meet with SRP to develop a program to monitor the quantity of seepage from Granite Reef Dam. The seepage quantity is not measured at this time but potentially is a dependable water source for the eastern portion of the project area. This supply currently supports wetland vegetation, so, if quantified, the use of seepage could be optimized to provide the greatest amount of restored habitat.

3. Discuss with each potential water supplier (SRP, CAP, SRPMIC, NWWRP, and Mesa) the possibility of using their water as a source for the habitat restoration project.

4. Develop specific restoration alternatives using combinations of habitat types to adhere to the project water supply. For example, a mix of open water-marsh and cottonwood-willow (no mesquite) habitat areas would have a high water demand; a mix of cottonwood-willow-mesquite with some open water-marsh habitat areas would require a moderate water demand, and a mix of cottonwood-willow-mesquite with limited open water-marsh habitat would require a low water demand. Tailoring the habitat types to the water supply would optimize the total area that could be restored for this project.

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Tables

TABLE 2-1

RIPARIAN AND CONSTRUCTED WETLAND VEGETATION REQUIREMENTS

Vegetation Type		Seedling Establishment	Sapling Growth	Mature Survival
Trees (Groundwater Depth Requirements)				
Cottonwood	Populus freemontii	Moist soils in March/April	0.66 to 6.6 feet	16.5 feet
Willow	Salix gooddingii	Moist soils in April/May	0.66 to 6.6 feet	10 feet
Mesquite	Prospis sp.	< 4 inches	3.3 to 33 feet	< 33 feet
Salt Cedar	Tamarix sp.	Moist soils in May to September	0.66 to 8.2 feet	33 feet
Common Aquatic Plants (Inundation Depth Requirements)				
Shallow Emergent Marsh	Scirpus validus, Scirpus americanus, Scirpus acutus, Sagittaria greggii, Sagittaria latifloa, Alisma triviale, Typha latifola	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 2.6 feet
Deep Emergent Marsh	Typha domingensis, Scirpus californicus, Phragmites australis	Saturated soils to 2 inches	Saturated soils	Saturated soils to < 4.9 feet
Floating Aquatic	Hydrocotyle sp., Ludwegia palustrus, Polygonum hydropeperoides, Potomogeton sp. Rorippa, Nasturtium-aquaticum	Moist soils to 4 inches	Moist soils to 8 inches	Moist soils to 8 inches
Transitional Marsh Plants	Eleocharisparishii, Eleocharis macrostachya, Equisetum laevigatum or similar sp., Cyperus niger, Cyperus laevigatus, Cypeus erythohizos or similar sp., Juncus balticus, Juncus bufonius, Juncius tenurs var. Dudleyi, Juncius inetrior, Juncus torreyi, or similar sp., Heteranthera limosa, Anemopsis californicus	Moist soils to 4 inches	Moist soils to 4 inches	Moist soils to 4 inches

Source: WASS Gerke + Associates, Inc.

TABLE 3-1

SUMMARY OF HISTORIC SALT RIVER FLOOD FLOWS
(floods with greater than 10,000 cfs discharge)

Period of Flow Start Date	Period of Flow End Date	Flow Event Maximum Daily Average Flow (cfs)
2/7/14	7/2/14	15,800
1/29/15	8/18/15	18,700
1/15/16	5/15/16	79,100
9/8/16	2/4/17	21,100
4/17/17	5/15/17	23,400
3/7/18	3/26/18	28,400
11/25/19	13/14/1919	46,200
1/4/20	4/25/20	87,800
12/26/21	1/9/22	24,100
2/8/22	2/18/22	10,000
3/16/22	4/10/22	18,000
9/18/23	9/22/23	24,100
12/26/23	1/8/24	42,800
3/31/26	4/16/26	28,800
2/14/27	3/19/27	49,800
9/12/27	9/20/27	16,200
4/4/29	4/19/29	17,200
2/12/31	2/20/31	22,900
2/9/32	3/29/32	48,700
2/6/37	3/25/37	36,981
2/28/39	3/17/39	58,739
2/5/41	5/25/41	32,206
12/21/65	1/12/66	64,000
2/20/73	6/5/73	22,273
2/28/78	4/11/78	95,800
12/16/78	4/19/79	110,000
1/29/80	6/3/80	137,725
2/2/83	6/17/83	30,000
9/27/83	10/24/83	39,878
12/24/83	1/24/84	11,200
12/21/84	6/1/85	25,604
12/22/91	6/21/92	12,898
8/21/92	9/8/19992	13,615
12/28/92	6/4/93	99,396
1/20/95	5/2/95	53,316

Source: U.S. Army Corps of Engineers' Tres Rios Project

TABLE 3-2

STORM DRAINS AVERAGE ANNUAL RUNOFF VOLUMES

(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[2]	31.2	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,620
Tempe Drain[3,4]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[3,4]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[3,4]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[3,4]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[3,4]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[3,4]	unknown							minimal						
Natural Drainage[3,4]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent of Annual Rainfall:		8.7	9.0	11.5	2.9	1.6	1.7	10.8	12.5	11.2	8.5	8.6	13.0	100.0

1. Drainage areas were estimated based on the drainage delineation made by personnel from the City of Mesa.
2. Monthly and annual storm water runoff volumes were computed from FCDMC flow records.
3. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
4. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

TABLE 3-3

CANAL DRAINS AVERAGE ANNUAL RUNOFF VOLUMES
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL[2]
Evergreen Drain	~ 0	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	567
Hennessey Drain	~ 0	4,788	3,704	3,367	2,264	4,288	3,868	4,604	4,937	4,654	4,171	2,853	2,423	45,921
Tempe Drain	10.0	2,607	2,556	2,559	1,678	835	158	64.2	193	72.6	80.2	69.2	8.0	10,880

1. Drainage areas were estimated based on the drainage delineation made by personnel from the City of Mesa.
2. Annual and monthly runoff volumes for the canal drains were computed from the SRP daily flow records.

Source: Computed from SRP Daily Flow Records

TABLE 4-1

WATER BUDGET MATRIX

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
In-Situ Groundwater					
Regional water table	Throughout the study area; all reaches	None	Not available	Unacceptable	Regional groundwater is too deep for use by the desired vegetation. Depth exceeds 30 feet, which is the limit for mesquite.
Local or perched water table	Extends from Granite Reef Dam approximately 1 mile downstream; Reach 1	Not measured	Continuous	Dependable	Local supply available at the surface from Granite Reef to about one mile downstream.
Pumped Groundwater					
Community Lands	Throughout the Community; all reaches	Pending	Continuous	Dependable or Supplemental	Requires a reallocation of water resources to project by the Community.
Non-Indian Lands					
Irrigation Grandfather Rights	Tied to specific parcels of land for growing crops.	Not Available	None	Unacceptable	IGR water must be used on a historically specified parcel of land.
Type I Non-Irrigation Rights	Tied to specific parcels of land for changes in land use.	Not Available	None	Unacceptable	Type I water cannot be used off of the specific land parcel.
Type II Non-Irrigation Rights	Pumping for uses not associated with historic farmland.	Pending	Continuous	Dependable or Supplemental	Requires purchase and transfer of Type II right.
Groundwater Permits	Pumping for new uses.	Not Available	None	Unacceptable	Project can not meet permit requirements and conditions.
Service Area Right	Pumping for public water providers.	Pending	Continuous	Dependable or Supplemental	Pumped water will impact Mesa's overall water resources unless credits to offset the pumping are purchased or developed.
Salt River Flood Flows					
Direct Use	Flow in the Salt River due to spills over Granite Reef Dam; all reaches	Quantity varies with each flood event	Approximately once every 3 years	Problem	Due to the unpredictable nature of the flood flows, they are not a dependable supply, and may cause damage to restored areas.
Indirect Use	Groundwater recharge due to flood flows in the Salt River; all reaches	Quantity varies with each flood event	During floods and for a short time after	Supplemental	Recharge of groundwater allows for indirect use; and, surface soil saturation will augment seed germination.
Storm Water Discharges					
Alma School Road Storm Drain	Storm runoff from the Community, outfalls along the west side of alma School Road; Reach 5	1 to 2 cfs estimated (no flow records available)	May be fairly continuous	Supplemental	Wetland vegetation are present indicating a fairly continuos flow; flow monitoring may permit reclassification as a dependable source.
Natural Surface Drainage - SRPMIC	Uncontrolled surface runoff from the Community; all reaches	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Price Drain	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	Averages 4 cfs; ~ 2,500 ac-ft per yr	Continuous	Dependable	Continuous base flow may be a dependable source; however, water quality may be a concern due to storm water runoff.
Tempe Drain (see Canal Drains)	Storm runoff from mesa, outfalls between Dobson Road and Alma School Road; Reach 5	(See Canal Drains)			This drain serves as a canal drain and intercepts storm water runoff from Mesa.
Price Road Freeway Local Drainage	Storm runoff from Mesa, outfalls along the east side of the Pima Freeway (Loop 101); Reach 6	~ 30 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.

TABLE 4-1 (CONTINUED)

WATER BUDGET MATRIX

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
Storm Water Discharges (continued)					
Dobson Road Storm Drain	Storm runoff from Mesa, outfalls along the east side of Dobson Road; Reach 6	~ 140 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
McLellan Road Storm Drain	Storm runoff from Mesa, outfalls west of Alma School Road; Reach 5	~ 80 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Country Club/McKellips Storm Drain	Storm runoff from Mesa, outfalls along Country Club Drive; Reach 5	~ 300 ac-ft per yr	During or immediate after rainfall events	Unacceptable to Supplemental	First flush is unacceptable due to potential water quality problems, but the remainder of the flow can be a supplemental water source.
Red Mountain Freeway Local Drainage	Storm runoff from the Red Mountain Freeway (Loop 202); Reach 3, 4, 5, and 6	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Natural Surface Drainage - Mesa	Uncontrolled runoff between Gilbert Road and Granite Reef Dam, south of the Salt River; Reach 1 and 2	Minimal	During or immediate after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; most runoff is uncontrolled overland flow.
Effluent					
Direct Use	Effluent from the NWWRP discharged directly into the project; Reach 6.	Pending; may be as high as 30 MGD (~34,000 ac-ft per yr)	Continuous	Dependable or Supplemental	The quantity and availability of effluent water is subject to an institutional commitment by Mesa; Mesa has existing commitments for this effluent.
Indirect Use	Effluent from the NWWRP recharged into the groundwater; Reach 6.	Pending	Continuous	Dependable or Supplemental	Mesa has incorporated the recharge credits for this effluent into its long-term water plan; it would require a reallocation to the project. Indirect use requires wells to recover the recharged water.
Irrigation Return Flows					
Irrigation Tailwater	Excess water applied to crops within the western portion of the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Irrigation Drainage	Excess water in lateral canals within the Community; Reach 4, 5, and 6	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Canal Drains					
Evergreen Drain	Drains the Arizona Canal, outfalls west of Horne Road; Reach 4	averages < 1 cfs; ~567 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases only occur once or twice each month and are not reliable.
Hennessey Drain	Drains the Southern Canal, outfalls east of Val Vista Road; Reach 4	averages 63 cfs; ~ 45,921 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases have occurred frequently in the past but only for two days since Nov. 2001; may not reliable in the future.
Tempe Drain	Drains the Tempe Canal, outfalls between Dobson Road and Alma School Road; Reach 5	averages 15 cfs; ~ 10,880 ac-ft per yr	In-frequent	Supplemental	This canal intercepts storm water so flow is due to controlled releases by SRP as well as rainfall events; releases occur on average 4 times each month and are not reliable.
Sand & Gravel Mining Releases					
	Within the Salt River; all reaches	None	Not available	Unacceptable	No known discharges from these operations.
Salt River Project & Central Arizona Project Water					
	Throughout the project area; all reaches	Pending	Pending	Dependable to Supplemental	The quantity and availability of water supply is subject to institutional commitments by SRP or CAP.

TABLE 4-2

RESTORED HABITAT WATER DEMANDS

		Consumptive Use		Evaporation		Precipitation		Infiltration	Unlined Open Water-Marsh			Lined Open Water-Marsh			Cottonwood-Willow-Mesquite		
Month	Days	%	acre-feet per acre	inches	acre-feet per acre	inches	acre-feet per acre	acre-feet per acre	acre-feet per acre	cfs per acre	mgd per acre	acre-feet per acre	cfs per acre	mgd per acre	acre-feet per acre	cfs per acre	mgd per acre
January	31	5	0.185	2.2	0.183	0.67	0.056	31	31.13	0.51	0.33	0.13	0.0021	0.0013	0.13	0.0021	0.0014
February	28	5	0.185	3.1	0.258	0.68	0.057	28	28.20	0.51	0.33	0.20	0.0036	0.0023	0.13	0.0023	0.0015
March	31	5	0.185	5.0	0.417	0.88	0.073	31	31.34	0.51	0.33	0.34	0.0056	0.0036	0.11	0.0018	0.0012
April	30	10	0.370	6.6	0.550	0.22	0.018	30	30.53	0.51	0.33	0.53	0.0089	0.0058	0.35	0.0059	0.0038
May	31	10	0.370	9.0	0.750	0.12	0.010	31	31.74	0.52	0.33	0.74	0.0120	0.0078	0.36	0.0059	0.0038
June	30	15	0.555	9.9	0.825	0.13	0.011	30	30.81	0.52	0.33	0.81	0.0137	0.0088	0.54	0.0091	0.0059
July	31	15	0.555	9.9	0.825	0.83	0.069	31	31.76	0.52	0.33	0.76	0.0123	0.0079	0.49	0.0079	0.0051
August	31	15	0.555	9.0	0.750	0.96	0.080	31	31.67	0.52	0.33	0.67	0.0109	0.0070	0.48	0.0077	0.0050
September	30	5	0.185	6.9	0.575	0.86	0.072	30	30.50	0.51	0.33	0.50	0.0085	0.0055	0.11	0.0019	0.0012
October	31	5	0.185	5.3	0.442	0.65	0.054	31	31.39	0.51	0.33	0.39	0.0063	0.0041	0.13	0.0021	0.0014
November	30	5	0.185	3.3	0.275	0.66	0.055	30	30.22	0.51	0.33	0.22	0.0037	0.0024	0.13	0.0022	0.0014
December	31	5	0.185	2.2	0.183	1.00	0.083	31	31.10	0.51	0.33	0.10	0.0016	0.0011	0.10	0.0017	0.0011
Annual	365	100	3.700	72.4	6.033	7.66	0.638	365	370.40	0.51	0.33	5.40	0.0075	0.0048	3.06	0.0042	0.0027
Peak	31		0.555		0.825		0.083	31	31.76	0.52	0.33	0.81	0.0137	0.0088	0.54	0.0091	0.0059

TABLE 4-3

HABITAT ACHIEVABLE UNDER EXISTING CONDITIONS

Month	Days	Price Drain			Alma School Drain			Total Water Available			Habitat Acres Achievable	
		acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd	Lined Open Water-Marsh	Cottonwood-Willow-Mesquite
January	31	202.19	3.29	2.13	61.49	1.00	0.65	263.68	4.29	2.77	1,337	1,319
February	28	125.58	2.26	1.46	55.54	1.00	0.65	181.12	3.26	2.11	580	912
March	31	266.86	4.34	2.81	61.49	1.00	0.65	328.34	5.34	3.45	618	1,900
April	30	178.75	3.00	1.94	59.50	1.00	0.65	238.26	4.00	2.59	290	438
May	31	311.10	5.06	3.27	61.49	1.00	0.65	372.59	6.06	3.92	325	669
June	30	136.49	2.29	1.48	59.50	1.00	0.65	195.99	3.29	2.13	156	233
July	31	283.07	4.60	2.98	61.49	1.00	0.65	344.56	5.60	3.62	295	458
August	31	337.12	5.48	3.54	61.49	1.00	0.65	398.60	6.48	4.19	385	542
September	30	267.75	4.50	2.91	59.50	1.00	0.65	327.25	5.50	3.55	420	1,866
October	31	193.77	3.15	2.04	61.49	1.00	0.65	255.26	4.15	2.68	426	1,261
November	30	150.54	2.53	1.64	59.50	1.00	0.65	210.05	3.53	2.28	617	1,044
December	31	166.48	2.71	1.75	61.49	1.00	0.65	227.97	3.71	2.40	1,473	1,449
Annual	365	2,619.69	3.62	2.34	723.97	1.00	0.65	279.83	4.62	2.99	401	706
Minimum		125.58	2.26	1.46	55.54	1.00	0.65	181.12	3.26	2.11	156	233

TABLE 4-4

WATER BUDGET PROJECTIONS

		Total Water Available			Restored Acreage = 730 Lined Open Water/Marsh			Restored Acreage = 4,000 Mesquite/Cottonwood/Willow			Restored Acreage = 4,730 Total Water Demand			Additional Water Needed		
Month	Days	acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd
January	31	263.68	4.29	2.77	93.08	1.51	0.98	516.67	8.40	5.43	609.74	9.92	6.41	346.06	5.63	3.64
February	28	181.12	3.26	2.11	147.22	2.65	1.71	513.33	9.24	5.97	660.55	11.89	7.69	479.43	8.63	5.58
March	31	328.34	5.34	3.45	250.63	4.08	2.63	446.67	7.26	4.70	697.30	11.34	7.33	368.96	6.00	3.88
April	30	238.26	4.00	2.59	388.12	6.52	4.22	1,406.67	23.64	15.28	1,794.78	30.16	19.49	1,556.53	26.16	16.91
May	31	372.59	6.06	3.92	540.20	8.79	5.68	1,440.00	23.42	15.14	1,980.20	32.20	20.81	1,607.61	26.15	16.90
June	30	195.99	3.29	2.13	594.34	9.99	6.46	2,176.67	36.58	23.64	2,771.01	46.57	30.10	2,575.01	43.27	27.97
July	31	344.56	5.60	3.62	551.76	8.97	5.80	1,943.33	31.61	20.43	2,495.09	40.58	26.23	2,150.54	34.98	22.60
August	31	398.60	6.48	4.19	489.10	7.95	5.14	1,900.00	30.90	19.97	2,389.10	38.85	25.11	1,990.50	32.37	20.92
September	30	327.25	5.50	3.55	367.43	6.17	3.99	453.33	7.62	4.92	820.77	13.79	8.91	493.52	8.29	5.36
October	31	255.26	4.15	2.68	282.88	4.60	2.97	523.33	8.51	5.50	806.21	13.11	8.47	550.95	8.96	5.79
November	30	210.05	3.53	2.28	160.60	2.70	1.74	520.00	8.74	5.65	680.60	11.44	7.39	470.55	7.91	5.11
December	31	227.97	3.71	2.40	73.00	1.19	0.77	406.67	6.61	4.27	479.67	7.80	5.04	251.70	4.09	2.65
Annual	365	279.83	4.62	2.99	3,938.35	5.44	3.52	12,246.67	16.92	10.93	16,185.02	22.36	14.45	15,905.19	17.74	11.46
Maximum		398.60	6.48	4.19	594.34	9.99	6.46	2,176.67	36.58	23.64	2,771.01	46.57	30.10	2,575.01	43.27	27.97

Drawings

SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
SALT RIVER RESTORATION FEASIBILITY STUDY
WATER BUDGET MAP
Knight Piésold
CONSULTING
1889M06C-100
C
SALT RIVER DISTRICT
LEHI DISTRICT
BEELINE HIGHWAY
ARIZONA CANAL
GRANITE REEF DIVERSION DAM
SALT RIVER LANDFILL
EVERGREEN DRAIN
HENNESSEY DRAIN
ALMA SCHOOL STORM DRAIN
TEMPE DRAIN
MESA DRIVE
CENTER STREET
LINDSAY ROAD
VAL VISTA DRIVE
GREENFIELD ROAD
HIGLEY ROAD
RECKER ROAD
GILBERT ROAD
DOBSON ROAD
McKELLIPS ROAD
INDIAN SCHOOL ROAD
RED MOUNTAIN FREEWAY (LOOP SR-202)
PLAN
LEGEND:

INTERIOR DRAINAGE

Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

July 17, 2002

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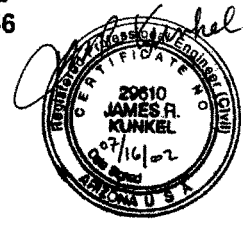

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Project 1889A/0120

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

Table of Contents

List of Tables iii
List of Figures v
List of Photos v
List of Drawings v
List of Appendices v
1.0 Introduction 1
2.0 Canal Drains 2
2.1 Evergreen Drain 2
2.2 Hennessey Drain 4
2.3 Tempe Drain 5
2.4 Lateral Canal Drains 6
2.4.1 Salt River Pima-Maricopa Indian Community 6
2.4.2 Salt River Project 6
2.4.3 Roosevelt Water Conservation District 6
3.0 Storm Drains 7
3.1 Salt River Pima-Maricopa Indian Community 8
3.2 City of Mesa 9
3.2.1 Price Drain 9
3.2.2 Tempe Drain 11
3.2.3 Price Road Freeway Local Drainage 12
3.2.4 Dobson Road Storm Drain 12
3.2.5 McLellan Road Storm Drain 13
3.2.6 Country Club/McKellips Storm Drain 14
3.2.7 Red Mountain Freeway Local Drainage 15

Table of Contents *(Continued)*

3.2.8 Natural Surface Drainage....15
4.0 Summary and Evaluation....16
4.1 Damage to Restored Habitat....16
4.2 Water Source....17
References....R-1

List of Tables

Table	Title
2-1a	Evergreen Drain – Average Daily Flow
2-1b	Evergreen Drain – Maximum Daily Flow
2-2a	Evergreen Drain – Average Daily Volume
2-2b	Evergreen Drain – Maximum Daily Volume
2-3	Evergreen Drain – Monthly Volume
2-4a	Hennessey Drain – Average Daily Flow
2-4b	Hennessey Drain – Maximum Daily Flow
2-5a	Hennessey Drain – Average Daily Volume
2-5b	Hennessey Drain – Maximum Daily Volume
2-6	Hennessey Drain – Monthly Volume
2-7a	Tempe Drain – Average Daily Flow
2-7b	Tempe Drain – Maximum Daily Flow
2-8a	Tempe Drain – Average Daily Volume
2-8b	Tempe Drain – Maximum Daily Volume
2-9	Tempe Drain – Monthly Volume
3-1a	Price Drain – Average Daily Flow
3-1b	Price Drain – Maximum Daily Flow
3-2a	Price Drain – Average Daily Volume
3-2b	Price Drain – Maximum Daily Volume
3-3	Price Drain – Monthly Volume

List of Tables *(Continued)*

Table	Title
3-4	Storm Drain Peak Flows for Various Return Periods
3-5	Storm Drain Average Annual Runoff Volumes
4-1a	Summary of Interior Drains – Canal Drains
4-2b	Summary of Interior Drains – Storm Drains
4-2a	Summary of Peak Flows – Canal Drains
4-2b	Summary of Peak Flows – Storm Drains
4-3a	Summary of Average Annual Runoff – Canal Drains
4-3b	Summary of Average Annual Runoff – Storm Drains

List of Figures

Figure	Title
3-1	Peak Flow Relationships for Various Return Periods
3-2	Typical Full-Flow Storm Drain Pipe Capacity
3-3	Average Annual Storm Drain Runoff for the Phoenix Metro Area

List of Photos

Photo	Title
2-1	Evergreen Drain Turnout
2-2	Hennessey Drain Turnout
3-1	Price Drain
3-2	McLellan Road Storm Drain

List of Drawings

Drawing	Title
100	Interior Drainage Map

List of Appendices

Appendix	Title
A	Evergreen Drain Daily Flow Records
B	Hennessey Drain Daily Flow Records
C	Tempe Drain Daily Flow Records
D	Price Drain Flow Records

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01G Interior Drainage
Final Report

1.0 Introduction

Interior drains, or side drains, that outfall into the Salt River between Granite Reef Diversion Dam (Granite Reef Dam) and the Pima Freeway (Loop SR-101) may have implications on the Va Shly'ay Akimel Salt River Restoration Project (SRRP). These drains have been evaluated to assess the potential damage that frequent inundation or high discharge velocities may cause to the restored habitat and the possibility of utilizing this water to support or nourish the reestablishment of riparian vegetation.

Two types of interior drains were identified that outfall into the Salt River within the project study limits – canal drains and storm drains. Canal drains are designed to release water from the major canals and discharge it into the Salt River. These drains are an operational mechanism to control flow in the canal system. Storm drains are designed to collect runoff generated by rainfall events. These drains are typically installed in urbanizing areas to protect developments from a design storm of a certain return period.

2.0 Canal Drains

Canal drains are often constructed along the major canals in the area to provide a means to discharge water from the canal other than the designated delivery turnouts. The drains may be used for a variety of reasons. During storm events, the canals intercept storm water runoff; if this storm water runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Additionally, the major canals occasionally convey more water than is needed by the downstream water users; in this case, the excess water can be released through these drains. They also provide a mechanism to empty or lower the water level in the canal to allow for periodic inspection and maintenance or for repairs whenever necessary.

Several canal drains were identified within the study area. The most significant identified include the Evergreen Drain, the Hennessey Drain, and the Tempe Drain; all of these canal drains are operated by the Salt River Project (SRP). There were also several lateral canals identified that could ultimately drain into the Salt River. These lateral canals, along with the three major canal drains, are shown on the Interior Drainage Map (Drawing 100).

Flow records for the three major canals have been provided by the SRP. These records provide the average daily flow rate for each canal for the period from 1992 through 2001. The records do not, however, provide an indication of the instantaneous peak flow rate. The Evergreen Drain and the Hennessey Drain do not intercept significant amounts of storm water runoff, so the canal flows are not greatly influenced by storm events. The average daily flow rates are indicative of the peak flow rates that occur in these canals. The Tempe Drain, however, does intercept storm runoff. The ramifications of this additional flow are further evaluated in the Storm Drains section of this report.

2.1 Evergreen Drain

The Evergreen Drain is located along the Arizona Canal approximately 7.0 miles downstream of Granite Reef Dam near Horne Road and immediately upstream of the Evergreen Canal turnout. The Evergreen Canal is operated by the Salt River Pima-Maricopa Indian Community (the Community); however, the Evergreen Drain is operated by the SRP. This open channel extends from the Arizona Canal in Section 23 of Township 2 North and Range 5 East to the Salt River in Section 26 of Township 2 North and Range 5 East, a distance of approximately one mile. Three gates at the turnout from the Arizona Canal control discharges into the drain. The turnout to the

Evergreen Drain is shown in Photo 2-1. The Evergreen Drain is shown on the Interior Drainage Map (Drawing 100).

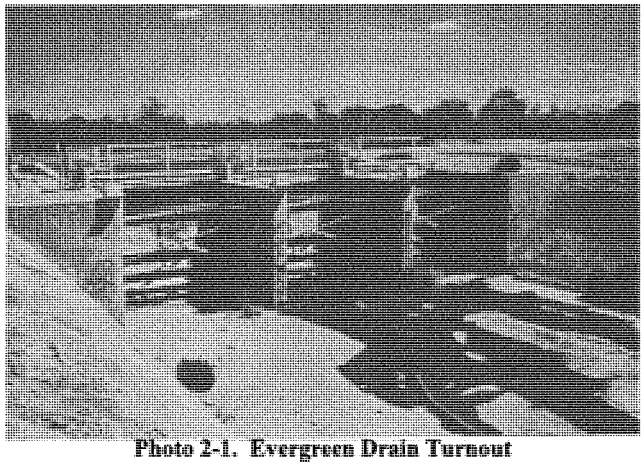

Photo 2-1. Evergreen Drain Turnout

Flow records for the Evergreen Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 0.18 cubic feet per second (cfs) in May to 1.25 cfs in September with an average of 0.78 cfs. The maximum daily flow rate that occurred during this period was 313.34 cfs during September 1996. Table 2-1 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. The complete daily flow records are provided in Appendix A.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 0.35 acre-feet in May to 2.48 acre-feet in September with an average of 1.55 acre-feet. The maximum daily volume that occurred during this period was 621.50 acre-feet during September 1996. Table 2-2 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 10.9 acre-feet in May to 74.5 acre-feet in September with an average annual total of 566.5 acre-feet. Table 2-3 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.2 Hennessey Drain

The Hennessey Drain is located along the Southern Canal approximately 4.5 miles downstream of Granite Reef Dam between Val Vista Drive and Greenfield Road. This open channel extends from the Southern Canal in Section 28 of Township 2 North and Range 6 East to the Salt River less than 0.5 miles away. Releases into the drain are controlled by three gates at the turnout from the Southern Canal. The turnout to the Hennessey Drain from the Southern Canal is shown in Photo 2-2. The Hennessey Drain is shown on the Interior Drainage Map (Drawing 100).

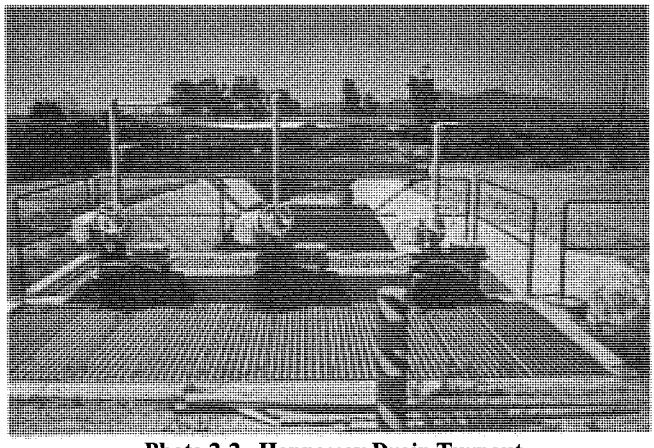

Photo 2-2. Hennessey Drain Turnout

Flow records for the Hennessey Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 38.05 cfs in April to 80.30 cfs in August with an average of 63.34 cfs. The maximum daily flow rate that occurred during this period was 845.89 cfs during January 1993. Table 2-4 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. It should be noted that these flow records do not include water delivered to the Granite Reef Underground Storage Project (GRUSP). The complete daily flow records are provided in Appendix B.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 75.48 acre-feet in April to 159.27 acre-feet in August with an average of 125.64 acre-feet. The maximum daily volume that occurred during this period was 1,677.80 acre-feet during January 1993. Table 2-5 summarizes the average daily and maximum

daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 2,264.3 acre-feet in April to 4,937.4 acre-feet in August with an average annual total of 45,920.7 acre-feet. Table 2-6 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.3 Tempe Drain

The Tempe Drain is located along the Tempe Canal between Dobson Road and Alma School Road. This open channel extends from the Tempe Canal in Section 17 of Township 1 North and Range 5 East to the Salt River in Section 8 of Township 1 North and Range 5 East, a distance of less than one mile. This canal drain also intercepts storm water runoff from a portion of the City of Mesa (Mesa). The contributing storm flows include an 84-inch storm drain in Alma School Road that drains a significant portion of Mesa. The Tempe Drain is shown on the Interior Drainage Map (Drawing 100). Inspection of aerial photography indicates that ponded water exists in the Salt River channel in the vicinity of the Tempe Drain outfall; this may indicate that the Tempe Drain may provide sufficient water to establish some restored habitat.

Flow records for the Tempe Drain were evaluated for the period from January 1992 through December 2001. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 0.13 cfs in December to 45.14 cfs in February with an average of 14.96 cfs. The maximum daily flow rate that occurred during this period was 530.63 cfs during January 1992. It should be noted that this flow rate is the maximum 24-hour flow rate that occurred and may not be indicative of the peak instantaneous flow rate. Table 2-7 summarizes the average daily and maximum daily flow rates for each month of the period of record evaluated. The complete flow records for this drain are provided in Appendix C.

The flow records also indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 0.26 acre-feet in December to 89.53 acre-feet in February with an average of 29.67 acre-feet. The maximum daily volume that occurred during this period was 1,052.49 acre-feet in January 1992. Table 2-8 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 8.0 acre-feet in December to 2,607.2 acre-feet in January with an average annual total of 10,880.2 acre-feet. Table 2-9 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

2.4 Lateral Canal Drains

2.4.1 Salt River Pima-Maricopa Indian Community

The Community operates a network of irrigation canals that deliver water to agricultural lands throughout the Community. There were nine lateral canals identified north of the Salt River and three canals identified in the Lehi District. In addition, there were nine outfall points identified that discharge surplus irrigation or storm water into the habitat restoration project area. Two of these outfall points are located between Hayden Road and the Pima Freeway; these sites are outside of the study area. The remaining seven locations, four north of the river and three in the Lehi District, are shown on the Interior Drainage Map (Drawing 100). Each of the lateral canals distributes irrigation water to the individual farming areas south of the Arizona Canal and north of the Salt River as well as to the Lehi District. There are no flow records available; however, the lateral canals are generally relatively small and rarely have excess water. Given their size and infrequent water surplus, these canals are not considered to have implications on the habitat restoration project.

2.4.2 Salt River Project

The SRP maintains a series of lateral canals within the study area. The two largest identified by the SRP are located between Gilbert Road and Lindsay Road and near Mesa Drive. There are no flow records available for any of these canals; however, there is rarely any excess water, and they reportedly never discharge into the Salt River. These canals are not considered to have implications on the habitat restoration project.

2.4.3 Roosevelt Water Conservation District

The Roosevelt Water Conservation District (RWCD) diverts water from the Southern Canal at a pumping station located approximately 5.0 miles downstream of Granite Reef Dam between Val Vista Drive and Greenfield Road. Irrigation water is pumped from the Southern Canal into the Roosevelt Canal in Section 33 of Township 2 North and Range 6 East, which then flows toward the southeast. The RWCD has water rights for up to 5.1 percent of the Salt River flow upstream of Granite Reef Dam, additional water from the Central Arizona Project (CAP), and some groundwater wells. The areas irrigated by the RWCD irrigation water are located in eastern Mesa, eastern Chandler, and Gilbert. Because these areas are located a great distance from the Salt River and south of the Southern Canal, there are no canal drains that return water to the Salt River from the RWCD system.

3.0 Storm Drains

Storm drains were evaluated with regard to the potential damage that peak flow rates might have on the restored habitat areas as well as to the possibility of using storm water runoff as a water source. Storm drains are often constructed in urban areas to collect and convey storm water runoff safely through developed or urbanized areas. With increased urbanization, the overall imperviousness of the land generally increases, thus increasing both the peak flow rate and volume of storm water runoff. This storm water runoff can be conveyed through a network of open channels or storm drains to a designated outfall point.

To quantify the potential damage that storm drains may cause to the habitat restoration project, the peak flow rates that occur during or immediately after storm events were examined. Unfortunately, very little information is available from which reasonable peak flow rates can be quantified. Estimates of peak flows were made, however, using the approach defined for the Rio Salado Project (USACE, 1998). The Rio Salado Project is a similar habitat restoration project within the Salt River downstream. The drainage areas within the Rio Salado study area are similar to those within the Va Shly'ay Akimel project area. In the Rio Salado Project, a series of storm drains were evaluated in which sufficient data were available to model storm runoff using computer modeling techniques. The results were then used to generate a series of curves representing the relationship between peak flow rate and drainage area. Curves were developed for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storm events. These curves are shown on Figure 3-1.

In many cases, the storm water runoff is conveyed to retention or detention basins. Retention basins are designed to completely capture the storm water runoff, thus eliminating flow to the outfall point. Detention basins are designed to temporarily capture storm water runoff in order to reduce the peak flow rate to a value that meets local drainage criteria, which is typically not greater than the historic peak flow. The detained storm water is then released gradually to the outfall point. The capacity of the outlet pipe is often used to control the rate at which water is released from the detention facilities. For these areas, the peak flow rate that can be discharged into the Salt River is governed by the capacity of the outlet pipe. The full-flow capacities for several pipe sizes were determined for a range of longitudinal slopes. These relationships are presented on Figure 3-2. For this analysis, a longitudinal slope of 0.5 percent was assumed to be typical for storm drains in this area.

To evaluate the possibility of using storm water as a water source, the approach used in the Rio Salado Project (USACE, 1998) was used to estimate the average annual volume of runoff. Curves similar to those developed that relate peak flow to drainage area were developed to represent the relationship between the average annual volume of runoff and the drainage area. These curves are shown on Figure 3-3. To estimate the average monthly volume of runoff, the annual amount was distributed according to the monthly rainfall distribution in the Phoenix area (Schmidli, 1996). The monthly pattern of rainfall is shown in the table below.

Rainfall Pattern for the Phoenix Area

Month	Rainfall Amount (inches)	Percent of Annual Amount
January	0.67	8.7
February	0.68	9.0
March	0.88	11.5
April	0.22	2.9
May	0.12	1.6
June	0.13	1.7
July	0.83	10.8
August	0.96	12.5
September	0.86	11.2
October	0.65	8.5
November	0.66	8.6
December	1.00	13.0
Annual Total	7.66	100.0

3.1 Salt River Pima-Maricopa Indian Community

The Community does not currently have an extensive storm water management system that collects and discharges storm water runoff. North of the Arizona Canal, storm water runoff flows overland southward and is intercepted by the Arizona Canal. South of the Arizona Canal and north of the Salt River, storm water is generally collected in roadside ditches or lateral canals where it becomes part of the irrigation system. In addition, storm water runoff from the areas immediately adjacent to the river will flow overland into the river bed. These areas, however, do not produce significant runoff. The areas that contribute storm water runoff to the Salt River as well as those that contribute to the Cypress Golf Course or the Salt River Sand and Rock Dobson Plant are depicted on the Interior Drainage Map (Drawing 100).

There is only one known storm drain with a defined outfall point that discharges into the Salt River from the Community. This outfall is comprised of a 60-inch reinforced concrete pipe located at the intersection of Alma School Road and McKellips Road. This outfall may also intercept some irrigation return flows from agricultural areas within the Community as well as from the Cypress Golf Course. There are no flow records for this outfall. At the time of the Knight Piésold site investigation, approximately 1 to 2 cfs was flowing from the drain, and natural plant species were developed near the outfall. From Figure 3-2, the maximum capacity of a 60-inch pipe is approximately 185 cfs; at this flow rate, a maximum discharge velocity of approximately 9.4 ft/sec would be attained at the outfall to the Salt River. The Alma School Road Storm Drain is shown on the Interior Drainage Map (Drawing 100).

3.2 City of Mesa

Within Mesa, several storm drains were identified that ultimately discharge into the Salt River (Haws, 2002). The two most significant drains are the Price Drain and the Tempe Drain (synonymous with the Tempe Canal drain described earlier in this report). The other, less significant drains include the Price Road Freeway Local Drainage, the Dobson Road Storm Drain, the McLellan Road Storm Drain, the Country Club/McKellips Storm Drain, the Red Mountain Freeway Local Drainage, and uncontrolled runoff from natural and undeveloped areas.

3.2.1 Price Drain

The Price Drain is located near the downstream end of the project area on the east side of the Price Road Freeway (Pima Freeway, Loop SR-101). Two significant storm water collection systems discharge into this drain: (1) a drainage channel along the north side of the Superstition Freeway (U.S. 60) that extends from the Price Road Freeway to the RWCD canal approximately one-half mile west of Power Road, and (2) a drainage tunnel under the Price Road Freeway. This drain receives runoff from approximately 31.2 mi^2. The Price Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Flow records for the Price Drain were obtained from the Flood Control District of Maricopa County (FCDMC). The gauge was installed in February 2001, and flow records from February 2001 through April 2002 were available. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 2.29 cfs in June to 7.71 cfs in May with an average of 3.95 cfs. The maximum daily flow rate that occurred during this period was 195.33 cfs during May 2002. Table 3-1 summarizes the average daily and maximum daily flow

rates for each month of the period of record evaluated. Records from the FCDMC also indicate that the instantaneous peak flow rate for period of record was 691 cfs. Ordinarily, storm drains only intercept storm water runoff that occurs during or immediately after significant rainfall events. However, this drain apparently receives significant return flows as evidenced by the fact that there is usually some flow in the channel. The complete flow records are provided in Appendix D. Photo 3-1 shows the Price Drain near the intersection of the Pima Freeway and the Red Mountain Freeway.

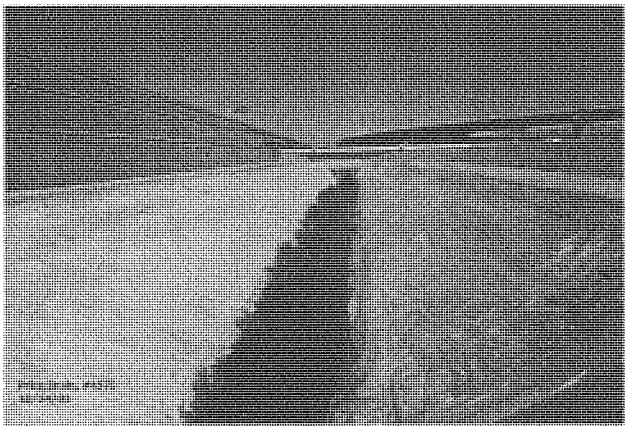

Photo 3-1. Price Drain

The flow records indicate that the average daily volume of flow, on a monthly basis, for this period ranged from 4.55 acre-feet in June to 15.30 acre-feet in May with an average of 7.83 acre-feet. The maximum daily volume that occurred during this period was 387.44 acre-feet in May 2002. Table 3-2 summarizes the average daily and maximum daily volumes of flow for each month of the period evaluated. The average monthly volume of flow for this period ranged from 125.6 acre-feet in February to 337.1 acre-feet in August. The average annual volume of runoff is estimated to be between 2,300 acre-feet and 2,800 acre-feet. Table 3-3 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

The Price Drain is a concrete-lined, trapezoidal channel with a longitudinal slope of 0.00035 ft/ft. The channel has a bottom width of 10 feet, side slopes of 2H:1V, and a maximum depth of 18 feet. According to the rating table provided by the FCDMC, the capacity of this

channel at a stage height of 16.0 feet is 5,142 cfs. Based on the channel geometric parameters, the maximum capacity of this channel was estimated to be approximately 6,800 cfs at a stage of 18 feet.

Because available records do not provide a long-term evaluation of the Price Drain flow, Figure 3-1 was also used to estimate the peak flow rates for a series of storm events. The results are provided in Table 3-4. A peak flow rate of approximately 10,000 cfs was estimated for the 100-year storm event. This rate is greater than the maximum capacity of the open channel. Thus, the peak flow that can realistically discharge from this drain is approximately 6,800 cfs. At this flow rate, a velocity of approximately 8.2 ft/sec would be attained at the outfall to the Salt River.

Figure 3-3 was also used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 2,240 acre-feet. This amount is similar to the actual amount measured by the FCDMC gauge.

3.2.2 Tempe Drain

The Tempe Drain is located along the Tempe Canal between Dobson Road and Alma School Road. This storm drain is synonymous with the canal drain described in Section 2.0 of this report. The primary intent of this drain is to provide a mechanism to release water from the Tempe Canal to the Salt River. However, the channel intercepts storm water runoff from a significant drainage area within Mesa. An area of approximately 10.0 mi^2 contributes runoff to this drain. The Tempe Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Flow records were obtained from SRP for the period from January 1992 through December 2001. These records, however, are more indicative of canal releases than storm water flows. In addition, these records provide the average daily flow rate and provide no indication to the instantaneous peak flow rates attributable to major storm events.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 4,000 cfs was estimated for the 100-year storm event. The geometric parameters for the open channel are not currently known, so it

is not currently possible to determine the maximum capacity and hydraulic characteristics of the channel. However, at a flow rate of 4,000 cfs, a velocity ranging from 6 ft/sec to 10 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 740 acre-feet.

3.2.3 Price Road Freeway Local Drainage

Local drainage from the Price Road Freeway is discharged into the Salt River via a 72-inch storm drain located on the west side of the freeway. This drain collects runoff from the Price Road Freeway between 8th Avenue and the Salt River. A drainage area of approximately 0.35 mi^2 contributes storm water runoff to this drain. There are no flow records available for this drain. The Price Road Freeway Local Drainage drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 270 cfs was estimated for the 100-year storm event. Additionally, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is also approximately 300 cfs. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec would be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 30 acre-feet.

3.2.4 Dobson Road Storm Drain

The Dobson Road Storm Drain is located east of Dobson Road. A 72-inch storm drain conveys runoff from this area under the Red Mountain Freeway and into the Salt River. This drain collects runoff from a drainage area of approximately 1.80 mi^2. There are no flow records available for this drain. The Dobson Road Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 1,000 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is approximately 300 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 140 acre-feet.

3.2.5 McLellan Road Storm Drain

The McLellan Road Storm Drain is located on the east side of the intersection of McLellan Road and Alma School Road. A wetland bottom detention facility is located immediately upstream of the Red Mountain Freeway. A 48-inch storm drain empties the detention facility into the Salt River. This drain collects runoff from a drainage area of approximately 1.04 mi^2. There are no flow records available for this drain. The McLellan Road Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 640 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 48-inch pipe is approximately 100 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the outlet pipe size. With a peak flow rate of 100 cfs, a maximum velocity of approximately 8.1 ft/sec could be attained at the outfall to the Salt River. Photo 3-2 shows the outlet from the wetland detention facility.

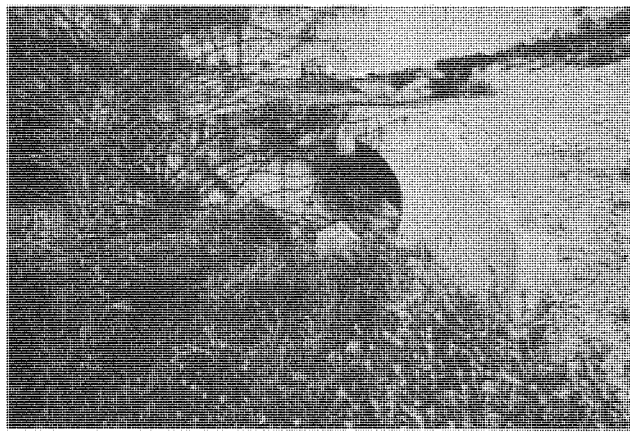

Photo 3-2. McLellan Road Storm Drain

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 80 acre-feet.

3.2.6 Country Club/McKellips Storm Drain

The Country Club/McKellips Storm Drain is located along Country Club Drive. A 72-inch pipe conveys runoff under the Red Mountain Freeway and into the Salt River. This storm drain serves an area adjacent to McKellips Road between Gilbert Road and Country Club Drive as well as along Country Club Drive between Main Street and the Salt River. The total drainage area for this drain is approximately 3.72 mi^2. There are no flow records available for this drain. The Country Club/McKellips Storm Drain and its drainage area are shown on the Interior Drainage Map (Drawing 100).

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-4. A peak flow rate of approximately 1,800 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 72-inch pipe is approximately 300 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. With a peak flow rate of 300 cfs, a maximum velocity of approximately 10.6 ft/sec could be attained at the outfall to the Salt River.

Figure 3-3 was used to estimate the average annual volume of storm runoff. The average annual volume of runoff and the monthly distribution of annual runoff are provided in Table 3-5. Using this approach, the average annual volume of storm runoff was estimated to be approximately 300 acre-feet.

3.2.7 Red Mountain Freeway Local Drainage

Local drainage from the Red Mountain Freeway (Loop SR-202) is discharged into the Salt River through several storm water systems. Storm runoff between Country Club Drive and Gilbert Road is initially conveyed to a retention basin near Center Street. The collected runoff is then pumped to the outfall point near Mesa Drive and discharged into the Salt River. Runoff from the remaining areas along the Red Mountain Freeway is discharged into the river through numerous smaller storm drains located sporadically along the freeway. The drainage area for the Red Mountain Freeway is not well defined; however, it is not expected to generate significant amounts of storm runoff. These areas are not expected to have implications on the habitat restoration project. The Red Mountain Freeway Local Drainage areas are shown on the Interior Drainage Map (Drawing 100).

3.2.8 Natural Surface Drainage

Natural surface drainageways east of Gilbert Road ultimately discharge into the Salt River. The Southern Canal intercepts all runoff from the areas south of the canal. The areas north of the canal, however, will discharge into the river. These areas encompass a total area of approximately 2 mi^2. Because runoff from these areas is not confined to a well defined drainageway, storm events will not generate significant flow rates at any location. These areas are not expected to have implications on the habitat restoration project.

4.0 Summary and Evaluation

4.1 Damage to Restored Habitat

The interior drains were evaluated to assess the potential damage that their flows may have on the habitat restoration project. A summary of the interior drains identified within the project area and their locations is provided in Table 4-1. These drains are shown on the Interior Drainage Map (Drawing 100).

The canal drains flow in response to controlled releases by the SRP. These releases are relatively consistent throughout the day and do not have instantaneous peak flow rates considerably greater than the average daily rate. Flow records for these drains indicate that the maximum daily flow rates recorded for these canals were 313 cfs, 846 cfs, and 531 cfs for the Evergreen Drain, the Hennessey Drain, and the Tempe Drain, respectively. The Evergreen Drain and the Hennessey Drain do not intercept a significant amount of storm runoff, so the average daily flow rates are indicative of the peak flow rates expected to occur. The Tempe Drain, however, does intercept storm runoff. For this drain, the peak flow rate that can be expected to occur is much greater than the average daily canal release. A summary of the peak flow rates recorded for each canal drain is provided in Table 4-2a.

The storm drains flow in response to rainfall events. The two major storm drains identified are the Price Drain and the Tempe Drain (synonymous with the Tempe Canal drain). For this study, the peak flow rate associated with the 100-year storm was assumed to represent the worst possible condition. The peak 100-year flow rates for these drains were estimated to be 10,000 cfs and 4,000 cfs, respectively. However, the maximum capacity of the Price Drain is considerably less. This open channel has a maximum capacity of 6,800 cfs. It is not currently possible to estimate the maximum capacity of the Tempe Drain. Thus, the peak flow rates that could realistically discharge from these drains are 6,800 cfs and 4,000 cfs, which would generate discharge velocities of 8.2 ft/sec and approximately 8 ft/sec, respectively.

The remaining storm drains within the project area could discharge peak flow rates as high as 300 cfs with velocities as high as 10.6 ft/sec into the Salt River. The peak flow rates generated by the drainage areas for these drains may be considerably greater; however, detention facilities or the maximum capacity of the outlet pipes govern the maximum rate at which storm water will be discharged into the restored habitat. A summary of peak flow rates for a series of storm events and the maximum capacities of each outlet is provided in Table 4-2b.

The peak flow rates and discharge velocities from the interior drains are sufficient to create localized damage at the outlet of each drain. However, this damage is not expected to extend beyond the immediate vicinity of the pipe outlet. There is little evidence to suggest that flows from these drains have historically done more than wet the river bed in the immediate vicinity of the drain outlet. Additionally, the maximum flow rates that could potentially discharge from these drains are significantly smaller in magnitude and occur less frequently than Salt River flood flows. The Salt River is expected to spill over Granite Reef Dam approximately once every three years, and the 5-year peak discharge from these spills is expected to exceed 20,000 cfs (USACE, 1998). To that regard, there is little advantage to providing extensive protection from the interior drainage discharge.

4.2 Water Source

The interior drains were also evaluated to assess the potential for using these flows as a water source to support and nourish the restored vegetation. For this evaluation, these drains were each evaluated based on the quantity, reliability, and quality of flow that is or may be available for habitat restoration. The water source analyses are described in further detail in the Water Budget Draft Report (Knight Piésold, 2002).

The canal drains, which flow in response to controlled releases, have received occasional flows throughout the period from 1992 through 2001. The average annual volumes of water released to the Salt River during this period were 567 acre-feet, 45,921 acre-feet, and 10,880 acre-feet for the Evergreen Drain, the Hennessey Drain, and the Tempe Drain, respectively. Although these amounts are sufficient to support some riparian vegetation, the timing of these flows is irregular. The Evergreen Drain and the Tempe Drain typically only receive flow for a few days each month. These releases are not reliable as the drains have historically been dry for long periods; for example, there were no releases to the Evergreen Drain during 1994. The Hennessey Drain flows were historically more frequent and reliable; however, there were no releases to this drain from February through December of 2001. Future releases to this drain are expected to be less frequent than the historic trend. Table 4-3a summarizes the average monthly and annual volumes of water released through the canal drains for the period of record evaluation.

The storm drains flow in response to rainfall events, so the discharge from these drains is typically infrequent and highly variable. The Price Drain, however, has discharged a relatively consistent supply of water since its inception in February 2001. Immediately downstream of the

Price Drain outfall, an abundance of vegetation has appeared since this drain was put into operation. This vegetation is presumably due to the consistent supply of water from the Price Drain. This supply is due to return flows from the adjacent urbanized areas. Over an 11-month period in 2001, this drain discharged 2,310 acre-feet of water into the river. These flows have also been relatively continuous for each month. The other storm drains provide an average annual volume of water to the Salt River ranging from 30 to 300 acre-feet. Table 4-3b summarizes the average monthly and annual volumes of water released through the storm drains.

The average monthly and annual volumes of water released from some of the interior drains are of sufficient magnitude to be considered as a potential water source. The three canal drains have historically supplied a significant amount of water to the Salt River. These drains, however, do not flow consistently, and releases into these drains may not be reliable. The Price Drain has historically supplied a relatively consistent flow to the river. However, long-term records are not available to ascertain this supply. The Evergreen Drain, the Hennessey Drain, the Tempe Drain, and the Price Drain should all be included in the water budget analyses.

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Tables

TABLE 2-1a
EVERGREEN DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	0.06	6.41	0.30	0.00	0.00	0.00	3.81	2.83	0.00	0.00	0.00	1.05	1.18
1993	0.45	0.00	4.37	0.00	0.00	0.00	0.00	2.27	0.00	0.61	9.80	0.00	1.46
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	9.56	0.06	0.00	0.00	1.18	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.99
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.44	0.00	0.00	0.00	0.86
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	3.59	4.93	11.57	0.00	0.00	0.44	1.09	0.14	0.00	0.00	0.00	1.79
1999	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.26	0.00	0.71	0.00	0.00	0.30
2000	0.46	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.63	0.00	0.00	0.24
2001	0.00	0.00	0.00	0.00	0.60	2.13	1.44	1.16	1.03	1.36	1.24	2.92	1.00
Average	1.05	1.01	1.03	1.16	0.18	0.21	0.73	0.86	1.25	0.43	1.10	0.40	0.78

TABLE 2-1b
EVERGREEN DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	2.00	94.50	9.17	0.00	0.00	0.00	112.58	60.19	0.00	0.00	0.00	21.71	112.58
1993	9.57	0.00	78.44	0.00	0.00	0.00	0.00	23.50	0.00	18.79	185.51	0.00	185.51
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	124.02	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00	124.02
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00	313.34
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08
1998	0.00	44.37	70.39	139.41	0.00	0.00	11.58	22.10	4.16	0.00	0.00	0.00	139.41
1999	0.00	0.00	0.00	0.00	0.00	0.00	36.59	39.11	0.00	11.03	0.00	0.00	39.11
2000	9.73	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00	50.66
2001	0.00	0.00	0.00	0.00	14.00	17.50	8.75	7.50	10.91	7.50	7.00	61.47	61.47
Maximum	124.02	94.50	78.44	139.41	36.61	17.50	112.58	60.19	313.34	50.66	185.51	61.47	313.34

Source: Computed from SRP Daily Flow Records

TABLE 2-2a
EVERGREEN DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	0.13	12.71	0.59	0.00	0.00	0.00	7.56	5.62	0.00	0.00	0.00	2.09	2.33
1993	0.89	0.00	8.66	0.00	0.00	0.00	0.00	4.50	0.00	1.22	19.43	0.00	2.89
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	18.95	0.11	0.00	0.00	2.34	0.00	0.00	0.00	1.79	0.00	0.00	0.00	1.96
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.72	0.00	0.00	0.00	1.70
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	7.13	9.77	22.94	0.00	0.00	0.88	2.15	0.28	0.00	0.00	0.00	3.54
1999	0.00	0.00	0.00	0.00	0.00	0.00	3.14	2.50	0.00	1.40	0.00	0.00	0.60
2000	0.92	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.00	0.47
2001	0.00	0.00	0.00	0.00	1.18	4.23	2.86	2.30	2.04	2.69	2.46	5.79	1.98
Average	2.09	2.00	2.04	2.29	0.35	0.42	1.44	1.71	2.48	0.86	2.19	0.79	1.55

TABLE 2-2b
EVERGREEN DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	3.97	187.44	18.19	0.00	0.00	0.00	223.30	119.39	0.00	0.00	0.00	43.06	223.30
1993	18.98	0.00	155.58	0.00	0.00	0.00	0.00	46.61	0.00	37.27	367.95	0.00	367.95
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	245.99	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00	245.99
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00	621.50
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
1998	0.00	88.01	139.62	276.52	0.00	0.00	22.97	43.83	8.25	0.00	0.00	0.00	276.52
1999	0.00	0.00	0.00	0.00	0.00	0.00	72.58	77.57	0.00	21.88	0.00	0.00	77.57
2000	19.30	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00	100.48
2001	0.00	0.00	0.00	0.00	27.77	34.71	17.36	14.88	21.64	14.88	13.88	121.92	121.92
Maximum	245.99	187.44	155.58	276.52	72.61	34.71	223.30	119.39	621.50	100.48	367.95	121.92	621.50

Source: Computed from SRP Daily Flow Records

TABLE 2-3
EVERGREEN DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	4.0	368.6	18.2	0.0	0.0	0.0	234.2	174.2	0.0	0.0	0.0	64.8	863.9
1993	27.7	0.0	268.4	0.0	0.0	0.0	0.0	139.6	0.0	37.7	582.9	0.0	1,056.3
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	587.6	3.2	0.0	0.0	72.6	0.0	0.0	0.0	53.7	0.0	0.0	0.0	717.1
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	621.5	0.0	0.0	0.0	621.5
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
1998	0.0	199.5	302.8	688.3	0.0	0.0	27.3	66.8	8.3	0.0	0.0	0.0	1,293.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	97.3	77.6	0.0	43.4	0.0	0.0	218.3
2000	28.5	0.0	44.4	0.0	0.0	0.0	0.0	0.0	0.0	100.5	0.0	0.0	173.4
2001	0.0	0.0	0.0	0.0	36.7	126.8	88.5	71.4	61.3	83.4	73.7	179.5	721.5
Average	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	566.5

Source: Computed from SRP Daily Flow Records

TABLE 2-4a
HENNESSEY DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	9.67	0.14	0.88	0.52	0.20	0.00	2.43	4.43	0.00	0.55	0.00	1.97	1.76
1993	96.78	0.00	10.90	54.81	5.10	0.00	4.20	2.93	0.00	1.21	0.00	0.00	14.79
1994	1.59	0.00	0.00	0.00	1.18	38.51	199.22	198.97	184.72	0.50	0.00	0.00	52.44
1995	141.40	66.41	0.00	0.00	136.02	153.96	144.72	143.45	107.94	78.89	125.20	64.86	97.16
1996	199.07	180.70	159.37	149.71	162.00	89.47	12.48	5.08	0.63	54.95	6.98	61.69	89.75
1997	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69	73.73
1998	116.63	166.00	128.38	0.00	67.87	85.37	76.34	80.77	78.40	70.54	22.19	30.46	76.51
1999	64.81	88.28	83.03	71.61	81.48	87.20	117.65	144.56	126.78	137.18	118.89	103.41	102.20
2000	121.02	132.60	124.48	88.28	119.50	140.59	154.00	184.73	196.80	176.75	60.67	0.00	124.93
2001	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Average	77.87	65.58	54.76	38.05	69.73	65.00	74.88	80.30	78.21	67.83	47.94	39.41	63.34

TABLE 2-4b
HENNESSEY DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	157.33	4.00	12.30	15.63	6.29	0.00	59.19	92.62	0.00	17.17	0.00	48.04	157.33
1993	845.89	0.00	129.06	169.25	59.09	0.00	130.19	33.75	0.00	37.58	0.00	0.00	845.89
1994	28.25	0.00	0.00	0.00	19.90	217.68	234.41	231.58	240.14	15.53	0.00	0.00	240.14
1995	247.51	146.87	0.00	0.00	194.06	193.15	168.47	165.00	133.94	129.01	161.25	216.07	247.51
1996	273.15	198.21	181.77	156.36	166.03	163.96	28.56	42.39	18.86	371.82	70.10	100.64	371.82
1997	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24	211.57
1998	128.13	442.24	355.82	0.00	82.08	86.97	81.27	87.59	89.62	80.56	214.37	49.80	442.24
1999	67.32	93.03	85.35	173.28	100.04	133.82	130.96	150.75	152.18	144.35	296.97	145.14	296.97
2000	128.71	151.50	133.02	90.51	126.83	148.48	182.62	197.10	204.13	202.03	86.07	0.00	204.13
2001	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.72
Maximum	845.89	442.24	355.82	173.28	194.06	217.68	234.41	231.58	240.14	371.82	296.97	216.07	845.89

Source: Computed from SRP Daily Flow Records

TABLE 2-5a
HENNESSEY DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	19.18	0.27	1.75	1.03	0.40	0.00	4.82	8.78	0.00	1.10	0.00	3.90	3.50
1993	191.97	0.00	21.62	108.72	10.12	0.00	8.33	5.81	0.00	2.40	0.00	0.00	29.34
1994	3.16	0.00	0.00	0.00	2.34	76.38	395.15	394.65	366.38	0.99	0.00	0.00	104.02
1995	280.46	131.71	0.00	0.00	269.79	305.38	287.04	284.54	214.10	156.48	248.33	128.64	192.71
1996	394.85	358.41	316.11	296.95	321.32	177.47	24.76	10.07	1.25	108.99	13.85	122.37	178.01
1997	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21	146.23
1998	231.34	329.26	254.63	0.00	134.61	169.33	151.41	160.21	155.50	139.91	44.02	60.43	151.76
1999	128.55	175.09	164.70	142.03	161.62	172.96	233.36	286.74	251.47	272.09	235.82	205.12	202.71
2000	240.04	263.00	246.91	175.11	237.02	278.86	305.45	366.41	390.34	350.59	120.34	0.00	247.79
2001	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Average	154.45	130.07	108.62	75.48	138.31	128.92	148.51	159.27	155.13	134.54	95.08	78.17	125.64

TABLE 2-5b
HENNESSEY DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	312.06	7.93	24.40	31.00	12.48	0.00	117.40	183.71	0.00	34.06	0.00	95.29	312.06
1993	1,677.80	0.00	255.99	335.70	117.20	0.00	258.23	66.94	0.00	74.54	0.00	0.00	1,677.80
1994	56.03	0.00	0.00	0.00	39.47	431.76	464.95	459.33	476.31	30.80	0.00	0.00	476.31
1995	490.93	291.31	0.00	0.00	384.91	383.11	334.16	327.27	265.67	255.89	319.83	428.57	490.93
1996	541.79	393.14	360.54	310.14	329.32	325.21	56.65	84.08	37.41	737.49	139.04	199.62	737.49
1997	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91	419.64
1998	254.14	877.17	705.76	0.00	162.80	172.50	161.20	173.73	177.76	159.79	425.20	98.78	877.17
1999	133.53	184.52	169.29	343.70	198.43	265.43	259.76	299.01	301.84	286.31	589.03	287.88	589.03
2000	255.29	300.50	263.84	179.52	251.56	294.51	362.22	390.94	404.89	400.72	170.72	0.00	404.89
2001	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.68
Maximum	1,677.80	877.17	705.76	343.70	384.91	431.76	464.95	459.33	476.31	737.49	589.03	428.57	1,677.80

Source: Computed from SRP Daily Flow Records

TABLE 2-6
HENNESSEY DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	594.7	7.9	54.4	31.0	12.5	0.0	149.4	272.3	0.0	34.1	0.0	121.0	1,277.3
1993	5,950.9	0.0	670.3	3,261.5	313.6	0.0	258.2	180.2	0.0	74.5	0.0	0.0	10,709.3
1994	98.0	0.0	0.0	0.0	72.4	2,291.4	12,249.8	12,234.0	10,991.3	30.8	0.0	0.0	37,967.7
1995	8,694.1	3,687.9	0.0	0.0	8,363.3	9,161.3	8,898.4	8,820.6	6,423.1	4,850.8	7,449.9	3,987.8	70,337.4
1996	12,240.5	10,393.8	9,799.3	8,908.4	9,960.9	5,324.1	767.5	312.2	37.4	3,378.8	415.6	3,793.4	65,331.7
1997	1,582.4	1,203.5	2,496.1	928.3	7,622.3	3,265.7	2,318.9	2,340.1	5,167.0	9,698.5	8,654.3	8,097.5	53,374.5
1998	7,171.5	9,219.4	7,893.6	0.0	4,173.0	5,079.8	4,693.8	4,966.5	4,665.1	4,337.1	1,320.5	1,873.2	55,393.4
1999	3,985.0	4,902.6	5,105.6	4,260.9	5,010.2	5,188.8	7,234.3	8,888.8	7,544.2	8,434.9	7,074.5	6,358.7	73,988.5
2000	7,441.3	7,627.0	7,654.3	5,253.3	7,347.5	8,365.8	9,468.8	11,358.8	11,710.3	10,868.2	3,610.3	0.0	90,705.7
2001	121.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	121.2
Average	4,788.0	3,704.2	3,367.3	2,264.3	4,287.6	3,867.7	4,603.9	4,937.4	4,653.8	4,170.8	2,852.5	2,423.2	45,920.7

Source: Computed from SRP Daily Flow Records

TABLE 2-6
HENNESSEY DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	594.7	7.9	54.4	31.0	12.5	0.0	149.4	272.3	0.0	34.1	0.0	121.0	1,277.3
1993	5,950.9	0.0	670.3	3,261.5	313.6	0.0	258.2	180.2	0.0	74.5	0.0	0.0	10,709.3
1994	98.0	0.0	0.0	0.0	72.4	2,291.4	12,249.8	12,234.0	10,991.3	30.8	0.0	0.0	37,967.7
1995	8,694.1	3,687.9	0.0	0.0	8,363.3	9,161.3	8,898.4	8,820.6	6,423.1	4,850.8	7,449.9	3,987.8	70,337.4
1996	12,240.5	10,393.8	9,799.3	8,908.4	9,960.9	5,324.1	767.5	312.2	37.4	3,378.8	415.6	3,793.4	65,331.7
1997	1,582.4	1,203.5	2,496.1	928.3	7,622.3	3,265.7	2,318.9	2,340.1	5,167.0	9,698.5	8,654.3	8,097.5	53,374.5
1998	7,171.5	9,219.4	7,893.6	0.0	4,173.0	5,079.8	4,693.8	4,966.5	4,665.1	4,337.1	1,320.5	1,873.2	55,393.4
1999	3,985.0	4,902.6	5,105.6	4,260.9	5,010.2	5,188.8	7,234.3	8,888.8	7,544.2	8,434.9	7,074.5	6,358.7	73,988.5
2000	7,441.3	7,627.0	7,654.3	5,253.3	7,347.5	8,365.8	9,468.8	11,358.8	11,710.3	10,868.2	3,610.3	0.0	90,705.7
2001	121.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	121.2
Average	4,788.0	3,704.2	3,367.3	2,264.3	4,287.6	3,867.7	4,603.9	4,937.4	4,653.8	4,170.8	2,852.5	2,423.2	45,920.7

Source: Computed from SRP Daily Flow Records

TABLE 2-7a
TEMPE DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	288.18	249.80	175.58	119.74	103.59	25.53	8.21	26.07	11.27	0.35	0.00	1.09	83.25
1993	118.56	191.96	219.92	108.72	31.87	0.99	0.00	3.15	0.00	0.23	0.36	0.00	55.51
1994	0.00	0.00	0.51	0.14	0.00	0.00	0.52	0.00	0.00	0.17	0.21	0.00	0.13
1995	16.60	1.54	16.58	26.07	0.00	0.00	0.00	1.84	0.92	0.00	9.79	0.00	6.12
1996	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	11.10	0.00	0.00	1.05
1997	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	1.16	0.00	0.00	0.17
1998	0.00	8.06	3.61	27.29	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	3.19
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.03	0.57	0.00	0.09
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.21	0.07
2001	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Average	42.40	45.14	41.62	28.20	13.57	2.65	1.04	3.14	1.22	1.30	1.16	0.13	14.96

TABLE 2-7b
TEMPE DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	530.63	368.75	313.54	304.92	257.45	91.75	157.34	134.00	69.75	7.43	0.00	27.70	530.63
1993	377.88	304.84	394.73	228.54	79.93	21.61	0.00	44.19	0.00	7.18	8.21	0.00	394.73
1994	0.00	0.00	9.43	4.10	0.00	0.00	8.70	0.00	0.00	5.16	2.49	0.00	9.43
1995	165.04	37.78	52.39	69.13	0.00	0.00	0.00	24.65	27.65	0.00	40.22	0.00	165.04
1996	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	70.90	0.00	0.00	70.90
1997	17.51	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	34.08	0.00	0.00	34.08
1998	0.00	73.75	103.98	132.44	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00	132.44
1999	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	10.74	0.00	13.19
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	6.66	9.43
2001	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.29
Maximum	530.63	368.75	394.73	304.92	257.45	91.75	157.34	134.00	69.75	70.90	40.22	27.70	530.63

Source: Computed from SRP Daily Flow Records

TABLE 2-8a
TEMPE DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1992	571.59	495.47	348.26	237.50	205.47	50.64	16.29	51.71	22.36	0.70	0.00	2.16	165.12
1993	235.15	380.75	436.21	215.65	63.21	1.96	0.00	6.25	0.00	0.46	0.72	0.00	110.11
1994	0.00	0.00	1.01	0.27	0.00	0.00	1.02	0.00	0.00	0.33	0.41	0.00	0.26
1995	32.93	3.06	32.88	51.71	0.00	0.00	0.00	3.65	1.83	0.00	19.42	0.00	12.13
1996	0.00	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	22.01	0.00	0.00	2.09
1997	1.36	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	2.31	0.00	0.00	0.33
1998	0.00	15.99	7.17	54.13	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	6.33
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.06	1.14	0.00	0.17
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.43	0.15
2001	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Average	84.10	89.53	82.55	55.93	26.92	5.26	2.07	6.23	2.42	2.59	2.31	0.26	29.67

TABLE 2-8b
TEMPE DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1992	1,052.49	731.40	621.90	604.80	510.64	181.98	312.08	265.79	138.35	14.74	0.00	54.94	1,052.49
1993	749.51	604.64	782.94	453.30	158.54	42.86	0.00	87.65	0.00	14.24	16.28	0.00	782.94
1994	0.00	0.00	18.70	8.13	0.00	0.00	17.26	0.00	0.00	10.23	4.94	0.00	18.70
1995	327.35	74.94	103.91	137.12	0.00	0.00	0.00	48.89	54.84	0.00	79.78	0.00	327.35
1996	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	140.63	0.00	0.00	140.63
1997	34.73	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	67.60	0.00	0.00	67.60
1998	0.00	146.28	206.24	262.69	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00	262.69
1999	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	21.30	0.00	26.16
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	13.21	18.70
2001	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.44
Maximum	1,052.49	731.40	782.94	604.80	510.64	181.98	312.08	265.79	138.35	140.63	79.78	54.94	1,052.49

Source: Computed from SRP Daily Flow Records

TABLE 2-9
TEMPE DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1992	17,719.4	14,368.6	10,796.1	7,124.9	6,369.7	1,519.2	505.0	1,603.1	670.7	21.6	0.0	67.1	60,765.4
1993	7,289.8	10,661.0	13,522.4	6,469.5	1,959.4	58.7	0.0	193.7	0.0	14.2	21.6	0.0	40,190.3
1994	0.0	0.0	31.3	8.1	0.0	0.0	31.7	0.0	0.0	10.2	12.4	0.0	93.7
1995	1,020.8	85.7	1,019.4	1,551.4	0.0	0.0	0.0	113.2	54.8	0.0	582.7	0.0	4,428.1
1996	0.0	0.0	0.0	0.0	0.0	0.0	79.6	0.0	0.0	682.3	0.0	0.0	761.9
1997	42.1	0.0	0.0	0.0	0.2	0.0	0.0	7.5	0.0	71.6	0.0	0.0	121.4
1998	0.0	447.8	222.2	1,623.9	0.0	0.0	0.0	14.7	0.0	0.0	0.0	0.0	2,308.6
1999	0.0	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	1.8	34.2	0.0	62.2
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.7	13.2	54.0
2001	0.0	0.0	0.0	0.0	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4
Average	2,607.2	2,556.3	2,559.1	1,677.8	834.6	157.8	64.2	193.2	72.6	80.2	69.2	8.0	10,880.2

Source: Computed from SRP Daily Flow Records

TABLE 3-1a
PRICE DRAIN
AVERAGE DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2001		4.34	5.51	3.98	1.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71	3.71
2002	3.29	2.82	3.17	2.03	13.72								4.32
Average	3.29	3.58	4.34	3.00	7.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71	3.95

TABLE 3-1b
PRICE DRAIN
MAXIMUM DAILY FLOW
(units are in cubic feet per second)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
2001		14.09	47.72	18.12	4.67	4.27	22.67	20.17	7.96	11.16	5.49	21.87	47.72
2002	7.35	6.43	8.35	5.67	195.33								195.33
Maximum	7.35	14.09	47.72	18.12	195.33	4.27	22.67	20.17	7.96	11.16	5.49	21.87	195.33

Source: Computed from FCDMC Flow Records

TABLE 3-2a
PRICE DRAIN
AVERAGE DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
2001		8.61	10.92	7.89	3.39	4.55	9.13	10.87	8.92	6.25	5.02	5.37	7.36
2002	6.52	5.59	6.30	4.03	27.21								8.57
Average	6.52	7.10	8.61	5.96	15.30	4.55	9.13	10.87	8.92	6.25	5.02	5.37	7.83

TABLE 3-2b
PRICE DRAIN
MAXIMUM DAILY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
2001		27.95	94.65	35.93	9.26	8.47	44.96	40.00	15.78	22.13	10.88	43.38	94.65
2002	14.58	12.75	16.56	11.25	387.44								387.44
Maximum	14.58	27.95	94.65	35.93	387.44	8.47	44.96	40.00	15.78	22.13	10.88	43.38	387.44

Source: Computed from FCDMC Flow Records

TABLE 3-3
PRICE DRAIN
MONTHLY VOLUME
(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
2001		94.7	338.6	236.6	105.2	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,310.3
2002	202.2	156.5	195.1	120.9	517.0								1,191.7
Average	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,619.7

TABLE 3-4
STORM DRAIN PEAK FLOWS FOR VARIOUS RETURN PERIODS
(units are in cubic feet per second)

Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	N-Year Peak Flow[2] 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Capacity[3]
Price Drain	31.2	trapezoidal channel	800	1,800	3,000	4,100	6,500	10,000	6,800
Tempe Drain	10.0	trapezoidal channel	350	800	1,200	1,800	2,700	4,000	N/A
Price Road Freeway Local Drainage	0.4	72-inch Pipe	34	75	100	140	200	270	300
Dobson Road Storm Drain	1.8	72-inch Pipe	100	240	340	470	700	1,000	300
McLellan Road Storm Drain	1.0	48-inch Pipe	70	160	220	300	450	640	100
Country Club/McKellips Storm Drain	3.7	72-inch Pipe	180	400	600	800	1,200	1,800	300
Red Mountain Freeway Local Drainage	unknown	various			minimal				N/A
Natural Drainage	2.0	overland flow			minimal				N/A
Alma School Storm Drain	unknown	60-inch Pipe	N/A	N/A	N/A	N/A	N/A	N/A	185

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. N-Year peak flow rates were computed from the drainage area vs. peak flow relationships developed for the Rio Salado Study (Figure 3-1).
3. A longitudinal slope of 0.5% was assumed for the storm drain capacity estimates if the existing slope is unknown (Figure 3-2).

TABLE 3-5
STORM DRAIN AVERAGE ANNUAL RUNOFF VOLUMES
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[2,3]	31.2	195.7	201.5	257.0	64.3	35.0	38.0	242.4	280.4	251.2	189.8	192.8	292.0	2,240
Tempe Drain[2,3]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[2,3]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[2,3]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[2,3]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[2,3]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[2,3]	unknown							minimal						
Natural Drainage[2,3]	2.0							minimal						
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent of Annual Rainfall:		8.7	9.0	11.5	2.9	1.6	1.7	10.8	12.5	11.2	8.5	8.6	13.0	100.0

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
3. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

TABLE 4-1a
SUMMARY OF INTERIOR DRAINS
CANAL DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Evergreen Drain	trapezoidal channel	23	T2N	R5E	Horne Road at Arizona Canal	Yes
Hennessey Drain	trapezoidal channel	28	T2N	R6E	Between Val Vista and Greenfield	Yes
Tempe Drain	trapezoidal channel	17	T1N	R5E	Between Dobson and Alma School	Yes
SRP Laterals	open channels	Throughout study area				No
SRPMIC Laterals	open channels	Throughout SRPMIC				No
RWCD Laterals	open channels	Outside of study area				No

TABLE 4-1b
SUMMARY OF INTERIOR DRAINS
STORM DRAINS

Interior Drain	Outlet Type and Dimensions	Section	Township	Range	Location Description	Flow Records
Price Drain	trapezoidal channel	18	T1N	R5E	East side of Price Road Freeway	Yes
Tempe Drain	trapezoidal channel	8	T1N	R5E	Between Val Vista and Greenfield	Yes
Price Road Freeway Local Drainage	72-inch pipe	18	T1N	R5E	West side of Price Road Freeway	No
Dobson Road Storm Drain	72-inch pipe	8	T1N	R5E	Along Dobson Road	No
McLellan Road Storm Drain	48-inch pipe	8	T1N	R5E	Along McLellan Road	No
Country Club/McKellips Storm Drain	72-inch pipe	4	T1N	R5E	Country Club Drive	No
Red Mountain Freeway Local Drainage	N/A	Along Red Mountain Freeway				No
Natural Drainage	N/A	East of Gilbert Road				No
Alma School Storm Drain	60-inch pipe	5	T1N	R5E	Alma School Road	No

TABLE 4-2a
SUMMARY OF PEAK FLOWS
CANAL DRAINS
(units are in cubic feet per second)

Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	Peak Flow for 10-year Period of Record[2]
Evergreen Drain	~ 0	trapezoidal channel	313
Hennessey Drain	~ 0	trapezoidal channel	846
Tempe Drain	10.0	trapezoidal channel	531

TABLE 4-2b
SUMMARY OF PEAK FLOWS
STORM DRAINS
(units are in cubic feet per second)

Interior Drain	Drainage Area (mi^2)[1]	Outlet Type and Size	N-Year Peak Flow[3] 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Capacity[4]
Price Drain	31.2	trapezoidal channel	800	1,800	3,000	4,100	6,500	10,000	6,800
Tempe Drain	10.0	trapezoidal channel	350	800	1,200	1,800	2,700	4,000	N/A
Price Road Freeway Local Drainage	0.4	72-inch pipe	34	75	100	140	200	270	300
Dobson Road Storm Drain	1.8	72-inch pipe	100	240	340	470	700	1,000	300
McLellan Road Storm Drain	1.0	48-inch pipe	70	160	220	300	450	640	100
Country Club/McKellips Storm Drain	3.7	72-inch pipe	180	400	600	800	1,200	1,800	300
Red Mountain Freeway Local Drainage	unknown	various			minimal				N/A
Natural Drainage	2.0	overland flow			minimal				N/A
Alma School Storm Drain	unknown	60-inch pipe	N/A	N/A	N/A	N/A	N/A	N/A	185

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Peak flow rates for the canal drains were computed from the SRP daily flow records.
3. N-Year peak flow rates for the storm drains were computed from the drainage area vs. peak flow relationships developed for the Rio Salado Study (Figure 3-1).
4. A longitudinal slope of 0.5% was assumed for the storm drain capacity estimates if the existing slope is unknown (Figure 3-2).

TABLE 4-3a
SUMMARY OF AVERAGE ANNUAL RUNOFF
CANAL DRAINS
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Evergreen Drain[2]	~ 0	64.8	57.1	63.4	68.8	10.9	12.7	44.8	53.0	74.5	26.5	65.7	24.4	567
Hennessey Drain[2]	~ 0	4,788	3,704	3,367	2,264	4,288	3,868	4,604	4,937	4,654	4,171	2,853	2,423	45,921
Tempe Drain[2]	10.0	2,607	2,556	2,559	1,678	835	158	64.2	193	72.6	80.2	69.2	8.0	10,880

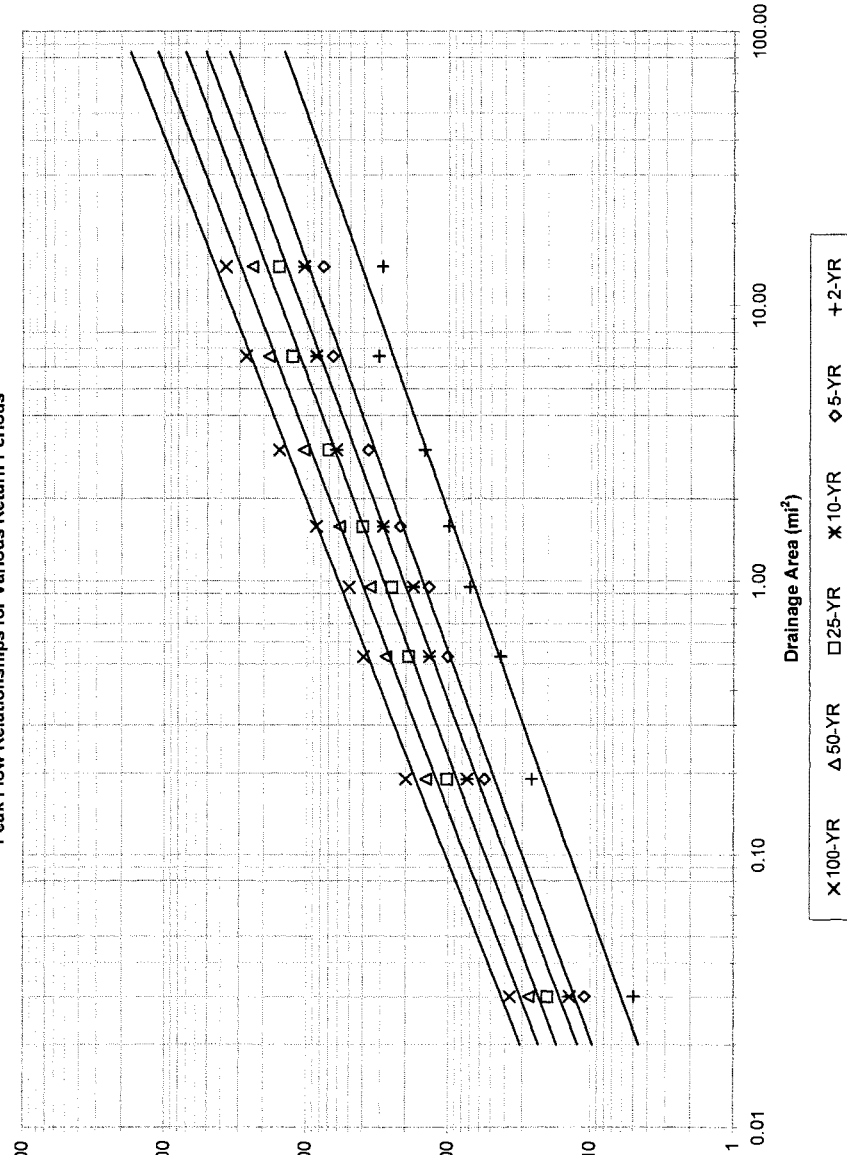
TABLE 4-3b
SUMMARY OF AVERAGE ANNUAL RUNOFF
STORM DRAINS
(units are in acre-feet)

Interior Drain	Drainage Area (mi^2)[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Price Drain[3]	31.2	202.2	125.6	266.9	178.8	311.1	136.5	283.1	337.1	267.7	193.8	150.5	166.5	2,620
Tempe Drain[4,5]	10.0	64.6	66.6	84.9	21.2	11.6	12.5	80.1	92.6	83.0	62.7	63.7	96.5	740
Price Road Freeway Local Drainage[4,5]	0.4	2.6	2.7	3.4	0.9	0.5	0.5	3.2	3.8	3.4	2.5	2.6	3.9	30
Dobson Road Storm Drain[4,5]	1.8	12.2	12.6	16.1	4.0	2.2	2.4	15.1	17.5	15.7	11.9	12.0	18.3	140
McLellan Road Storm Drain[4,5]	1.0	7.0	7.2	9.2	2.3	1.3	1.4	8.7	10.0	9.0	6.8	6.9	10.4	80
Country Club/McKellips Storm Drain[4,5]	3.7	26.2	27.0	34.4	8.6	4.7	5.1	32.5	37.5	33.6	25.4	25.8	39.1	300
Red Mountain Freeway Local Drainage[4,5]	unknown	minimal												
Natural Drainage[4,5]	2.0	minimal												
Alma School Storm Drain	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1. Drainage areas were estimated based on the drainage delineations made by personnel from the City of Mesa.
2. Monthly and annual runoff volumes for the canal drains were computed from the SRP daily flow records.
3. Monthly and annual storm water runoff volumes were computed from FCDMC flow records.
4. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
5. Annual runoff volumes for the storm drains were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study (Figure 3-3).

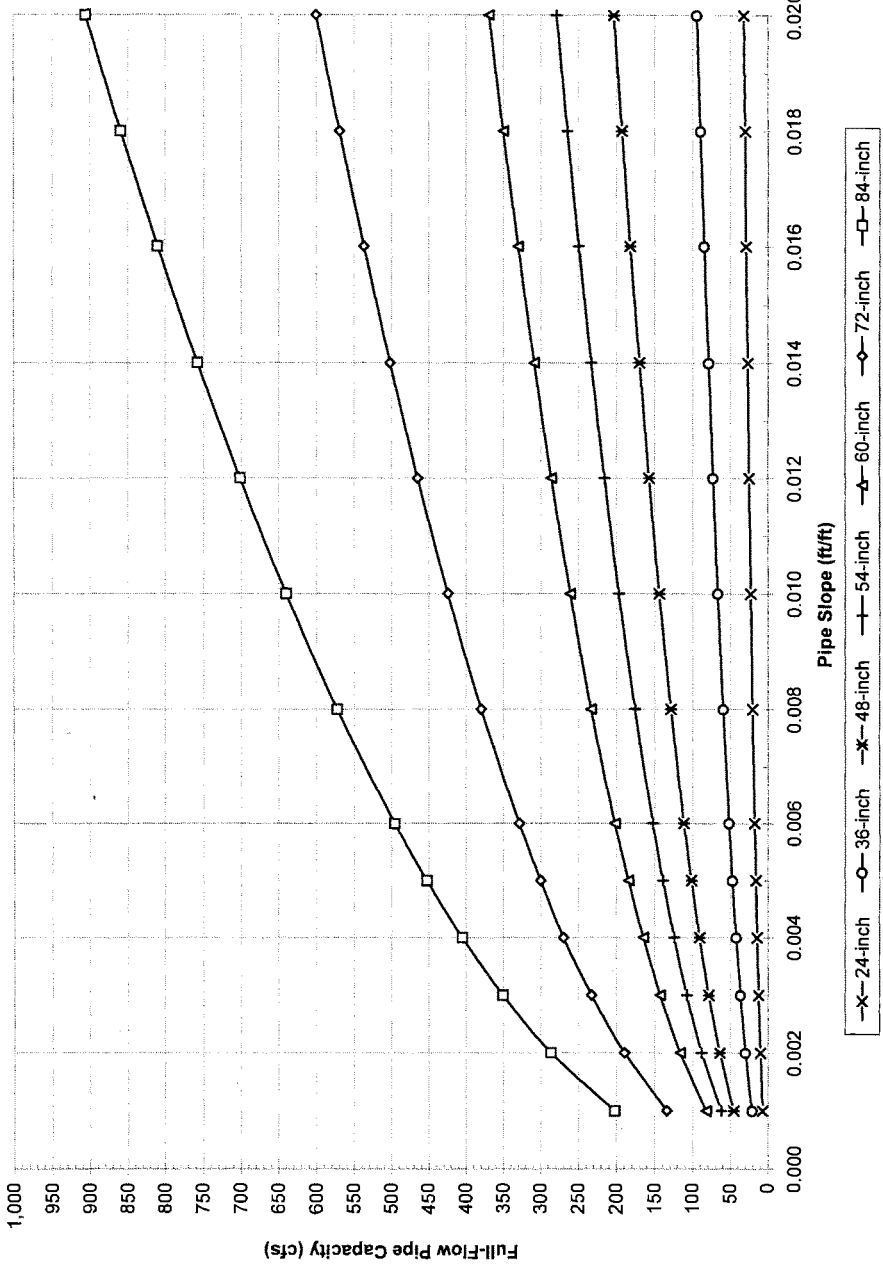
Figures

FIGURE 3-1
Peak Flow Relationships for Various Return Periods



Source: U. S. Army Corps of Engineers' Rio Salado Project.

FIGURE 3-2
Typical Full-Flow Storm Drain Pipe Capacity



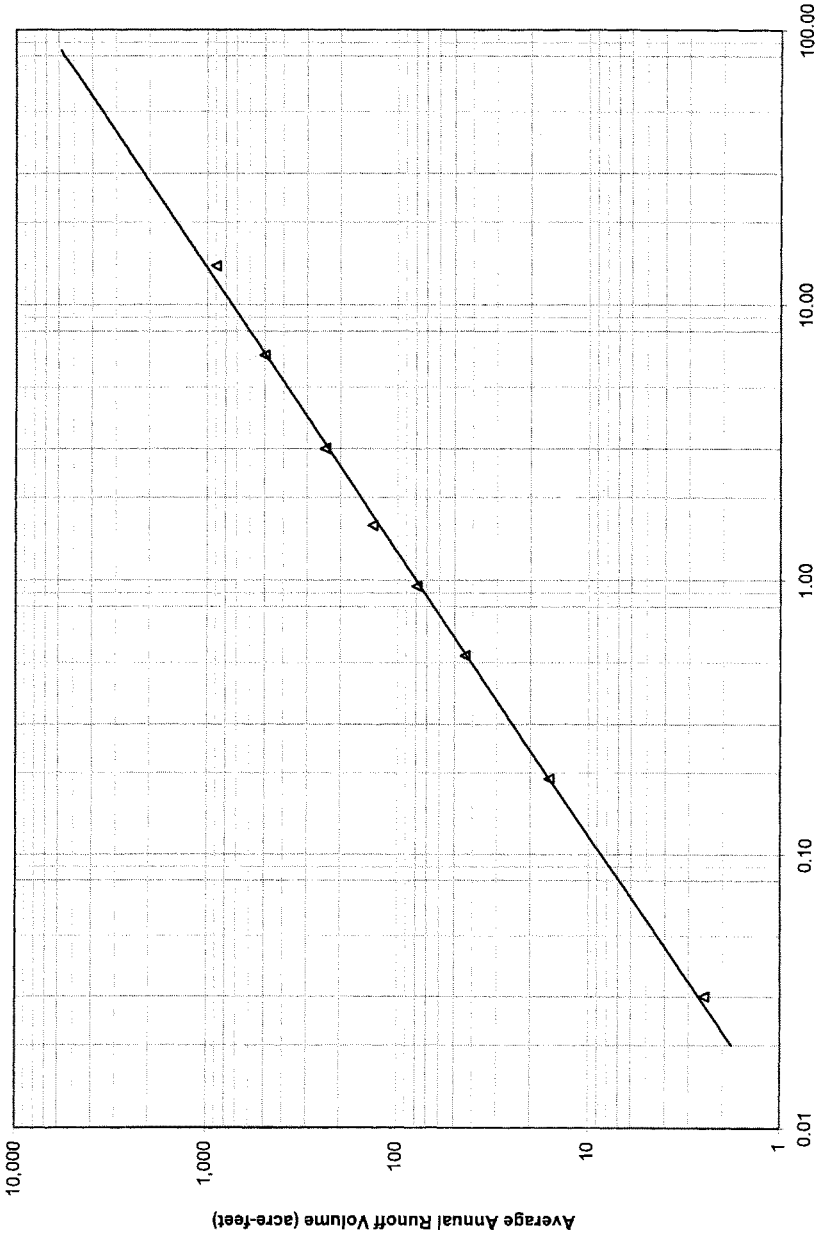
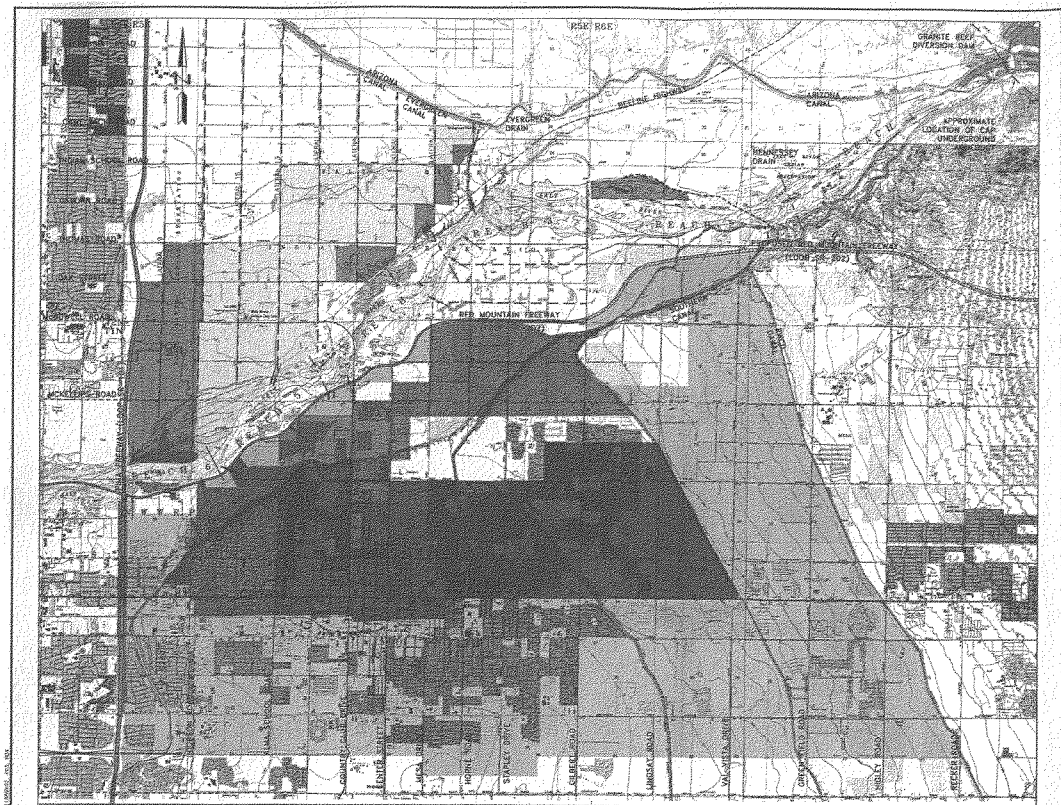


FIGURE 3-3
Average Annual Storm Drain Runoff for the Phoenix Metro Area

Source: U. S. Army Corps of Engineers' Rio Salado Project.

Drawings



LEGEND:

- SRPMIC LATERAL CANAL (3)
- SRP CANAL DRAIN
- REACH BOUNDARY
- STORM DRAIN OUTFALL
- AGRICULTURAL OUTFALL
- RECHARGE PONDS
- PRICE FREEWAY LOCAL DRAINAGE (2)
- PRICE DRAIN (2)
- TEMPE WASTEWAY/ALMA SCHOOL STORM DRAIN (3)
- DOBSON ROAD STORM DRAIN (3)
- MCKELLIAN ROAD STORM DRAIN (2)
- COUNTRY CLUB/MCKELLIPS STORM DRAIN (2)
- WATER DRAINS INTO EITHER THE CYPRESS GOLF COURSE RESERVOIR OR THE SALT RIVER SAND AND ROCK RESERVOIR (1)
- WATER DRAINS DIRECTLY INTO SALT RIVER (1)
- RED MOUNTAIN FREEWAY LOCAL DRAINAGE

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTHWEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT

REFERENCE:
1) FOSDYCK ASSOCIATES, INC., WELLFIELD MANAGEMENT PROGRAM, RECOMMENDATIONS AND CON PIMA AREAS FOR SIZING OF SCHOOL WELLS AND/OR MODIFICATION OF EXISTING WELLS AT SCHOOLS WELLS, FINAL REPORT.
2) VISTA TECH, INC., CITY OF MESA, ARIZONA AND SURROUNDING AREAS, DIGITIZED STORM DRAINAGE SYSTEM, SEPTEMBER 1990.

FOSDYCK ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

REV	DATE	DESCRIPTION	APP'D BY
C	7/15/02	ISSUED FOR FINAL REPORT	MA
B	5/24/02	ISSUED FOR REVIEW	MA
A	5/09/02	ISSUED FOR REVIEW	MCS

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29810 JAMES R. KUNKEL 07/15/02 REGISTERED PROFESSIONAL ENGINEER ARIZONA U.S.A.

CLIENT: SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PROJECT: SALT RIVER RESTORATION FEASIBILITY STUDY

TITLE: INTERIOR DRAINAGE MAP

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY	DRAWING No.	REV.
DRAWN BY	MA	APPROVED BY	1889M05C – 100	C

Appendix A

Evergreen Drain
Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	94.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	11.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.71
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.96
9	0.00	0.00	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.19	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	112.58	5.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.11	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	2.00	185.83	9.17	0.00	0.00	0.00	118.08	87.82	0.00	0.00	0.00	32.67
Count	1	3	1	0	0	0	2	7	0	0	0	2
Average	0.06	6.41	0.30	0.00	0.00	0.00	3.81	2.83	0.00	0.00	0.00	1.05
Maximum	2.00	94.50	9.17	0.00	0.00	0.00	112.58	60.19	0.00	0.00	0.00	21.71
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	187.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	22.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.06
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	3.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.74
9	0.00	0.00	18.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	158.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	119.39	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.17	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	223.30	9.92	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.92	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.14	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.18	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.49	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	10.91	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	3.97	368.59	18.19	0.00	0.00	0.00	234.21	174.19	0.00	0.00	0.00	64.80
Count	1	3	1	0	0	0	2	7	0	0	0	2
Average	0.13	12.71	0.59	0.00	0.00	0.00	7.56	5.62	0.00	0.00	0.00	2.09
Maximum	3.97	187.44	18.19	0.00	0.00	0.00	223.30	119.39	0.00	0.00	0.00	43.06
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.64	0.00	18.79	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.21	0.00	0.24	0.00	0.00
8	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00
9	0.50	0.00	0.00	0.00	0.00	0.00	0.00	12.36	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.50	0.00	0.00	0.00	0.00
11	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.21	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.10	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.51	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.06	0.00
17	9.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	31.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	78.44	0.00	0.00	0.00	0.00	18.23	0.00	0.00	0.00	0.00
28	0.00	0.00	17.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		7.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.14		0.00		0.00	0.00		0.00		0.00
Total	13.95	0.00	135.33	0.00	0.00	0.00	0.00	70.37	0.00	19.03	293.88	0.00
Count	4	0	6	0	0	0	0	6	0	2	5	0
Average	0.45	0.00	4.37	0.00	0.00	0.00	0.00	2.27	0.00	0.61	9.80	0.00
Maximum	9.57	0.00	78.44	0.00	0.00	0.00	0.00	23.50	0.00	18.79	185.51	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.10	0.00	37.27	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.33	0.00	0.48	0.00	0.00
8	3.93	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
9	0.99	0.00	0.00	0.00	0.00	0.00	0.00	24.52	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.61	0.00	0.00	0.00	0.00
11	3.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.28	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.49	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	367.95	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.34	0.00
17	18.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.83	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	62.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	155.58	0.00	0.00	0.00	0.00	36.16	0.00	0.00	0.00	0.00
28	0.00	0.00	35.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		14.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.28		0.00		0.00	0.00		0.00		0.00
Total	27.67	0.00	268.42	0.00	0.00	0.00	0.00	139.58	0.00	37.75	582.90	0.00
Count	4	0	6	0	0	0	0	6	0	2	5	0
Average	0.89	0.00	8.66	0.00	0.00	0.00	0.00	4.50	0.00	1.22	19.43	0.00
Maximum	18.98	0.00	155.58	0.00	0.00	0.00	0.00	46.61	0.00	37.27	367.95	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	36.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	21.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	124.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	118.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	17.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	4.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.07	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	296.23	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00
Count	6	1	0	0	1	0	0	0	1	0	0	0
Average	9.56	0.06	0.00	0.00	1.18	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Maximum	124.02	1.61	0.00	0.00	36.61	0.00	0.00	0.00	27.07	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	72.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	42.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	245.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	235.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	35.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	19.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	8.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.69	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	587.56	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00
Count	6	1	0	0	1	0	0	0	1	0	0	0
Average	18.95	0.11	0.00	0.00	2.34	0.00	0.00	0.00	1.79	0.00	0.00	0.00
Maximum	245.99	3.19	0.00	0.00	72.61	0.00	0.00	0.00	53.69	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	1	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.44	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.34	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
Count	0	0	0	0	0	0	0	0	1	0	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.72	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	621.50	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	58.83	8.48	120.19	142.98	33.17	36.31	2.64	124.20	50.37	134.65
2	0.00	24.91	6.67	14.33	124.76	150.41	39.23	37.22	2.58	124.67	96.64	132.88
3	90.33	43.29	6.77	8.55	125.86	76.03	39.40	36.74	21.81	124.74	116.05	131.93
4	0.00	85.10	6.90	8.16	125.28	27.15	39.75	36.43	38.15	124.53	143.33	131.34
5	0.00	104.51	127.33	31.40	125.36	26.03	38.01	36.56	38.46	125.48	144.56	131.46
6	0.00	106.24	131.59	31.23	125.10	25.60	37.03	37.23	38.53	144.00	143.07	130.95
7	0.00	105.44	132.53	31.63	125.67	25.30	37.00	37.13	37.96	142.32	155.35	130.51
8	0.00	0.00	133.49	31.25	124.79	26.26	36.91	48.02	38.91	142.93	150.01	130.55
9	22.91	0.00	137.63	30.80	125.34	26.75	37.64	52.92	65.09	144.22	149.61	130.25
10	22.62	0.00	137.57	29.69	126.02	47.55	37.35	52.27	80.76	143.01	150.40	131.12
11	22.74	0.00	135.12	29.54	124.76	55.32	36.58	53.03	79.58	169.50	151.86	131.71
12	22.08	0.00	81.62	29.95	126.41	55.38	37.47	52.92	79.53	179.84	151.69	131.04
13	22.93	0.00	6.07	29.80	124.93	54.36	36.58	51.59	79.87	183.88	151.35	130.06
14	23.59	0.00	7.15	30.01	125.46	53.66	37.84	58.52	79.80	189.13	152.50	130.48
15	24.13	0.00	7.19	31.56	124.56	54.90	37.71	54.39	79.15	183.75	160.60	130.08
16	24.31	0.00	7.24	30.71	124.44	54.36	36.60	53.84	95.69	181.26	157.44	130.82
17	22.71	0.00	7.06	30.81	125.20	55.49	38.02	52.02	117.71	177.94	151.57	131.15
18	23.79	0.00	7.21	30.10	126.43	55.13	37.48	52.36	124.41	179.41	151.72	130.87
19	23.62	0.00	7.16	0.00	125.91	54.45	37.52	52.13	123.42	177.78	153.82	130.23
20	22.78	0.00	7.23	0.00	125.26	55.20	37.64	53.34	122.83	177.97	155.18	131.22
21	22.47	0.00	6.83	0.00	125.82	54.53	37.85	53.42	123.34	188.94	152.71	131.51
22	22.47	0.00	22.98	0.00	125.84	55.57	38.30	39.09	124.48	195.76	151.70	142.09
23	22.37	0.00	9.09	0.00	125.04	56.19	38.75	55.96	124.36	196.07	151.60	155.24
24	0.00	0.00	8.59	0.00	122.92	55.99	43.98	55.56	125.47	86.90	147.22	129.11
25	0.00	0.00	8.62	0.00	123.02	55.28	37.98	13.92	125.04	41.41	142.91	129.13
26	0.00	0.00	8.64	0.00	123.92	55.83	38.23	3.49	132.58	136.72	141.96	128.50
27	0.00	19.15	8.58	0.00	122.55	56.08	37.06	3.45	127.81	211.57	141.88	126.87
28	0.00	118.13	7.92	0.00	121.73	56.08	36.29	3.15	125.81	210.97	154.71	125.88
29	184.27		8.44	0.00	104.69	51.74	37.29	2.56	124.97	209.95	169.64	129.00
30	177.68		8.21	0.00	123.22	26.84	37.53	2.79	124.29	207.94	171.74	130.38
31	0.00		8.19		122.41		36.93	1.46		62.85		131.49
Total	797.80	606.77	1,258.45	468.00	3,842.89	1,646.44	1,169.12	1,179.82	2,605.03	4,889.64	4,363.19	4,082.50
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69
Maximum	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24
Minimum	0.00	0.00	6.07	0.00	104.69	25.30	33.17	1.46	2.58	41.41	50.37	125.88

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	116.69	16.82	238.39	283.60	65.79	72.02	5.24	246.35	99.91	267.07
2	0.00	49.41	13.23	28.42	247.46	298.33	77.81	73.82	5.12	247.28	191.68	263.56
3	179.17	85.86	13.43	16.96	249.64	150.80	78.15	72.87	43.26	247.42	230.18	261.68
4	0.00	168.79	13.69	16.19	248.49	53.85	78.84	72.26	75.67	247.00	284.29	260.51
5	0.00	207.29	252.56	62.28	248.65	51.63	75.39	72.52	76.28	248.89	286.73	260.75
6	0.00	210.72	261.00	61.94	248.13	50.78	73.45	73.84	76.42	285.62	283.78	259.74
7	0.00	209.14	262.87	62.74	249.26	50.18	73.39	73.65	75.29	282.29	308.13	258.86
8	0.00	0.00	264.77	61.98	247.52	52.09	73.21	95.25	77.18	283.50	297.54	258.94
9	45.44	0.00	272.99	61.09	248.61	53.06	74.66	104.97	129.10	286.06	296.75	258.35
10	44.87	0.00	272.87	58.89	249.96	94.31	74.08	103.68	160.19	283.66	298.31	260.07
11	45.10	0.00	268.01	58.59	247.46	109.73	72.56	105.18	157.84	336.20	301.21	261.24
12	43.80	0.00	161.89	59.40	250.73	109.84	74.32	104.97	157.75	356.71	300.87	259.91
13	45.48	0.00	12.04	59.11	247.80	107.82	72.56	102.33	158.42	364.72	300.20	257.97
14	46.79	0.00	14.18	59.52	248.85	106.43	75.05	116.07	158.28	375.13	302.48	258.80
15	47.86	0.00	14.26	62.60	247.06	108.89	74.80	107.88	156.99	364.46	318.55	258.01
16	48.22	0.00	14.36	60.91	246.82	107.82	72.60	106.79	189.80	359.52	312.28	259.48
17	45.04	0.00	14.00	61.11	248.33	110.06	75.41	103.18	233.47	352.94	300.63	260.13
18	47.19	0.00	14.30	59.70	250.77	109.35	74.34	103.85	246.76	355.85	300.93	259.58
19	46.85	0.00	14.20	0.00	249.74	108.00	74.42	103.40	244.80	352.62	305.10	258.31
20	45.18	0.00	14.34	0.00	248.45	109.49	74.66	105.80	243.63	353.00	307.80	260.27
21	44.57	0.00	13.55	0.00	249.56	108.16	75.07	105.96	244.64	374.76	302.90	260.85
22	44.57	0.00	45.58	0.00	249.60	110.22	75.97	77.53	246.90	388.28	300.89	281.83
23	44.37	0.00	18.03	0.00	248.01	111.45	76.86	111.00	246.66	388.90	300.69	307.91
24	0.00	0.00	17.04	0.00	243.81	111.05	87.23	110.20	248.87	172.36	292.01	256.09
25	0.00	0.00	17.10	0.00	244.01	109.65	75.33	27.61	248.01	82.14	283.46	256.13
26	0.00	0.00	17.14	0.00	245.79	110.74	75.83	6.92	262.97	271.18	281.57	254.88
27	0.00	37.98	17.02	0.00	243.07	111.23	73.51	6.84	253.51	419.64	281.41	251.64
28	0.00	234.31	15.71	0.00	241.45	111.23	71.98	6.25	249.54	418.45	306.86	249.68
29	365.49		16.74	0.00	207.65	102.62	73.96	5.08	247.87	416.43	336.48	255.87
30	352.42		16.28	0.00	244.40	53.24	74.44	5.53	246.53	412.44	340.64	258.60
31	0.00		16.24		242.80		73.25	2.90		124.66		260.81
Total	1,582.41	1,203.51	2,496.10	928.26	7,622.26	3,265.67	2,318.92	2,340.14	5,167.00	9,698.46	8,654.26	8,097.52
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21
Maximum	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91
Minimum	0.00	0.00	12.04	0.00	207.65	50.18	65.79	2.90	5.12	82.14	99.91	249.68

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	2.18	0.00	4.16	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	11.58	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	139.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	125.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	27.36	0.00	81.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	1.37	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	11.03	0.00	0.00	0.00	0.00	0.00	11.57	0.00	0.00	0.00	0.00
18	0.00	4.21	0.00	0.00	0.00	0.00	0.00	22.10	0.00	0.00	0.00	0.00
19	0.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	4.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	44.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	44.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	36.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.08	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		70.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	100.60	152.68	347.02	0.00	0.00	13.76	33.67	4.16	0.00	0.00	0.00
Count	0	12	4	4	0	0	2	2	1	0	0	0
Average	0.00	3.59	4.93	11.57	0.00	0.00	0.44	1.09	0.14	0.00	0.00	0.00
Maximum	0.00	44.37	70.39	139.41	0.00	0.00	11.58	22.10	4.16	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	4.32	0.00	8.25	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	22.97	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	276.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	249.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	54.27	0.00	161.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	2.72	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	21.88	0.00	0.00	0.00	0.00	0.00	22.95	0.00	0.00	0.00	0.00
18	0.00	8.35	0.00	0.00	0.00	0.00	0.00	43.83	0.00	0.00	0.00	0.00
19	0.00	3.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	3.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	3.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	9.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	88.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	88.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	73.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.16	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		139.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	199.54	302.84	688.30	0.00	0.00	27.29	66.78	8.25	0.00	0.00	0.00
Count	0	12	4	4	0	0	2	2	1	0	0	0
Average	0.00	7.13	9.77	22.94	0.00	0.00	0.88	2.15	0.28	0.00	0.00	0.00
Maximum	0.00	88.01	139.62	276.52	0.00	0.00	22.97	43.83	8.25	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	36.59	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	12.48	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.85	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.03	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	39.11		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	49.07	39.11	0.00	21.88	0.00	0.00
Count	0	0	0	0	0	0	2	1	0	2	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.26	0.00	0.71	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	36.59	39.11	0.00	11.03	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	72.58	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	24.75	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.52	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.88	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	77.57		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	97.33	77.57	0.00	43.40	0.00	0.00
Count	0	0	0	0	0	0	2	1	0	2	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	3.14	2.50	0.00	1.40	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	72.58	77.57	0.00	21.88	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	4.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	9.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	14.36	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
Count	2	0	1	0	0	0	0	0	0	1	0	0
Average	0.46	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.63	0.00	0.00
Maximum	9.73	0.00	22.38	0.00	0.00	0.00	0.00	0.00	0.00	50.66	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	19.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	28.48	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
Count	2	0	1	0	0	0	0	0	0	1	0	0
Average	0.92	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.00
Maximum	19.30	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00	100.48	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	7.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.00	1.75	0.00
3	0.00	0.00	0.00	0.00	0.00	6.75	7.50	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	2.25	3.33	0.00	0.00	0.00	0.00	17.03
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	7.50	0.00	0.00	61.47
6	0.00	0.00	0.00	0.00	0.00	7.66	0.00	2.50	2.50	0.00	5.25	0.00
7	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.00	0.00	3.75	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	3.18	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
12	0.00	0.00	0.00	0.00	0.00	17.50	8.75	0.00	0.00	5.25	6.00	0.50
13	0.00	0.00	0.00	0.00	0.00	7.33	2.55	0.00	0.00	1.75	2.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	7.50	7.50	0.00	3.75
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	3.13	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	3.75	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00
20	0.00	0.00	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	6.61	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	3.75
25	0.00	0.00	0.00	0.00	0.00	0.00	7.50	0.00	10.91	0.00	0.18	1.25
26	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	3.75	0.00
27	0.00	0.00	0.00	0.00	14.00	0.00	0.00	6.00	0.00	0.00	1.25	0.00
28	0.00	0.00	0.00	0.00	4.49	0.00	0.00	2.00	0.00	6.00	3.75	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.25	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		4.50		0.00
Total	0.00	0.00	0.00	0.00	18.49	63.94	44.64	36.00	30.91	42.06	37.18	90.52
Count	0	0	0	0	2	8	9	8	5	11	12	7
Average	0.00	0.00	0.00	0.00	0.60	2.13	1.44	1.16	1.03	1.36	1.24	2.92
Maximum	0.00	0.00	0.00	0.00	14.00	17.50	8.75	7.50	10.91	7.50	7.00	61.47
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

EVERGREEN DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	11.17	0.00	0.00	0.00	13.88	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	3.73	0.00	0.00	0.00	3.47	0.00
3	0.00	0.00	0.00	0.00	0.00	13.39	14.88	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	4.46	6.60	0.00	0.00	0.00	0.00	33.78
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.88	14.88	0.00	0.00	121.92
6	0.00	0.00	0.00	0.00	0.00	15.23	0.00	4.96	4.96	0.00	10.41	0.00
7	0.00	0.00	0.00	0.00	0.00	5.79	0.00	0.00	0.00	7.44	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.90	0.00	6.31	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.49
12	0.00	0.00	0.00	0.00	0.00	34.71	17.36	0.00	0.00	10.41	11.90	0.99
13	0.00	0.00	0.00	0.00	0.00	14.54	5.06	0.00	0.00	3.47	3.97	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.88	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	14.88	14.88	0.00	7.44
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	6.21	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	9.92	0.00	0.00	0.00	7.44	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.48	0.00
20	0.00	0.00	0.00	0.00	0.00	25.59	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	13.11	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	7.44
25	0.00	0.00	0.00	0.00	0.00	0.00	14.88	0.00	21.64	0.00	0.36	2.48
26	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	0.00	0.00	7.44	0.00
27	0.00	0.00	0.00	0.00	27.77	0.00	0.00	11.90	0.00	0.00	2.48	0.00
28	0.00	0.00	0.00	0.00	8.91	0.00	0.00	3.97	0.00	11.90	7.44	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	2.48	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		8.93		0.00
Total	0.00	0.00	0.00	0.00	36.67	126.82	88.54	71.40	61.31	83.42	73.75	179.54
Count	0	0	0	0	2	8	9	8	5	11	12	7
Average	0.00	0.00	0.00	0.00	1.18	4.23	2.86	2.30	2.04	2.69	2.46	5.79
Maximum	0.00	0.00	0.00	0.00	27.77	34.71	17.36	14.88	21.64	14.88	13.88	121.92
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix B

Hennessey Drain
Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.04
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.95
6	26.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	80.83	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	157.33	0.00	12.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	6.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	6.29	0.00	0.00	2.11	0.00	0.00	0.00	0.00
12	35.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	15.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.62	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	59.19	0.00	0.00	17.17	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	7.17	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	8.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.57	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	8.96	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	299.83	4.00	27.42	15.63	6.29	0.00	75.32	137.30	0.00	17.17	0.00	60.99
Count	4	1	3	1	1	0	3	3	0	1	0	2
Average	9.67	0.14	0.88	0.52	0.20	0.00	2.43	4.43	0.00	0.55	0.00	1.97
Maximum	157.33	4.00	12.30	15.63	6.29	0.00	59.19	92.62	0.00	17.17	0.00	48.04
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.29
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.69
6	51.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	160.32	7.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	312.06	0.00	24.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	13.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	12.48	0.00	0.00	4.19	0.00	0.00	0.00	0.00
12	70.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	31.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	183.71	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	117.40	0.00	0.00	34.06	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	14.22	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	16.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.44	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	17.77	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	594.70	7.93	54.39	31.00	12.48	0.00	149.40	272.33	0.00	34.06	0.00	120.97
Count	4	1	3	1	1	0	3	3	0	1	0	2
Average	19.18	0.27	1.75	1.03	0.40	0.00	4.82	8.78	0.00	1.10	0.00	3.90
Maximum	312.06	7.93	24.40	31.00	12.48	0.00	117.40	183.71	0.00	34.06	0.00	95.29
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	169.25	59.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	138.20	38.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	29.27	0.00	0.00	127.51	0.00	0.00	0.00	0.00	0.00	37.58	0.00	0.00
4	753.89	0.00	0.00	115.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	845.89	0.00	0.00	98.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	832.96	0.00	0.00	53.05	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00
7	467.34	0.00	0.00	87.03	0.00	0.00	0.00	11.81	0.00	0.00	0.00	0.00
8	44.98	0.00	0.00	63.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	25.93	0.00	129.06	52.55	0.93	0.00	0.00	15.49	0.00	0.00	0.00	0.00
10	0.00	0.00	78.86	75.88	37.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	41.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	35.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	67.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	32.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	48.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	44.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	47.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	61.60	0.00	0.00	0.00	8.74	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	63.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	15.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.44	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	8.95	17.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	24.60	4.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	34.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	21.90	36.14	0.00	0.00	0.00	33.75	0.00	0.00	0.00	0.00
28	0.00	0.00	17.90	28.07	0.00	0.00	130.19	0.00	0.00	0.00	0.00	0.00
29	0.00		25.10	29.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		53.70	43.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		11.41		0.00		0.00	0.00		0.00		0.00
Total	3,000.26	0.00	337.93	1,644.36	158.12	0.00	130.19	90.83	0.00	37.58	0.00	0.00
Count	7	0	7	27	6	0	1	6	0	1	0	0
Average	96.78	0.00	10.90	54.81	5.10	0.00	4.20	2.93	0.00	1.21	0.00	0.00
Maximum	845.89	0.00	129.06	169.25	59.09	0.00	130.19	33.75	0.00	37.58	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	335.70	117.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	274.12	76.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	58.06	0.00	0.00	252.91	0.00	0.00	0.00	0.00	0.00	74.54	0.00	0.00
4	1,495.32	0.00	0.00	229.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1,677.80	0.00	0.00	194.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1,652.15	0.00	0.00	105.22	0.00	0.00	0.00	5.16	0.00	0.00	0.00	0.00
7	926.96	0.00	0.00	172.62	0.00	0.00	0.00	23.42	0.00	0.00	0.00	0.00
8	89.22	0.00	0.00	126.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	51.43	0.00	255.99	104.23	1.84	0.00	0.00	30.72	0.00	0.00	0.00	0.00
10	0.00	0.00	156.42	150.51	75.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	81.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	70.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	133.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	64.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	96.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	87.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	94.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	122.18	0.00	0.00	0.00	17.34	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	126.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	30.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.58	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	17.75	34.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	48.79	8.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	68.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	43.44	71.68	0.00	0.00	0.00	66.94	0.00	0.00	0.00	0.00
28	0.00	0.00	35.50	55.68	0.00	0.00	258.23	0.00	0.00	0.00	0.00	0.00
29	0.00		49.79	58.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		106.51	86.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		22.63		0.00		0.00	0.00		0.00		0.00
Total	5,950.93	0.00	670.27	3,261.54	313.63	0.00	258.23	180.16	0.00	74.54	0.00	0.00
Count	7	0	7	27	6	0	1	6	0	1	0	0
Average	191.97	0.00	21.62	108.72	10.12	0.00	8.33	5.81	0.00	2.40	0.00	0.00
Maximum	1,677.80	0.00	255.99	335.70	117.20	0.00	258.23	66.94	0.00	74.54	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	32.98	227.59	195.23	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	136.76	228.83	194.65	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	171.61	231.58	196.38	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	176.44	218.47	193.77	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	196.59	202.50	193.62	0.00	0.00	0.00
6	21.14	0.00	0.00	0.00	0.00	0.00	227.23	201.61	194.35	0.00	0.00	0.00
7	28.25	0.00	0.00	0.00	0.00	0.00	231.35	210.78	196.95	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	233.80	210.85	196.88	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	234.41	211.75	193.88	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	231.87	207.53	203.49	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	231.53	193.10	203.01	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	227.86	185.82	191.99	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	231.56	198.72	191.51	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	229.31	206.06	197.82	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	194.02	221.11	219.76	15.53	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	167.36	226.49	207.55	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	164.64	223.60	205.71	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	163.40	196.81	212.32	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	163.43	163.82	219.16	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	27.31	176.85	174.75	240.14	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	40.37	189.01	159.20	199.28	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	41.55	194.88	168.75	184.87	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	107.06	192.87	179.66	189.46	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	16.60	210.66	206.49	179.29	202.61	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	19.90	217.68	216.78	183.53	209.33	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	199.70	216.60	182.96	233.96	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	196.11	219.46	202.87	180.07	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	114.79	230.95	190.86	51.59	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	230.41	193.76	24.17	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	229.38	189.09	17.95	0.00	0.00	0.00
31	0.00		0.00		0.00		226.09	196.26		0.00		0.00
Total	49.39	0.00	0.00	0.00	36.50	1,155.23	6,175.92	6,168.00	5,541.46	15.53	0.00	0.00
Count	2	0	0	0	2	9	31	31	30	1	0	0
Average	1.59	0.00	0.00	0.00	1.18	38.51	199.22	198.97	184.72	0.50	0.00	0.00
Maximum	28.25	0.00	0.00	0.00	19.90	217.68	234.41	231.58	240.14	15.53	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	32.98	159.20	17.95	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	65.41	451.42	387.23	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	271.26	453.88	386.08	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	340.38	459.33	389.51	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	349.96	433.33	384.34	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	389.93	401.65	384.04	0.00	0.00	0.00
6	41.93	0.00	0.00	0.00	0.00	0.00	450.70	399.89	385.49	0.00	0.00	0.00
7	56.03	0.00	0.00	0.00	0.00	0.00	458.88	418.08	390.64	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	463.74	418.21	390.51	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	464.95	420.00	384.56	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	459.91	411.63	403.62	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	459.23	383.01	402.66	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	451.95	368.57	380.81	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	459.29	394.16	379.85	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	454.83	408.71	392.37	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	384.83	438.57	435.89	30.80	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	331.95	449.24	411.67	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	326.56	443.50	408.02	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	324.10	390.37	421.13	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	324.16	324.93	434.70	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	54.17	350.78	346.61	476.31	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	80.07	374.90	315.77	395.27	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	82.41	386.54	334.71	366.68	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	212.35	382.55	356.35	375.79	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	32.93	417.84	409.57	355.62	401.87	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	39.47	431.76	429.98	364.03	415.20	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	396.10	429.62	362.90	464.05	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	388.98	435.29	402.39	357.16	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	227.68	458.08	378.57	102.33	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	457.01	384.32	47.94	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	454.97	375.05	35.60	0.00	0.00	0.00
31	0.00		0.00		0.00		448.44	389.28		0.00		0.00
Total	97.96	0.00	0.00	0.00	72.40	2,291.37	12,249.76	12,234.05	10,991.33	30.80	0.00	0.00
Count	2	0	0	0	2	9	31	31	30	1	0	0
Average	3.16	0.00	0.00	0.00	2.34	76.38	395.15	394.65	366.38	0.99	0.00	0.00
Maximum	56.03	0.00	0.00	0.00	39.47	431.76	464.95	459.33	476.31	30.80	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	65.41	315.77	35.60	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	120.35	0.00	0.00	0.00	185.37	132.80	136.16	133.94	97.76	127.57	174.02
2	0.00	119.29	0.00	0.00	0.00	186.11	132.36	136.79	118.12	101.48	130.32	179.35
3	0.00	121.61	0.00	0.00	0.00	190.55	151.19	134.49	116.19	98.34	129.97	103.80
4	25.74	114.98	0.00	0.00	24.02	190.10	156.15	135.87	113.21	97.91	129.90	0.00
5	109.32	135.29	0.00	0.00	35.03	154.22	154.56	136.30	114.26	96.42	128.82	0.00
6	200.76	146.87	0.00	0.00	68.85	139.18	165.89	135.07	112.62	100.55	144.93	0.00
7	209.14	144.75	0.00	0.00	84.97	134.14	162.34	133.40	110.36	98.73	154.56	0.00
8	214.06	145.13	0.00	0.00	116.37	128.84	164.51	137.02	103.86	101.54	130.03	0.00
9	208.48	143.22	0.00	0.00	131.35	136.36	164.72	139.07	107.16	100.71	154.83	0.00
10	207.94	143.09	0.00	0.00	133.85	139.71	168.47	138.80	104.45	111.18	144.32	0.00
11	228.34	145.83	0.00	0.00	134.89	134.83	168.44	137.74	106.29	118.37	147.68	0.00
12	247.51	143.69	0.00	0.00	135.59	135.65	165.27	136.02	106.25	116.40	150.54	0.00
13	207.70	142.72	0.00	0.00	133.57	170.54	166.53	134.22	105.91	118.77	158.77	0.00
14	185.38	92.52	0.00	0.00	134.49	193.05	147.82	131.68	107.76	119.07	0.00	0.00
15	181.27	0.00	0.00	0.00	132.52	187.88	135.03	136.41	106.65	116.32	0.00	0.00
16	198.96	0.00	0.00	0.00	132.53	193.15	132.49	136.10	105.83	114.44	0.00	0.00
17	38.09	0.00	0.00	0.00	168.69	185.53	132.99	135.74	105.37	115.53	104.60	0.00
18	156.48	0.00	0.00	0.00	183.07	190.45	129.80	138.61	103.78	116.36	120.03	0.00
19	195.50	0.00	0.00	0.00	191.03	168.06	129.67	142.44	108.69	111.99	121.78	0.00
20	194.49	0.00	0.00	0.00	188.36	157.40	129.72	145.31	105.47	93.35	139.42	0.00
21	185.49	0.00	0.00	0.00	191.38	141.49	133.08	142.78	107.90	0.00	141.73	0.00
22	184.14	0.00	0.00	0.00	193.26	130.61	136.05	144.29	108.13	0.00	145.99	0.00
23	189.27	0.00	0.00	0.00	189.75	130.27	135.04	149.66	105.92	0.00	143.55	0.00
24	139.37	0.00	0.00	0.00	189.73	128.15	134.22	153.93	104.96	0.00	142.69	92.81
25	117.15	0.00	0.00	0.00	189.70	128.21	138.09	160.84	104.67	0.00	147.10	203.24
26	92.17	0.00	0.00	0.00	187.91	130.18	134.22	160.10	102.71	0.00	138.70	205.52
27	90.01	0.00	0.00	0.00	190.28	130.95	135.86	162.92	101.36	0.00	137.27	210.80
28	90.54	0.00	0.00	0.00	194.06	130.65	138.22	165.00	102.80	0.00	140.26	207.03
29	92.08		0.00	0.00	186.49	134.68	136.69	163.03	102.18	57.32	139.39	207.78
30	92.74		0.00	0.00	187.99	132.51	137.23	154.31	101.51	114.08	161.25	210.10
31	101.16		0.00		186.79		136.82	152.97		129.01		216.07
Total	4,383.28	1,859.34	0.00	0.00	4,216.52	4,618.82	4,486.27	4,447.07	3,238.31	2,445.63	3,756.00	2,010.52
Count	28	14	0	0	28	30	31	31	30	23	27	11
Average	141.40	66.41	0.00	0.00	136.02	153.96	144.72	143.45	107.94	78.89	125.20	64.86
Maximum	247.51	146.87	0.00	0.00	194.06	193.15	168.47	165.00	133.94	129.01	161.25	216.07
Minimum	0.00	0.00	0.00	0.00	0.00	128.15	129.67	131.68	101.36	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	238.71	0.00	0.00	0.00	367.68	263.40	270.07	265.67	193.90	253.03	345.16
2	0.00	236.61	0.00	0.00	0.00	369.14	262.53	271.32	234.29	201.28	258.49	355.74
3	0.00	241.21	0.00	0.00	0.00	377.95	299.88	266.76	230.46	195.05	257.79	205.88
4	51.05	228.06	0.00	0.00	47.64	377.06	309.72	269.49	224.55	194.20	257.65	0.00
5	216.83	268.34	0.00	0.00	69.48	305.89	306.57	270.35	226.63	191.25	255.51	0.00
6	398.20	291.31	0.00	0.00	136.56	276.06	329.04	267.91	223.38	199.44	287.46	0.00
7	414.82	287.11	0.00	0.00	168.54	266.06	322.00	264.60	218.90	195.83	306.57	0.00
8	424.58	287.86	0.00	0.00	230.82	255.55	326.30	271.78	206.00	201.40	257.91	0.00
9	413.51	284.07	0.00	0.00	260.53	270.47	326.72	275.84	212.55	199.76	307.10	0.00
10	412.44	283.81	0.00	0.00	265.49	277.11	334.16	275.31	207.17	220.52	286.25	0.00
11	452.91	289.25	0.00	0.00	267.55	267.43	334.10	273.20	210.82	234.78	292.92	0.00
12	490.93	285.00	0.00	0.00	268.94	269.06	327.81	269.79	210.74	230.88	298.59	0.00
13	411.97	283.08	0.00	0.00	264.93	338.26	330.31	266.22	210.07	235.58	314.92	0.00
14	367.70	183.51	0.00	0.00	266.76	382.91	293.20	261.18	213.74	236.17	0.00	0.00
15	359.54	0.00	0.00	0.00	262.85	372.65	267.83	270.57	211.54	230.72	0.00	0.00
16	394.63	0.00	0.00	0.00	262.87	383.11	262.79	269.95	209.91	226.99	0.00	0.00
17	75.55	0.00	0.00	0.00	334.59	367.99	263.78	269.24	209.00	229.15	207.47	0.00
18	310.37	0.00	0.00	0.00	363.11	377.75	257.45	274.93	205.84	230.80	238.08	0.00
19	387.77	0.00	0.00	0.00	378.90	333.34	257.20	282.53	215.58	222.13	241.55	0.00
20	385.77	0.00	0.00	0.00	373.61	312.20	257.30	288.22	209.20	185.16	276.54	0.00
21	367.91	0.00	0.00	0.00	379.60	280.64	263.96	283.20	214.02	0.00	281.12	0.00
22	365.24	0.00	0.00	0.00	383.33	259.06	269.85	286.20	214.47	0.00	289.57	0.00
23	375.41	0.00	0.00	0.00	376.36	258.39	267.85	296.85	210.09	0.00	284.73	0.00
24	276.44	0.00	0.00	0.00	376.32	254.18	266.22	305.32	208.19	0.00	283.02	184.09
25	232.36	0.00	0.00	0.00	376.26	254.30	273.90	319.02	207.61	0.00	291.77	403.12
26	182.82	0.00	0.00	0.00	372.71	258.21	266.22	317.55	203.72	0.00	275.11	407.64
27	178.53	0.00	0.00	0.00	377.41	259.74	269.47	323.15	201.04	0.00	272.27	418.12
28	179.58	0.00	0.00	0.00	384.91	259.14	274.16	327.27	203.90	0.00	278.20	410.64
29	182.64		0.00	0.00	369.90	267.13	271.12	323.37	202.67	113.69	276.48	412.13
30	183.95		0.00	0.00	372.87	262.83	272.19	306.07	201.34	226.27	319.83	416.73
31	200.65		0.00		370.49		271.38	303.41		255.89		428.57
Total	8,694.11	3,687.95	0.00	0.00	8,363.35	9,161.30	8,898.39	8,820.63	6,423.09	4,850.84	7,449.92	3,987.81
Count	28	14	0	0	28	30	31	31	30	23	27	11
Average	280.46	131.71	0.00	0.00	269.79	305.38	287.04	284.54	214.10	156.48	248.33	128.64
Maximum	490.93	291.31	0.00	0.00	384.91	383.11	334.16	327.27	265.67	255.89	319.83	428.57
Minimum	0.00	0.00	0.00	0.00	0.00	254.18	257.20	261.18	201.04	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	237.12	162.99	171.84	146.06	157.75	155.37	21.95	10.44	0.00	0.00	0.00	97.71
2	235.30	161.93	174.50	146.03	155.45	157.76	28.56	42.20	18.86	0.00	0.00	100.64
3	234.81	160.90	175.69	147.75	155.05	159.87	27.41	42.02	0.00	0.00	0.00	96.91
4	233.02	159.69	172.74	151.01	155.85	158.34	27.14	42.39	0.00	0.00	0.00	95.88
5	235.62	178.15	176.11	147.95	158.71	159.06	26.42	0.00	0.00	0.00	0.00	97.80
6	245.78	193.50	176.38	149.09	158.77	160.78	27.29	0.00	0.00	0.00	0.00	96.69
7	234.59	194.68	177.95	147.50	159.59	161.11	27.09	0.00	0.00	4.05	0.00	96.63
8	242.76	192.92	181.77	144.39	161.24	160.84	27.03	0.00	0.00	0.00	0.00	96.21
9	273.15	194.34	158.24	145.57	160.92	160.43	27.03	0.00	0.00	0.00	0.00	96.56
10	239.40	191.65	150.08	143.95	165.23	160.10	27.29	0.00	0.00	0.00	0.00	96.01
11	241.25	195.54	150.78	146.67	162.05	162.63	27.17	0.00	0.00	0.00	0.00	96.12
12	235.29	193.55	149.85	148.39	161.11	162.30	28.27	0.00	0.00	0.00	0.00	96.00
13	241.33	193.98	148.62	148.92	163.70	162.88	28.09	0.00	0.00	0.00	0.00	92.68
14	245.63	196.41	148.45	151.66	165.34	163.96	20.91	0.00	0.00	0.00	0.00	94.89
15	246.00	196.13	153.37	149.08	165.24	163.66	7.12	0.00	0.00	0.00	0.00	95.65
16	227.57	196.76	151.34	149.37	163.48	163.94	0.00	0.00	0.00	0.00	0.00	95.35
17	210.42	198.21	151.47	154.32	165.06	78.91	0.00	0.00	0.00	0.00	0.00	96.13
18	215.76	197.07	152.78	156.36	166.03	0.00	0.00	4.86	0.00	0.00	0.00	95.21
19	227.69	179.47	158.30	154.91	165.57	0.00	0.00	0.00	0.00	0.00	0.00	94.02
20	223.67	170.36	158.25	153.53	164.61	0.00	0.00	0.00	0.00	0.00	0.00	85.41
21	220.10	167.98	163.44	149.13	163.08	0.00	0.00	0.00	0.00	16.00	0.00	0.00
22	209.40	172.82	178.68	150.28	164.33	0.00	0.00	0.00	0.00	149.89	0.00	0.00
23	181.25	169.62	168.82	150.37	165.24	0.00	0.00	11.09	0.00	153.11	0.00	0.00
24	78.31	172.36	149.78	148.88	164.95	7.31	0.00	0.00	0.00	153.80	0.00	0.00
25	0.00	171.32	146.65	150.21	163.51	20.20	8.20	0.00	0.00	103.02	0.00	0.00
26	0.00	166.13	145.17	149.30	162.79	4.76	0.00	0.00	0.00	101.66	0.00	0.00
27	101.05	170.41	150.01	152.88	163.09	0.00	0.00	4.38	0.00	129.01	0.00	0.00
28	162.96	171.30	150.49	151.04	164.91	0.00	0.00	0.00	0.00	128.80	70.10	0.00
29	163.75	170.04	149.86	154.10	160.89	0.00	0.00	0.00	0.00	128.48	69.68	0.00
30	164.41		149.77	152.63	160.08	0.00	0.00	0.00	0.00	263.82	69.75	0.00
31	163.84		149.29		158.32		0.00	0.00		371.82		0.00
Total	6,171.23	5,240.21	4,940.47	4,491.33	5,021.94	2,684.21	386.97	157.38	18.86	1,703.46	209.53	1,912.50
Count	29	29	31	30	31	20	16	7	1	12	3	20
Average	199.07	180.70	159.37	149.71	162.00	89.47	12.48	5.08	0.63	54.95	6.98	61.69
Maximum	273.15	198.21	181.77	156.36	166.03	163.96	28.56	42.39	18.86	371.82	70.10	100.64
Minimum	0.00	159.69	145.17	143.95	155.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	470.32	323.29	340.84	289.71	312.89	308.17	43.54	20.71	0.00	0.00	0.00	193.80
2	466.71	321.18	346.12	289.65	308.33	312.91	56.65	83.70	37.41	0.00	0.00	199.62
3	465.74	319.14	348.48	293.06	307.54	317.10	54.37	83.35	0.00	0.00	0.00	192.22
4	462.19	316.74	342.62	299.52	309.12	314.06	53.83	84.08	0.00	0.00	0.00	190.18
5	467.35	353.36	349.31	293.45	314.80	315.49	52.40	0.00	0.00	0.00	0.00	193.98
6	487.50	383.80	349.84	295.72	314.92	318.90	54.13	0.00	0.00	0.00	0.00	191.78
7	465.30	386.14	352.96	292.56	316.54	319.56	53.73	0.00	0.00	8.03	0.00	191.66
8	481.51	382.65	360.54	286.39	319.81	319.02	53.61	0.00	0.00	0.00	0.00	190.83
9	541.79	385.47	313.86	288.73	319.18	318.21	53.61	0.00	0.00	0.00	0.00	191.52
10	474.84	380.13	297.68	285.52	327.73	317.55	54.13	0.00	0.00	0.00	0.00	190.43
11	478.51	387.85	299.07	290.92	321.42	322.57	53.89	0.00	0.00	0.00	0.00	190.65
12	466.69	383.90	297.22	294.33	319.56	321.92	56.07	0.00	0.00	0.00	0.00	190.41
13	478.67	384.75	294.78	295.38	324.69	323.07	55.72	0.00	0.00	0.00	0.00	183.83
14	487.20	389.57	294.45	300.81	327.95	325.21	41.47	0.00	0.00	0.00	0.00	188.21
15	487.93	389.02	304.20	295.70	327.75	324.61	14.12	0.00	0.00	0.00	0.00	189.72
16	451.38	390.27	300.18	296.27	324.26	325.17	0.00	0.00	0.00	0.00	0.00	189.12
17	417.36	393.14	300.44	306.09	327.39	156.52	0.00	0.00	0.00	0.00	0.00	190.67
18	427.95	390.88	303.03	310.14	329.32	0.00	0.00	9.64	0.00	0.00	0.00	188.85
19	451.62	355.97	313.98	307.26	328.40	0.00	0.00	0.00	0.00	0.00	0.00	186.49
20	443.64	337.90	313.88	304.52	326.50	0.00	0.00	0.00	0.00	0.00	0.00	169.41
21	436.56	333.18	324.18	295.80	323.46	0.00	0.00	0.00	0.00	31.74	0.00	0.00
22	415.34	342.78	354.41	298.08	325.94	0.00	0.00	0.00	0.00	297.30	0.00	0.00
23	359.50	336.44	334.85	298.25	327.75	0.00	0.00	22.00	0.00	303.69	0.00	0.00
24	155.33	341.87	297.08	295.30	327.17	14.50	0.00	0.00	0.00	305.06	0.00	0.00
25	0.00	339.81	290.88	297.94	324.32	40.07	16.26	0.00	0.00	204.34	0.00	0.00
26	0.00	329.51	287.94	296.13	322.89	9.44	0.00	0.00	0.00	201.64	0.00	0.00
27	200.43	338.00	297.54	303.23	323.48	0.00	0.00	8.69	0.00	255.89	0.00	0.00
28	323.23	339.77	298.49	299.58	327.09	0.00	0.00	0.00	0.00	255.47	139.04	0.00
29	324.79	337.27	297.24	305.65	319.12	0.00	0.00	0.00	0.00	254.84	138.21	0.00
30	326.10		297.06	302.74	317.51	0.00	0.00	0.00	0.00	523.28	138.35	0.00
31	324.97		296.11		314.02		0.00	0.00		737.49		0.00
Total	12,240.46	10,393.80	9,799.28	8,908.42	9,960.87	5,324.05	767.54	312.16	37.41	3,378.76	415.60	3,793.39
Count	29	29	31	30	31	20	16	7	1	12	3	20
Average	394.85	358.41	316.11	296.95	321.32	177.47	24.76	10.07	1.25	108.99	13.85	122.37
Maximum	541.79	393.14	360.54	310.14	329.32	325.21	56.65	84.08	37.41	737.49	139.04	199.62
Minimum	0.00	316.74	287.94	285.52	307.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	58.83	8.48	120.19	142.98	33.17	36.31	2.64	124.20	50.37	134.65
2	0.00	24.91	6.67	14.33	124.76	150.41	39.23	37.22	2.58	124.67	96.64	132.88
3	90.33	43.29	6.77	8.55	125.86	76.03	39.40	36.74	21.81	124.74	116.05	131.93
4	0.00	85.10	6.90	8.16	125.28	27.15	39.75	36.43	38.15	124.53	143.33	131.34
5	0.00	104.51	127.33	31.40	125.36	26.03	38.01	36.56	38.46	125.48	144.56	131.46
6	0.00	106.24	131.59	31.23	125.10	25.60	37.03	37.23	38.53	144.00	143.07	130.95
7	0.00	105.44	132.53	31.63	125.67	25.30	37.00	37.13	37.96	142.32	155.35	130.51
8	0.00	0.00	133.49	31.25	124.79	26.26	36.91	48.02	38.91	142.93	150.01	130.55
9	22.91	0.00	137.63	30.80	125.34	26.75	37.64	52.92	65.09	144.22	149.61	130.25
10	22.62	0.00	137.57	29.69	126.02	47.55	37.35	52.27	80.76	143.01	150.40	131.12
11	22.74	0.00	135.12	29.54	124.76	55.32	36.58	53.03	79.58	169.50	151.86	131.71
12	22.08	0.00	81.62	29.95	126.41	55.38	37.47	52.92	79.53	179.84	151.69	131.04
13	22.93	0.00	6.07	29.80	124.93	54.36	36.58	51.59	79.87	183.88	151.35	130.06
14	23.59	0.00	7.15	30.01	125.46	53.66	37.84	58.52	79.80	189.13	152.50	130.48
15	24.13	0.00	7.19	31.56	124.56	54.90	37.71	54.39	79.15	183.75	160.60	130.08
16	24.31	0.00	7.24	30.71	124.44	54.36	36.60	53.84	95.69	181.26	157.44	130.82
17	22.71	0.00	7.06	30.81	125.20	55.49	38.02	52.02	117.71	177.94	151.57	131.15
18	23.79	0.00	7.21	30.10	126.43	55.13	37.48	52.36	124.41	179.41	151.72	130.87
19	23.62	0.00	7.16	0.00	125.91	54.45	37.52	52.13	123.42	177.78	153.82	130.23
20	22.78	0.00	7.23	0.00	125.26	55.20	37.64	53.34	122.83	177.97	155.18	131.22
21	22.47	0.00	6.83	0.00	125.82	54.53	37.85	53.42	123.34	188.94	152.71	131.51
22	22.47	0.00	22.98	0.00	125.84	55.57	38.30	39.09	124.48	195.76	151.70	142.09
23	22.37	0.00	9.09	0.00	125.04	56.19	38.75	55.96	124.36	196.07	151.60	155.24
24	0.00	0.00	8.59	0.00	122.92	55.99	43.98	55.56	125.47	86.90	147.22	129.11
25	0.00	0.00	8.62	0.00	123.02	55.28	37.98	13.92	125.04	41.41	142.91	129.13
26	0.00	0.00	8.64	0.00	123.92	55.83	38.23	3.49	132.58	136.72	141.96	128.50
27	0.00	19.15	8.58	0.00	122.55	56.08	37.06	3.45	127.81	211.57	141.88	126.87
28	0.00	118.13	7.92	0.00	121.73	56.08	36.29	3.15	125.81	210.97	154.71	125.88
29	184.27		8.44	0.00	104.69	51.74	37.29	2.56	124.97	209.95	169.64	129.00
30	177.68		8.21	0.00	123.22	26.84	37.53	2.79	124.29	207.94	171.74	130.38
31	0.00		8.19		122.41		36.93	1.46		62.85		131.49
Total	797.80	606.77	1,258.45	468.00	3,842.89	1,646.44	1,169.12	1,179.82	2,605.03	4,889.64	4,363.19	4,082.50
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	25.74	21.67	40.60	15.60	123.96	54.88	37.71	38.06	86.83	157.73	145.44	131.69
Maximum	184.27	118.13	137.63	31.63	126.43	150.41	43.98	58.52	132.58	211.57	171.74	155.24
Minimum	0.00	0.00	6.07	0.00	104.69	25.30	33.17	1.46	2.58	41.41	50.37	125.88

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	116.69	16.82	238.39	283.60	65.79	72.02	5.24	246.35	99.91	267.07
2	0.00	49.41	13.23	28.42	247.46	298.33	77.81	73.82	5.12	247.28	191.68	263.56
3	179.17	85.86	13.43	16.96	249.64	150.80	78.15	72.87	43.26	247.42	230.18	261.68
4	0.00	168.79	13.69	16.19	248.49	53.85	78.84	72.26	75.67	247.00	284.29	260.51
5	0.00	207.29	252.56	62.28	248.65	51.63	75.39	72.52	76.28	248.89	286.73	260.75
6	0.00	210.72	261.00	61.94	248.13	50.78	73.45	73.84	76.42	285.62	283.78	259.74
7	0.00	209.14	262.87	62.74	249.26	50.18	73.39	73.65	75.29	282.29	308.13	258.86
8	0.00	0.00	264.77	61.98	247.52	52.09	73.21	95.25	77.18	283.50	297.54	258.94
9	45.44	0.00	272.99	61.09	248.61	53.06	74.66	104.97	129.10	286.06	296.75	258.35
10	44.87	0.00	272.87	58.89	249.96	94.31	74.08	103.68	160.19	283.66	298.31	260.07
11	45.10	0.00	268.01	58.59	247.46	109.73	72.56	105.18	157.84	336.20	301.21	261.24
12	43.80	0.00	161.89	59.40	250.73	109.84	74.32	104.97	157.75	356.71	300.87	259.91
13	45.48	0.00	12.04	59.11	247.80	107.82	72.56	102.33	158.42	364.72	300.20	257.97
14	46.79	0.00	14.18	59.52	248.85	106.43	75.05	116.07	158.28	375.13	302.48	258.80
15	47.86	0.00	14.26	62.60	247.06	108.89	74.80	107.88	156.99	364.46	318.55	258.01
16	48.22	0.00	14.36	60.91	246.82	107.82	72.60	106.79	189.80	359.52	312.28	259.48
17	45.04	0.00	14.00	61.11	248.33	110.06	75.41	103.18	233.47	352.94	300.63	260.13
18	47.19	0.00	14.30	59.70	250.77	109.35	74.34	103.85	246.76	355.85	300.93	259.58
19	46.85	0.00	14.20	0.00	249.74	108.00	74.42	103.40	244.80	352.62	305.10	258.31
20	45.18	0.00	14.34	0.00	248.45	109.49	74.66	105.80	243.63	353.00	307.80	260.27
21	44.57	0.00	13.55	0.00	249.56	108.16	75.07	105.96	244.64	374.76	302.90	260.85
22	44.57	0.00	45.58	0.00	249.60	110.22	75.97	77.53	246.90	388.28	300.89	281.83
23	44.37	0.00	18.03	0.00	248.01	111.45	76.86	111.00	246.66	388.90	300.69	307.91
24	0.00	0.00	17.04	0.00	243.81	111.05	87.23	110.20	248.87	172.36	292.01	256.09
25	0.00	0.00	17.10	0.00	244.01	109.65	75.33	27.61	248.01	82.14	283.46	256.13
26	0.00	0.00	17.14	0.00	245.79	110.74	75.83	6.92	262.97	271.18	281.57	254.88
27	0.00	37.98	17.02	0.00	243.07	111.23	73.51	6.84	253.51	419.64	281.41	251.64
28	0.00	234.31	15.71	0.00	241.45	111.23	71.98	6.25	249.54	418.45	306.86	249.68
29	365.49		16.74	0.00	207.65	102.62	73.96	5.08	247.87	416.43	336.48	255.87
30	352.42		16.28	0.00	244.40	53.24	74.44	5.53	246.53	412.44	340.64	258.60
31	0.00		16.24		242.80		73.25	2.90		124.66		260.81
Total	1,582.41	1,203.51	2,496.10	928.26	7,622.26	3,265.67	2,318.92	2,340.14	5,167.00	9,698.46	8,654.26	8,097.52
Count	18	8	31	18	31	30	31	31	30	31	30	31
Average	51.05	42.98	80.52	30.94	245.88	108.86	74.80	75.49	172.23	312.85	288.48	261.21
Maximum	365.49	234.31	272.99	62.74	250.77	298.33	87.23	116.07	262.97	419.64	340.64	307.91
Minimum	0.00	0.00	12.04	0.00	207.65	50.18	65.79	2.90	5.12	82.14	99.91	249.68

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	116.05	115.48	109.13	0.00	0.00	86.37	73.03	76.25	0.00	80.56	83.36	0.00
2	116.24	115.43	106.73	0.00	36.40	86.97	75.17	76.34	0.00	77.51	91.54	0.01
3	113.49	123.64	107.76	0.00	69.05	86.92	74.97	76.18	0.00	76.44	214.37	0.00
4	110.79	146.85	107.45	0.00	78.99	86.90	74.87	75.30	58.93	75.61	0.00	0.00
5	110.63	153.28	107.00	0.00	78.96	86.36	74.80	75.39	89.41	76.01	0.00	0.00
6	110.71	159.24	108.67	0.00	78.96	86.00	73.72	75.74	89.62	76.69	0.00	0.00
7	111.10	159.49	111.38	0.00	78.95	86.13	71.23	75.22	89.18	76.89	0.00	0.00
8	109.85	165.54	107.69	0.00	79.17	86.39	71.04	75.20	88.61	76.78	0.00	0.00
9	111.08	172.21	108.33	0.00	78.38	86.46	70.51	74.19	89.26	76.79	0.00	0.00
10	108.80	171.05	161.24	0.00	77.99	86.18	70.34	74.48	88.65	76.42	0.00	16.75
11	110.34	141.83	189.71	0.00	80.18	85.26	69.66	74.69	88.50	76.22	0.00	49.80
12	109.87	145.06	135.80	0.00	80.16	84.92	70.53	74.52	88.90	76.57	0.00	49.18
13	113.80	150.98	134.61	0.00	79.05	85.04	70.04	74.87	89.08	76.95	0.00	48.79
14	118.41	158.99	123.12	0.00	78.63	85.33	69.82	75.22	89.16	77.12	0.00	46.73
15	118.99	168.33	116.59	0.00	78.85	84.11	77.58	75.26	89.06	76.30	0.00	45.66
16	119.67	189.34	120.09	0.00	78.70	83.60	80.88	84.06	88.79	75.81	0.00	45.64
17	120.35	442.24	193.75	0.00	79.53	84.39	81.21	85.32	88.39	74.74	0.00	44.62
18	120.83	211.79	355.82	0.00	82.08	84.86	80.65	84.61	88.14	75.98	0.00	44.00
19	123.03	197.30	158.81	0.00	81.07	84.64	79.36	85.73	88.49	75.90	0.00	45.12
20	123.28	199.64	168.08	0.00	79.86	85.10	79.23	85.41	87.69	75.79	0.00	45.34
21	125.23	140.90	143.16	0.00	80.25	84.80	79.96	85.84	87.85	76.04	0.00	45.24
22	128.13	139.14	117.11	0.00	80.66	85.73	80.02	85.91	88.10	76.03	0.00	44.32
23	124.57	138.94	135.78	0.00	81.07	85.34	79.79	85.64	87.64	77.14	0.00	43.86
24	120.42	140.91	107.10	0.00	80.81	84.84	79.08	85.75	87.02	78.49	21.52	41.58
25	120.56	153.16	96.77	0.00	80.79	84.97	79.93	85.66	86.61	80.08	42.48	40.24
26	120.21	150.67	89.75	0.00	81.92	84.29	81.27	85.69	87.00	23.13	42.06	41.22
27	119.42	147.10	92.66	0.00	81.86	84.72	79.45	86.99	87.34	27.46	42.01	41.19
28	118.50	149.57	91.72	0.00	81.57	84.90	79.57	86.98	87.17	51.85	43.57	41.59
29	118.57		91.79	0.00	0.00	84.53	79.55	86.82	86.89	46.82	42.33	40.72
30	118.17		91.27	0.00	0.00	85.04	79.34	87.09	86.53	41.62	42.49	42.07
31	104.52		90.81		0.00		79.85	87.59		76.89		40.73
Total	3,615.61	4,648.10	3,979.68	0.00	2,103.89	2,561.09	2,366.45	2,503.94	2,352.01	2,186.63	665.73	944.40
Count	31	28	31	0	27	30	31	31	27	31	10	23
Average	116.63	166.00	128.38	0.00	67.87	85.37	76.34	80.77	78.40	70.54	22.19	30.46
Maximum	128.13	442.24	355.82	0.00	82.08	86.97	81.27	87.59	89.62	80.56	214.37	49.80
Minimum	104.52	115.43	89.75	0.00	0.00	83.60	69.66	74.19	0.00	23.13	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	230.18	229.05	216.46	0.00	0.00	171.31	144.85	151.24	0.00	159.79	165.34	0.00
2	230.56	228.95	211.70	0.00	72.20	172.50	149.10	151.42	0.00	153.74	181.57	0.02
3	225.10	245.24	213.74	0.00	136.96	172.40	148.70	151.10	0.00	151.62	425.20	0.00
4	219.75	291.27	213.12	0.00	156.67	172.36	148.50	149.36	116.89	149.97	0.00	0.00
5	219.43	304.03	212.23	0.00	156.61	171.29	148.36	149.53	177.34	150.76	0.00	0.00
6	219.59	315.85	215.54	0.00	156.61	170.58	146.22	150.23	177.76	152.11	0.00	0.00
7	220.36	316.34	220.92	0.00	156.60	170.84	141.28	149.20	176.89	152.51	0.00	0.00
8	217.88	328.34	213.60	0.00	157.03	171.35	140.91	149.16	175.76	152.29	0.00	0.00
9	220.32	341.57	214.87	0.00	155.46	171.49	139.85	147.15	177.04	152.31	0.00	0.00
10	215.80	339.27	319.81	0.00	154.69	170.94	139.52	147.73	175.83	151.58	0.00	33.22
11	218.86	281.32	376.28	0.00	159.03	169.11	138.17	148.15	175.54	151.18	0.00	98.78
12	217.92	287.72	269.36	0.00	159.00	168.44	139.89	147.81	176.33	151.87	0.00	97.55
13	225.72	299.46	267.00	0.00	156.79	168.67	138.92	148.50	176.69	152.63	0.00	96.77
14	234.86	315.35	244.20	0.00	155.96	169.25	138.49	149.20	176.85	152.97	0.00	92.69
15	236.01	333.88	231.25	0.00	156.40	166.83	153.88	149.28	176.65	151.34	0.00	90.57
16	237.36	375.55	238.20	0.00	156.10	165.82	160.42	166.73	176.11	150.37	0.00	90.53
17	238.71	877.17	384.30	0.00	157.75	167.39	161.08	169.23	175.32	148.24	0.00	88.50
18	239.66	420.08	705.76	0.00	162.80	168.32	159.97	167.82	174.82	150.70	0.00	87.27
19	244.03	391.34	315.00	0.00	160.80	167.88	157.41	170.04	175.52	150.55	0.00	89.49
20	244.52	395.98	333.38	0.00	158.40	168.79	157.15	169.41	173.93	150.33	0.00	89.93
21	248.39	279.47	283.95	0.00	159.17	168.20	158.60	170.26	174.25	150.82	0.00	89.73
22	254.14	275.98	232.28	0.00	159.99	170.04	158.72	170.40	174.74	150.80	0.00	87.91
23	247.08	275.58	269.32	0.00	160.80	169.27	158.26	169.86	173.83	153.00	0.00	87.00
24	238.85	279.49	212.43	0.00	160.28	168.28	156.85	170.08	172.60	155.68	42.68	82.47
25	239.13	303.79	191.94	0.00	160.24	168.54	158.54	169.90	171.79	158.84	84.26	79.81
26	238.43	298.85	178.02	0.00	162.49	167.19	161.20	169.96	172.56	45.88	83.42	81.76
27	236.87	291.77	183.79	0.00	162.37	168.04	157.59	172.54	173.24	54.47	83.33	81.70
28	235.04	296.67	181.92	0.00	161.79	168.40	157.82	172.52	172.90	102.84	86.42	82.49
29	235.18		182.06	0.00	0.00	167.66	157.79	172.20	172.34	92.87	83.96	80.77
30	234.39		181.03	0.00	0.00	168.67	157.37	172.74	171.63	82.55	84.28	83.44
31	207.31		180.12		0.00		158.38	173.73		152.51		80.79
Total	7,171.46	9,219.37	7,893.58	0.00	4,173.00	5,079.85	4,693.79	4,966.49	4,665.14	4,337.12	1,320.46	1,873.19
Count	31	28	31	0	27	30	31	31	27	31	10	23
Average	231.34	329.26	254.63	0.00	134.61	169.33	151.41	160.21	155.50	139.91	44.02	60.43
Maximum	254.14	877.17	705.76	0.00	162.80	172.50	161.20	173.73	177.76	159.79	425.20	98.78
Minimum	207.31	228.95	178.02	0.00	0.00	165.82	138.17	147.15	0.00	45.88	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	54.01	81.60	83.17	146.74	79.36	0.00	74.45	140.91	150.47	123.72	146.37	145.14
2	63.64	90.03	82.14	170.46	79.73	0.00	99.02	147.28	152.18	129.58	162.87	115.51
3	64.38	89.21	83.26	170.69	78.82	100.64	99.59	144.75	146.67	135.49	185.79	106.02
4	64.22	88.84	83.04	170.10	78.05	133.06	99.43	143.27	128.09	135.86	183.27	106.07
5	65.42	89.59	83.53	172.57	79.09	133.14	100.41	144.19	127.73	137.83	196.85	103.69
6	64.88	90.01	85.35	170.86	79.65	133.82	99.61	145.24	129.29	136.78	238.83	103.84
7	64.70	90.31	82.51	172.45	79.56	132.96	98.68	145.15	129.39	130.25	220.12	104.78
8	63.53	90.74	84.77	172.56	79.54	132.29	98.07	147.43	128.46	130.20	296.97	104.48
9	63.00	91.30	85.10	173.28	79.23	133.22	99.49	142.48	125.71	128.30	165.52	103.37
10	64.62	89.93	84.79	172.69	78.75	0.00	120.45	146.82	125.62	128.53	170.11	104.11
11	65.59	90.21	83.77	172.28	80.03	0.00	122.21	142.23	123.15	129.87	107.22	101.93
12	65.22	90.75	84.03	0.00	78.59	0.00	121.65	144.10	122.53	137.33	13.48	101.64
13	65.99	91.08	84.96	0.00	79.79	90.78	122.23	143.65	122.72	137.91	0.00	101.45
14	67.13	91.70	84.02	0.00	79.01	119.05	122.64	145.29	123.98	137.51	0.00	102.78
15	66.15	90.76	84.35	0.00	79.32	119.97	124.53	146.10	123.03	137.24	0.00	104.84
16	66.14	90.13	84.95	0.00	79.74	119.71	124.94	146.44	119.80	136.03	0.00	104.24
17	66.04	90.42	84.48	0.00	80.57	118.33	125.82	146.51	121.14	135.60	0.00	104.99
18	64.88	91.80	84.52	0.00	90.02	118.17	125.77	147.34	120.36	138.24	0.00	104.58
19	64.04	91.23	83.33	0.00	98.86	117.99	126.70	145.79	121.92	140.86	0.00	104.35
20	67.23	91.23	81.78	0.00	99.19	117.95	126.07	144.00	121.40	141.87	0.00	103.98
21	64.99	91.55	81.71	0.00	100.04	118.45	128.98	145.55	121.82	140.84	0.00	103.65
22	64.41	93.03	81.86	0.00	98.44	118.96	127.34	146.94	120.14	141.63	115.73	103.31
23	64.73	89.87	82.27	0.00	99.15	117.18	127.81	146.22	118.52	141.71	172.45	102.06
24	65.26	59.82	82.63	0.00	99.17	117.42	127.27	147.93	117.20	141.27	172.65	103.37
25	64.35	77.92	82.27	0.00	99.82	89.22	127.20	150.75	123.78	141.87	169.86	103.67
26	64.29	85.98	81.49	0.00	99.18	46.77	130.53	149.16	126.02	141.54	170.23	105.10
27	66.78	86.10	80.19	38.01	98.52	47.09	128.79	147.73	127.36	141.86	170.50	103.12
28	65.50	86.61	81.22	81.17	97.92	46.03	127.96	134.89	128.18	141.82	170.36	101.87
29	64.90		81.37	81.87	96.82	46.66	129.35	135.14	129.03	144.35	168.04	102.03
30	65.78		81.34	82.47	0.00	47.18	130.96	137.49	127.85	142.94	169.51	94.98
31	67.32		79.87		0.00		129.35	140.66		143.75		50.89
Total	2,009.12	2,471.75	2,574.07	2,148.20	2,525.96	2,616.04	3,647.30	4,481.43	3,803.54	4,252.58	3,566.73	3,205.84
Count	31	28	31	15	29	25	31	31	30	31	21	31
Average	64.81	88.28	83.03	71.61	81.48	87.20	117.65	144.56	126.78	137.18	118.89	103.41
Maximum	67.32	93.03	85.35	173.28	100.04	133.82	130.96	150.75	152.18	144.35	296.97	145.14
Minimum	54.01	59.82	79.87	0.00	0.00	0.00	74.45	134.89	117.20	123.72	0.00	50.89

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	107.13	161.85	164.97	291.05	157.41	0.00	147.67	279.49	298.45	245.40	290.32	287.88
2	126.23	178.57	162.92	338.10	158.14	0.00	196.40	292.13	301.84	257.02	323.05	229.11
3	127.70	176.95	165.14	338.56	156.34	199.62	197.53	287.11	290.92	268.74	368.51	210.29
4	127.38	176.21	164.71	337.39	154.81	263.92	197.22	284.17	254.06	269.47	363.51	210.39
5	129.76	177.70	165.68	342.29	156.87	264.08	199.16	286.00	253.35	273.38	390.45	205.67
6	128.69	178.53	169.29	338.90	157.98	265.43	197.57	288.08	256.44	271.30	473.71	205.96
7	128.33	179.13	163.66	342.05	157.80	263.72	195.73	287.90	256.64	258.35	436.60	207.83
8	126.01	179.98	168.14	342.27	157.77	262.39	194.52	292.42	254.80	258.25	589.03	207.23
9	124.96	181.09	168.79	343.70	157.15	264.24	197.34	282.60	249.34	254.48	328.30	205.03
10	128.17	178.37	168.18	342.53	156.20	0.00	238.91	291.21	249.16	254.94	337.41	206.50
11	130.10	178.93	166.16	341.71	158.74	0.00	242.40	282.11	244.26	257.59	212.67	202.18
12	129.36	180.00	166.67	0.00	155.88	0.00	241.29	285.82	243.03	272.39	26.74	201.60
13	130.89	180.65	168.52	0.00	158.26	180.06	242.44	284.93	243.41	273.54	0.00	201.22
14	133.15	181.88	166.65	0.00	156.71	236.13	243.25	288.18	245.91	272.75	0.00	203.86
15	131.21	180.02	167.31	0.00	157.33	237.96	247.00	289.79	244.03	272.21	0.00	207.95
16	131.19	178.77	168.50	0.00	158.16	237.44	247.81	290.46	237.62	269.81	0.00	206.76
17	130.99	179.35	167.56	0.00	159.81	234.70	249.56	290.60	240.28	268.96	0.00	208.24
18	128.69	182.08	167.64	0.00	178.55	234.39	249.46	292.24	238.73	274.20	0.00	207.43
19	127.02	180.95	165.28	0.00	196.09	234.03	251.31	289.17	241.82	279.39	0.00	206.98
20	133.35	180.95	162.21	0.00	196.74	233.95	250.06	285.62	240.79	281.40	0.00	206.24
21	128.91	181.59	162.07	0.00	198.43	234.94	255.83	288.69	241.63	279.35	0.00	205.59
22	127.76	184.52	162.37	0.00	195.25	235.95	252.58	291.45	238.29	280.92	229.55	204.91
23	128.39	178.25	163.18	0.00	196.66	232.42	253.51	290.02	235.08	281.08	342.05	202.43
24	129.44	118.65	163.89	0.00	196.70	232.90	252.44	293.41	232.46	280.20	342.45	205.03
25	127.64	154.55	163.18	0.00	197.99	176.97	252.30	299.01	245.51	281.40	336.91	205.63
26	127.52	170.54	161.63	0.00	196.72	92.77	258.90	295.85	249.96	280.74	337.65	208.46
27	132.46	170.78	159.05	75.39	195.41	93.40	255.45	293.02	252.61	281.38	338.18	204.54
28	129.92	171.79	161.10	161.00	194.22	91.30	253.80	267.55	254.24	281.30	337.90	202.06
29	128.73		161.40	162.39	192.04	92.55	256.56	268.05	255.93	286.31	333.30	202.37
30	130.47		161.34	163.58	0.00	93.58	259.76	272.71	253.59	283.52	336.22	188.39
31	133.53		158.42		0.00		256.56	279.00		285.12		100.94
Total	3,985.03	4,902.64	5,105.59	4,260.89	5,010.17	5,188.84	7,234.31	8,888.79	7,544.21	8,434.87	7,074.51	6,358.69
Count	31	28	31	15	29	25	31	31	30	31	21	31
Average	128.55	175.09	164.70	142.03	161.62	172.96	233.36	286.74	251.47	272.09	235.82	205.12
Maximum	133.53	184.52	169.29	343.70	198.43	265.43	259.76	299.01	301.84	286.31	589.03	287.88
Minimum	107.13	118.65	158.42	0.00	0.00	0.00	147.67	267.55	232.46	245.40	0.00	100.94

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	129.77	133.02	90.51	87.27	134.42	168.56	146.86	194.53	202.03	84.52	0.00
2	83.80	131.69	126.53	87.97	122.11	138.07	173.93	97.61	199.37	193.13	86.01	0.00
3	125.29	129.81	125.02	88.03	123.70	136.66	179.65	66.12	202.41	195.16	86.07	0.00
4	127.02	130.82	125.04	87.34	122.47	135.65	175.58	168.10	198.97	193.16	85.00	0.00
5	126.39	131.08	123.64	89.86	126.83	138.84	175.44	191.98	198.25	197.60	83.91	0.00
6	126.22	129.77	123.32	90.02	124.51	140.42	182.62	191.95	202.10	192.46	83.43	0.00
7	127.27	0.00	127.39	87.65	122.86	136.35	168.22	191.80	201.05	198.03	85.05	0.00
8	126.02	91.46	124.89	87.85	126.72	138.81	169.80	194.39	201.79	198.24	83.29	0.00
9	125.63	133.25	126.81	86.68	123.68	137.43	169.77	190.63	201.91	197.19	85.32	0.00
10	126.13	133.52	124.13	87.35	121.28	137.89	170.53	190.32	204.13	191.85	84.41	0.00
11	125.89	133.04	123.95	86.64	121.34	138.97	170.34	191.69	202.10	192.51	81.44	0.00
12	126.74	136.84	124.79	87.26	119.66	138.87	167.81	193.86	202.83	189.47	83.58	0.00
13	127.60	151.50	124.77	86.98	120.58	139.05	169.39	197.10	199.76	191.55	82.53	0.00
14	127.47	145.22	125.30	88.32	120.00	139.00	168.55	195.16	200.95	190.91	82.20	0.00
15	127.60	143.69	124.86	86.34	121.22	139.59	169.10	194.67	200.76	191.72	80.83	0.00
16	126.34	143.41	126.02	87.77	121.73	138.81	170.47	192.10	202.31	191.57	84.18	0.00
17	124.95	142.04	126.87	87.88	118.90	140.40	166.66	194.12	200.93	194.23	81.53	0.00
18	125.85	143.30	124.34	89.04	118.29	140.17	169.26	194.56	199.14	189.67	76.51	0.00
19	126.61	142.11	125.58	89.43	119.85	139.06	166.74	195.68	200.93	191.20	77.40	0.00
20	125.88	143.93	124.82	88.82	120.33	139.92	168.64	196.80	199.24	189.57	76.98	0.00
21	125.28	142.47	125.60	90.39	118.28	142.08	86.78	195.26	200.41	188.72	78.51	0.00
22	124.74	141.92	125.10	89.56	119.39	141.27	84.01	195.98	199.37	191.70	78.95	0.00
23	126.48	141.51	125.64	87.93	117.89	141.58	138.96	196.71	201.15	191.58	8.55	0.00
24	125.45	142.58	119.79	87.80	119.88	148.34	170.88	195.39	202.48	189.21	0.00	0.00
25	127.06	142.10	119.03	88.75	119.47	145.36	173.88	195.31	174.92	193.55	0.00	0.00
26	124.55	141.83	121.27	88.49	117.54	144.50	109.21	196.36	156.14	192.92	0.00	0.00
27	127.51	142.67	121.28	88.39	118.35	146.43	111.18	196.95	155.63	103.06	0.00	0.00
28	128.71	143.04	122.39	87.87	118.07	145.67	107.07	194.93	200.10	104.72	0.00	0.00
29	128.03	140.90	121.70	88.54	118.43	145.68	109.68	195.73	197.01	85.12	0.00	0.00
30	128.03		123.75	89.06	116.79	148.48	115.20	194.21	203.27	84.03	0.00	0.00
31	127.14		122.39		116.96		145.95	194.42		83.54		0.00
Total	3,751.68	3,845.27	3,859.03	2,648.52	3,704.38	4,217.77	4,773.86	5,726.75	5,903.94	5,479.40	1,820.20	0.00
Count	30	28	31	30	31	30	31	31	30	31	23	0
Average	121.02	132.60	124.48	88.28	119.50	140.59	154.00	184.73	196.80	176.75	60.67	0.00
Maximum	128.71	151.50	133.02	90.51	126.83	148.48	182.62	197.10	204.13	202.03	86.07	0.00
Minimum	0.00	0.00	119.03	86.34	87.27	134.42	84.01	66.12	155.63	83.54	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	257.40	263.84	179.52	173.10	266.62	334.33	291.29	385.84	400.72	167.64	0.00
2	166.21	261.20	250.97	174.49	242.20	273.86	344.99	193.61	395.44	383.07	170.60	0.00
3	248.51	257.47	247.97	174.60	245.36	271.06	356.33	131.15	401.47	387.09	170.72	0.00
4	251.94	259.48	248.01	173.24	242.92	269.06	348.26	333.42	394.65	383.13	168.60	0.00
5	250.69	259.99	245.24	178.23	251.56	275.39	347.98	380.79	393.22	391.93	166.43	0.00
6	250.35	257.40	244.60	178.55	246.96	278.52	362.22	380.73	400.86	381.74	165.48	0.00
7	252.44	0.00	252.67	173.85	243.69	270.45	333.66	380.43	398.78	392.79	168.69	0.00
8	249.96	181.41	247.72	174.25	251.35	275.33	336.79	385.57	400.24	393.20	165.20	0.00
9	249.18	264.30	251.52	171.93	245.32	272.59	336.73	378.11	400.48	391.12	169.23	0.00
10	250.18	264.83	246.21	173.26	240.56	273.50	338.24	377.49	404.89	380.53	167.42	0.00
11	249.70	263.88	245.85	171.85	240.67	275.64	337.86	380.21	400.86	381.84	161.53	0.00
12	251.39	271.42	247.52	173.08	237.34	275.44	332.85	384.52	402.31	375.81	165.78	0.00
13	253.09	300.50	247.48	172.52	239.17	275.80	335.98	390.94	396.22	379.93	163.70	0.00
14	252.83	288.04	248.53	175.18	238.02	275.70	334.31	387.09	398.58	378.66	163.04	0.00
15	253.09	285.00	247.66	171.25	240.44	276.87	335.40	386.12	398.20	380.27	160.32	0.00
16	250.59	284.45	249.96	174.09	241.45	275.33	338.12	381.02	401.28	379.97	166.97	0.00
17	247.83	281.73	251.64	174.31	235.83	278.48	330.57	385.03	398.54	385.25	161.71	0.00
18	249.62	284.23	246.62	176.61	234.62	278.02	335.72	385.90	394.99	376.20	151.76	0.00
19	251.13	281.87	249.08	177.38	237.72	275.82	330.72	388.13	398.54	379.24	153.52	0.00
20	249.68	285.48	247.58	176.17	238.67	277.53	334.49	390.35	395.19	376.01	152.69	0.00
21	248.49	282.59	249.12	179.29	234.60	281.81	172.13	387.29	397.51	374.32	155.72	0.00
22	247.42	281.49	248.13	177.64	236.81	280.20	166.63	388.72	395.44	380.23	156.60	0.00
23	250.87	280.68	249.20	174.41	233.83	280.82	275.62	390.17	398.98	379.99	16.96	0.00
24	248.83	282.80	237.60	174.15	237.78	294.23	338.94	387.55	401.61	375.29	0.00	0.00
25	252.02	281.85	236.09	176.03	236.97	288.32	344.89	387.39	346.95	383.90	0.00	0.00
26	247.04	281.32	240.54	175.52	233.14	286.61	216.61	389.47	309.70	382.65	0.00	0.00
27	252.91	282.98	240.56	175.32	234.74	290.44	220.52	390.64	308.69	204.42	0.00	0.00
28	255.29	283.72	242.76	174.29	234.19	288.93	212.37	386.64	396.89	207.71	0.00	0.00
29	253.94	279.47	241.39	175.62	234.90	288.95	217.55	388.22	390.76	168.83	0.00	0.00
30	253.94		245.45	176.65	231.65	294.51	228.50	385.21	403.18	166.67	0.00	0.00
31	252.18		242.76		231.99		289.49	385.63		165.70		0.00
Total	7,441.35	7,626.98	7,654.27	5,253.26	7,347.53	8,365.82	9,468.81	11,358.84	11,710.29	10,868.23	3,610.31	0.00
Count	30	28	31	30	31	30	31	31	30	31	23	0
Average	240.04	263.00	246.91	175.11	237.02	278.86	305.45	366.41	390.34	350.59	120.34	0.00
Maximum	255.29	300.50	263.84	179.52	251.56	294.51	362.22	390.94	404.89	400.72	170.72	0.00
Minimum	0.00	0.00	236.09	171.25	173.10	266.62	166.63	131.15	308.69	165.70	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	15.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	61.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	2	0	0	0	0	0	0	0	0	0	0	0
Average	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

HENNESSEY DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	30.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	121.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	2	0	0	0	0	0	0	0	0	0	0	0
Average	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	90.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix C

Tempe Drain
Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1992
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	244.88	177.42	0.00	74.51	38.26	0.00	0.00	67.88	0.00	0.00	0.00
2	0.00	200.00	212.17	0.00	81.70	19.68	0.00	0.00	42.33	0.00	0.00	0.00
3	0.00	187.50	263.79	0.00	137.48	18.43	0.00	0.00	69.75	0.00	0.00	0.00
4	4.96	178.13	253.88	11.54	93.06	24.09	0.00	0.00	38.54	0.00	0.00	27.70
5	0.00	171.50	286.63	117.29	105.24	22.58	0.00	5.57	49.00	0.00	0.00	6.13
6	9.46	182.04	300.00	304.92	113.98	33.83	0.00	1.00	49.38	0.00	0.00	0.00
7	285.25	185.88	259.71	287.29	120.22	53.42	0.00	24.00	21.25	0.00	0.00	0.00
8	462.21	239.46	267.50	279.17	95.00	53.33	0.00	0.00	0.00	0.00	0.00	0.00
9	530.63	288.33	297.79	259.38	164.04	55.20	0.00	0.00	0.00	0.00	0.00	0.00
10	475.00	300.00	293.75	229.50	228.94	91.75	20.61	0.00	0.00	0.00	0.00	0.00
11	483.08	347.58	297.46	181.42	257.45	19.96	49.09	13.50	0.00	0.00	0.00	0.00
12	339.83	368.75	313.54	200.54	201.95	5.07	0.00	0.00	0.00	0.00	0.00	0.00
13	317.29	276.58	305.00	236.46	183.74	46.00	0.00	0.00	0.00	0.00	0.00	0.00
14	320.00	200.00	279.71	113.71	167.97	47.16	0.00	0.00	0.00	0.00	0.00	0.00
15	318.46	214.58	278.79	70.01	133.29	77.80	0.00	0.00	0.00	0.00	0.00	0.00
16	322.33	336.21	227.50	75.12	83.41	66.57	0.00	0.00	0.00	0.00	0.00	0.00
17	321.08	350.00	197.96	61.78	33.32	17.34	0.00	0.00	0.00	0.00	0.00	0.00
18	349.04	350.00	185.00	143.79	22.16	26.64	0.00	0.00	0.00	0.00	0.00	0.00
19	387.50	329.38	196.63	119.03	31.66	27.07	0.00	0.00	0.00	0.00	0.00	0.00
20	382.58	350.00	157.04	106.49	94.91	21.73	0.00	0.00	0.00	0.00	0.00	0.00
21	354.08	301.50	54.79	129.89	92.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	375.00	278.08	26.67	83.19	95.93	0.00	0.00	57.58	0.00	0.00	0.00	0.00
23	375.00	244.96	31.42	98.37	86.96	0.00	2.10	41.08	0.00	0.00	0.00	0.00
24	370.13	207.13	30.00	92.45	115.31	0.00	157.34	134.00	0.00	0.00	0.00	0.00
25	325.00	200.00	30.00	79.24	98.72	0.00	15.11	129.76	0.00	7.43	0.00	0.00
26	325.00	189.92	56.25	61.69	108.54	0.00	0.00	101.53	0.00	2.54	0.00	0.00
27	325.00	200.00	102.04	60.72	58.68	0.00	0.00	48.15	0.00	0.93	0.00	0.00
28	325.00	173.92	51.63	54.02	29.57	0.00	0.00	40.10	0.00	0.00	0.00	0.00
29	325.00	147.88	8.96	64.78	18.26	0.00	10.33	13.45	0.00	0.00	0.00	0.00
30	299.21		0.00	70.36	37.53	0.00	0.00	75.44	0.00	0.00	0.00	0.00
31	226.42		0.00		45.01		0.00	123.08		0.00		0.00
Total	8,933.54	7,244.19	5,443.03	3,592.15	3,211.40	765.91	254.58	808.24	338.13	10.90	0.00	33.83
Count	27	29	29	27	31	20	6	14	7	3	0	2
Average	288.18	249.80	175.58	119.74	103.59	25.53	8.21	26.07	11.27	0.35	0.00	1.09
Maximum	530.63	368.75	313.54	304.92	257.45	91.75	157.34	134.00	69.75	7.43	0.00	27.70
Minimum	0.00	147.88	0.00	0.00	18.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1992
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	485.71	351.91	0.00	147.79	75.89	0.00	0.00	134.64	0.00	0.00	0.00
2	0.00	396.69	420.83	0.00	162.05	39.03	0.00	0.00	83.96	0.00	0.00	0.00
3	0.00	371.90	523.22	0.00	272.69	36.56	0.00	0.00	138.35	0.00	0.00	0.00
4	9.84	353.32	503.56	22.89	184.58	47.78	0.00	0.00	76.44	0.00	0.00	54.94
5	0.00	340.17	568.52	232.64	208.74	44.79	0.00	11.05	97.19	0.00	0.00	12.16
6	18.76	361.07	595.04	604.80	226.08	67.10	0.00	1.98	97.94	0.00	0.00	0.00
7	565.79	368.69	515.13	569.83	238.45	105.96	0.00	47.60	42.15	0.00	0.00	0.00
8	916.78	474.96	530.58	553.73	188.43	105.78	0.00	0.00	0.00	0.00	0.00	0.00
9	1,052.49	571.89	590.66	514.47	325.37	109.49	0.00	0.00	0.00	0.00	0.00	0.00
10	942.15	595.04	582.64	455.21	454.10	181.98	40.88	0.00	0.00	0.00	0.00	0.00
11	958.18	689.41	590.00	359.84	510.64	39.59	97.37	26.78	0.00	0.00	0.00	0.00
12	674.04	731.40	621.90	397.77	400.56	10.06	0.00	0.00	0.00	0.00	0.00	0.00
13	629.34	548.59	604.96	469.01	364.44	91.24	0.00	0.00	0.00	0.00	0.00	0.00
14	634.71	396.69	554.80	225.54	333.16	93.54	0.00	0.00	0.00	0.00	0.00	0.00
15	631.66	425.61	552.97	138.86	264.38	154.31	0.00	0.00	0.00	0.00	0.00	0.00
16	639.33	666.86	451.24	149.00	165.44	132.04	0.00	0.00	0.00	0.00	0.00	0.00
17	636.85	694.21	392.65	122.54	66.09	34.39	0.00	0.00	0.00	0.00	0.00	0.00
18	692.31	694.21	366.94	285.20	43.95	52.84	0.00	0.00	0.00	0.00	0.00	0.00
19	768.60	653.32	390.01	236.09	62.80	53.69	0.00	0.00	0.00	0.00	0.00	0.00
20	758.84	694.21	311.48	211.22	188.25	43.10	0.00	0.00	0.00	0.00	0.00	0.00
21	702.31	598.02	108.67	257.63	184.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	743.80	551.56	52.90	165.00	190.27	0.00	0.00	114.21	0.00	0.00	0.00	0.00
23	743.80	485.87	62.32	195.11	172.48	0.00	4.17	81.48	0.00	0.00	0.00	0.00
24	734.14	410.84	59.50	183.37	228.71	0.00	312.08	265.79	0.00	0.00	0.00	0.00
25	644.63	396.69	59.50	157.17	195.81	0.00	29.97	257.38	0.00	14.74	0.00	0.00
26	644.63	376.70	111.57	122.36	215.29	0.00	0.00	201.38	0.00	5.04	0.00	0.00
27	644.63	396.69	202.39	120.44	116.39	0.00	0.00	95.50	0.00	1.84	0.00	0.00
28	644.63	344.97	102.41	107.15	58.65	0.00	0.00	79.54	0.00	0.00	0.00	0.00
29	644.63	293.32	17.77	128.49	36.22	0.00	20.49	26.68	0.00	0.00	0.00	0.00
30	593.47		0.00	139.56	74.44	0.00	0.00	149.63	0.00	0.00	0.00	0.00
31	449.10		0.00		89.28		0.00	244.13		0.00		0.00
Total	17,719.42	14,368.64	10,796.09	7,124.93	6,369.72	1,519.16	504.95	1,603.12	670.67	21.62	0.00	67.10
Count	27	29	29	27	31	20	6	14	7	3	0	2
Average	571.59	495.47	348.26	237.50	205.47	50.64	16.29	51.71	22.36	0.70	0.00	2.16
Maximum	1,052.49	731.40	621.90	604.80	510.64	181.98	312.08	265.79	138.35	14.74	0.00	54.94
Minimum	0.00	293.32	0.00	0.00	36.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1993
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	139.17	369.29	220.85	38.04	4.92	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	142.66	394.73	208.72	54.75	21.61	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	131.27	386.38	228.54	49.49	3.05	0.00	0.00	0.00	0.00	0.00	0.00
4	213.70	118.56	359.21	205.02	30.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	370.57	111.10	318.74	173.34	54.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	377.88	120.00	317.79	187.54	47.09	0.00	0.00	15.67	0.00	7.18	0.00	0.00
7	295.08	110.46	253.04	169.89	79.93	0.00	0.00	12.40	0.00	0.00	0.00	0.00
8	121.75	137.37	289.73	154.08	52.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	56.54	137.09	357.45	145.01	53.95	0.00	0.00	17.17	0.00	0.00	0.00	0.00
10	60.92	157.90	277.88	152.62	70.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	73.63	152.05	131.13	151.98	52.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	52.21	174.92	88.20	128.03	49.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	72.42	183.89	154.02	130.94	24.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	127.34	193.06	97.60	132.18	53.10	0.00	0.00	0.00	0.00	0.00	2.70	0.00
15	235.40	200.28	167.96	80.87	54.56	0.00	0.00	0.00	0.00	0.00	8.21	0.00
16	41.79	166.46	191.04	57.01	50.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	45.88	138.88	216.01	45.66	59.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	58.21	147.28	227.11	55.02	45.03	0.00	0.00	8.21	0.00	0.00	0.00	0.00
19	17.68	253.85	194.73	76.61	10.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	21.18	285.46	137.74	41.53	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	13.36	297.69	155.07	59.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	94.83	304.84	186.30	65.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	24.88	254.87	157.78	36.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	22.11	224.42	110.55	37.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	21.36	257.05	118.34	76.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	98.83	285.31	161.04	82.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	238.55	276.20	194.56	63.48	3.88	0.00	0.00	44.19	0.00	0.00	0.00	0.00
28	238.52	272.82	236.24	45.24	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	238.21		167.22	32.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	241.63		189.42	17.66	30.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	200.80		211.26		11.54		0.00	0.00		0.00		0.00
Total	3,675.26	5,374.91	6,817.56	3,261.69	987.88	29.58	0.00	97.64	0.00	7.18	10.91	0.00
Count	28	28	31	30	24	3	0	5	0	1	2	0
Average	118.56	191.96	219.92	108.72	31.87	0.99	0.00	3.15	0.00	0.23	0.36	0.00
Maximum	377.88	304.84	394.73	228.54	79.93	21.61	0.00	44.19	0.00	7.18	8.21	0.00
Minimum	0.00	110.46	88.20	17.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	276.04	732.48	438.05	75.45	9.76	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	282.96	782.94	413.99	108.60	42.86	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	260.37	766.37	453.30	98.16	6.05	0.00	0.00	0.00	0.00	0.00	0.00
4	423.87	235.16	712.48	406.65	60.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	735.01	220.36	632.21	343.81	107.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	749.51	238.02	630.33	371.98	93.40	0.00	0.00	31.08	0.00	14.24	0.00	0.00
7	585.28	219.09	501.90	336.97	158.54	0.00	0.00	24.60	0.00	0.00	0.00	0.00
8	241.49	272.47	574.67	305.61	103.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	112.15	271.91	708.99	287.62	107.01	0.00	0.00	34.06	0.00	0.00	0.00	0.00
10	120.83	313.19	551.17	302.72	139.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	146.04	301.59	260.09	301.45	103.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	103.56	346.95	174.94	253.94	98.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	143.64	364.74	305.49	259.72	48.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	252.58	382.93	193.59	262.18	105.32	0.00	0.00	0.00	0.00	0.00	5.36	0.00
15	466.91	397.25	333.14	160.40	108.22	0.00	0.00	0.00	0.00	0.00	16.28	0.00
16	82.89	330.17	378.92	113.08	99.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	91.00	275.46	428.45	90.57	117.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	115.46	292.13	450.47	109.13	89.32	0.00	0.00	16.28	0.00	0.00	0.00	0.00
19	35.07	503.50	386.24	151.95	21.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	42.01	566.20	273.20	82.37	14.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	26.50	590.46	307.58	118.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	188.09	604.64	369.52	130.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	49.35	505.53	312.95	72.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	43.85	445.13	219.27	73.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	42.37	509.85	234.72	151.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	196.03	565.90	319.42	163.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	473.16	547.83	385.90	125.91	7.70	0.00	0.00	87.65	0.00	0.00	0.00	0.00
28	473.10	541.13	468.58	89.73	7.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	472.48		331.68	63.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	479.27		375.71	35.03	61.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	398.28		419.03		22.89		0.00	0.00		0.00		0.00
Total	7,289.77	10,660.98	13,522.43	6,469.47	1,959.43	58.67	0.00	193.67	0.00	14.24	21.64	0.00
Count	28	28	31	30	24	3	0	5	0	1	2	0
Average	235.15	380.75	436.21	215.65	63.21	1.96	0.00	6.25	0.00	0.46	0.72	0.00
Maximum	749.51	604.64	782.94	453.30	158.54	42.86	0.00	87.65	0.00	14.24	16.28	0.00
Minimum	0.00	219.09	174.94	35.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1994
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	9.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.49	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	4.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	8.70	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	7.29	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		5.16		0.00
Total	0.00	0.00	15.77	4.10	0.00	0.00	15.99	0.00	0.00	5.16	6.23	0.00
Count	0	0	3	1	0	0	2	0	0	1	4	0
Average	0.00	0.00	0.51	0.14	0.00	0.00	0.52	0.00	0.00	0.17	0.21	0.00
Maximum	0.00	0.00	9.43	4.10	0.00	0.00	8.70	0.00	0.00	5.16	2.49	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	18.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.94	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.07	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	8.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	5.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	7.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	17.26	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	14.46	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		10.23		0.00
Total	0.00	0.00	31.28	8.13	0.00	0.00	31.72	0.00	0.00	10.23	12.36	0.00
Count	0	0	3	1	0	0	2	0	0	1	4	0
Average	0.00	0.00	1.01	0.27	0.00	0.00	1.02	0.00	0.00	0.33	0.41	0.00
Maximum	0.00	0.00	18.70	8.13	0.00	0.00	17.26	0.00	0.00	10.23	4.94	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1995
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.70	0.00
2	0.00	0.00	0.00	53.07	0.00	0.00	0.00	0.00	0.00	0.00	31.99	0.00
3	0.00	0.00	0.00	49.90	0.00	0.00	0.00	0.00	0.00	0.00	21.54	0.00
4	0.00	0.00	0.00	45.67	0.00	0.00	0.00	0.00	0.00	0.00	3.19	0.00
5	0.00	0.00	0.00	37.21	0.00	0.00	0.00	0.00	0.00	0.00	2.61	0.00
6	15.63	0.00	0.00	65.04	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00
7	30.27	0.00	0.00	69.13	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00
8	52.12	0.00	0.00	63.65	0.00	0.00	0.00	0.00	0.00	0.00	34.27	0.00
9	101.98	0.00	0.00	65.43	0.00	0.00	0.00	0.00	0.00	0.00	40.22	0.00
10	165.04	0.00	0.00	40.79	0.00	0.00	0.00	0.00	0.00	0.00	35.22	0.00
11	149.63	0.00	12.78	51.35	0.00	0.00	0.00	0.00	0.00	0.00	29.53	0.00
12	0.00	0.00	21.96	41.19	0.00	0.00	0.00	0.00	0.00	0.00	30.08	0.00
13	0.00	0.00	29.08	36.88	0.00	0.00	0.00	0.00	0.00	0.00	29.31	0.00
14	0.00	0.00	25.27	28.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	26.85	37.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	31.42	19.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	12.30	39.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	18.82	17.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	16.24	20.38	0.00	0.00	0.00	24.65	0.00	0.00	0.00	0.00
20	0.00	0.00	13.62	0.00	0.00	0.00	0.00	18.70	0.00	0.00	0.00	0.00
21	0.00	0.00	14.78	0.00	0.00	0.00	0.00	13.72	0.00	0.00	0.00	0.00
22	0.00	0.00	29.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	28.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	42.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	46.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	47.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	37.78	52.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	5.45	17.94	0.00	0.00	0.00	0.00	0.00	27.65	0.00	0.00	0.00
29	0.00		6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		14.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		5.47		0.00		0.00	0.00		0.00		0.00
Total	514.67	43.23	513.93	782.15	0.00	0.00	0.00	57.07	27.65	0.00	293.78	0.00
Count	6	2	21	18	0	0	0	3	1	0	13	0
Average	16.60	1.54	16.58	26.07	0.00	0.00	0.00	1.84	0.92	0.00	9.79	0.00
Maximum	165.04	37.78	52.39	69.13	0.00	0.00	0.00	24.65	27.65	0.00	40.22	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.88	0.00
2	0.00	0.00	0.00	105.26	0.00	0.00	0.00	0.00	0.00	0.00	63.45	0.00
3	0.00	0.00	0.00	98.98	0.00	0.00	0.00	0.00	0.00	0.00	42.72	0.00
4	0.00	0.00	0.00	90.59	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00
5	0.00	0.00	0.00	73.80	0.00	0.00	0.00	0.00	0.00	0.00	5.18	0.00
6	31.00	0.00	0.00	129.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00
7	60.04	0.00	0.00	137.12	0.00	0.00	0.00	0.00	0.00	0.00	5.67	0.00
8	103.38	0.00	0.00	126.25	0.00	0.00	0.00	0.00	0.00	0.00	67.97	0.00
9	202.27	0.00	0.00	129.78	0.00	0.00	0.00	0.00	0.00	0.00	79.78	0.00
10	327.35	0.00	0.00	80.91	0.00	0.00	0.00	0.00	0.00	0.00	69.86	0.00
11	296.79	0.00	25.35	101.85	0.00	0.00	0.00	0.00	0.00	0.00	58.57	0.00
12	0.00	0.00	43.56	81.70	0.00	0.00	0.00	0.00	0.00	0.00	59.66	0.00
13	0.00	0.00	57.68	73.15	0.00	0.00	0.00	0.00	0.00	0.00	58.14	0.00
14	0.00	0.00	50.12	56.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	53.26	75.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	62.32	38.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	24.40	77.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	37.33	35.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	32.21	40.42	0.00	0.00	0.00	48.89	0.00	0.00	0.00	0.00
20	0.00	0.00	27.01	0.00	0.00	0.00	0.00	37.09	0.00	0.00	0.00	0.00
21	0.00	0.00	29.32	0.00	0.00	0.00	0.00	27.21	0.00	0.00	0.00	0.00
22	0.00	0.00	58.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	56.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	84.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	92.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	94.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	74.94	103.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	10.81	35.58	0.00	0.00	0.00	0.00	0.00	54.84	0.00	0.00	0.00
29	0.00		12.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		27.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		10.85		0.00		0.00	0.00		0.00		0.00
Total	1,020.83	85.75	1,019.37	1,551.37	0.00	0.00	0.00	113.20	54.84	0.00	582.70	0.00
Count	6	2	21	18	0	0	0	3	1	0	13	0
Average	32.93	3.06	32.88	51.71	0.00	0.00	0.00	3.65	1.83	0.00	19.42	0.00
Maximum	327.35	74.94	103.91	137.12	0.00	0.00	0.00	48.89	54.84	0.00	79.78	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1996
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	9.89	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	3.12	0.00	0.00	23.35	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.90	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.45	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.09	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.39	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		60.81		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	40.14	0.00	0.00	343.99	0.00	0.00
Count	0	0	0	0	0	0	3	0	0	6	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	11.10	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	27.13	0.00	0.00	70.90	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	19.62	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	6.19	0.00	0.00	46.31	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.63	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135.77	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	115.22	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.75	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		120.61		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	79.62	0.00	0.00	682.29	0.00	0.00
Count	0	0	0	0	0	0	3	0	0	6	0	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	22.01	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	53.81	0.00	0.00	140.63	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1997
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	17.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	34.08	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	21.25	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	36.08	0.00	0.00
Count	4	0	0	0	1	0	0	1	0	2	0	0
Average	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	1.16	0.00	0.00
Maximum	17.51	0.00	0.00	0.00	0.08	0.00	0.00	3.80	0.00	34.08	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	34.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.54	0.00	67.60	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	42.15	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	71.56	0.00	0.00
Count	4	0	0	0	1	0	0	1	0	2	0	0
Average	1.36	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	2.31	0.00	0.00
Maximum	34.73	0.00	0.00	0.00	0.16	0.00	0.00	7.54	0.00	67.60	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1998
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	20.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	48.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	35.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	4.29	0.00	48.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	73.75	0.00	48.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	43.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	15.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	27.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	51.46	0.00	36.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.97	0.00	63.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	1.07	0.00	67.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.23	0.00	94.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.37	0.00	132.44	0.00	0.00	0.00	1.97	0.00	0.00	0.00	0.00
15	0.00	33.72	0.00	102.23	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	34.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	53.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	2.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		103.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		5.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		2.33		0.00		0.00	0.00		0.00		0.00
Total	0.00	225.75	112.04	818.73	0.00	0.00	0.00	7.42	0.00	0.00	0.00	0.00
Count	0	14	3	16	0	0	0	2	0	0	0	0
Average	0.00	8.06	3.61	27.29	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Maximum	0.00	73.75	103.98	132.44	0.00	0.00	0.00	5.45	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	41.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	96.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	70.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	8.51	0.00	95.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	146.28	0.00	96.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	86.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	30.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	53.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	102.07	0.00	71.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	1.92	0.00	126.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	2.12	0.00	133.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.46	0.00	186.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.73	0.00	262.69	0.00	0.00	0.00	3.91	0.00	0.00	0.00	0.00
15	0.00	66.88	0.00	202.77	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	67.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	105.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		206.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		11.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		4.62		0.00		0.00	0.00		0.00		0.00
Total	0.00	447.77	222.23	1,623.93	0.00	0.00	0.00	14.72	0.00	0.00	0.00	0.00
Count	0	14	3	16	0	0	0	2	0	0	0	0
Average	0.00	15.99	7.17	54.13	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00
Maximum	0.00	146.28	206.24	262.69	0.00	0.00	0.00	10.81	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1999
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.74	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	17.24	0.00
Count	0	0	0	0	0	0	1	0	0	1	2	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.03	0.57	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.91	10.74	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.89	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.30	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	34.20	0.00
Count	0	0	0	0	0	0	1	0	0	1	2	0
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.06	1.14	0.00
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	26.16	0.00	0.00	1.80	21.30	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2000
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.66
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.02	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.74	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.54	6.66
Count	0	0	0	0	0	0	0	0	0	0	4	1
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.21
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	6.66
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.21
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.01	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.34	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.74	13.21
Count	0	0	0	0	0	0	0	0	0	0	4	1
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.43
Maximum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.70	13.21
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	1	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

TEMPE DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00
Total	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Count	0	0	0	0	1	0	0	0	0	0	0	0
Average	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.00	0.00	0.00	0.00	16.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

Appendix D

Price Drain Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2001
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			4.55	2.44	1.70	1.38	2.02	6.82	3.49	4.67	1.00	0.70
2			2.11	7.62	1.49	2.43	2.50	9.26	6.02	2.90	1.56	0.56
3			1.89	4.55	1.74	2.52	3.56	7.04	5.83	2.64	2.72	1.00
4			1.37	4.41	1.47	2.99	3.54	3.87	4.51	3.01	3.60	21.87
5			0.50	12.70	1.76	2.93	4.80	5.46	3.89	2.63	4.99	11.71
6			1.95	18.12	1.00	2.65	5.34	3.55	4.77	3.31	2.15	4.58
7			47.72	6.20	1.34	3.68	3.64	2.74	3.33	3.79	2.01	1.25
8			25.07	3.18	1.24	2.33	3.21	4.20	3.89	3.35	5.49	0.83
9			29.69	3.85	1.24	1.99	3.63	20.17	3.77	4.74	4.36	0.00
10			15.38	5.24	1.71	1.92	2.85	8.87	5.65	2.96	2.32	0.00
11			2.55	1.88	3.21	2.18	1.59	5.66	4.26	8.19	2.62	1.25
12			1.21	2.00	1.66	1.50	1.36	5.53	2.93	11.16	3.24	1.00
13			1.68	1.01	1.67	1.43	2.41	6.15	6.71	5.29	3.46	0.36
14			0.98	1.20	2.35	1.81	2.18	7.15	6.56	3.12	1.76	0.78
15			1.26	1.27	1.44	1.47	2.57	5.02	6.14	1.80	3.97	2.54
16			1.13	1.77	1.36	3.67	2.68	7.89	4.61	0.34	2.62	3.00
17			1.55	1.23	0.72	2.10	4.41	5.94	5.82	0.41	1.11	2.76
18		2.27	1.05	1.25	0.58	2.08	3.71	3.35	2.09	1.01	1.00	3.39
19		6.66	1.25	2.66	0.89	2.57	5.57	2.39	3.15	1.02	3.52	2.90
20		6.00	1.00	1.31	1.00	3.15	4.50	2.68	1.84	1.36	2.09	3.21
21		2.34	0.85	4.40	1.00	4.27	4.17	2.16	2.80	1.18	3.46	2.64
22		1.32	1.00	7.80	1.48	2.96	3.77	1.81	3.20	2.43	5.10	2.18
23		1.34	3.30	3.88	1.71	1.73	2.94	3.60	3.40	3.17	3.08	2.56
24		3.55	2.53	2.59	4.32	1.93	1.90	3.20	3.89	4.92	2.00	2.35
25		2.27	2.21	1.92	4.67	2.55	3.15	3.08	4.48	4.60	1.00	2.06
26		3.80	2.86	2.28	2.56	1.94	4.07	3.49	5.33	3.00	1.22	1.95
27		4.09	2.42	4.68	2.33	1.80	2.56	3.65	7.96	3.00	0.78	1.00
28		14.09	3.71	2.89	2.10	2.44	2.38	4.12	5.02	2.58	1.00	1.65
29			3.13	3.59	1.29	1.24	17.93	4.33	4.58	1.57	1.15	1.56
30			2.18	1.39	1.00	1.18	22.67	10.27	5.07	1.43	1.50	1.14
31			2.60		1.00		11.13	6.53		2.11		1.15
Total		47.75	170.69	119.31	53.03	68.81	142.71	169.96	134.99	97.69	75.90	83.93
Count		11	31	30	31	30	31	31	30	31	30	30
Average		4.34	5.51	3.98	1.71	2.29	4.60	5.48	4.50	3.15	2.53	2.71
Maximum		14.09	47.72	18.12	4.67	4.27	22.67	20.17	7.96	11.16	5.49	21.87
Minimum		1.32	0.50	1.01	0.58	1.18	1.36	1.81	1.84	0.34	0.78	0.00

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			9.03	4.83	3.38	2.73	4.00	13.54	6.92	9.26	1.98	1.38
2			4.18	15.12	2.96	4.82	4.95	18.37	11.95	5.76	3.10	1.10
3			3.75	9.02	3.44	4.99	7.06	13.96	11.57	5.24	5.39	1.98
4			2.72	8.75	2.92	5.93	7.01	7.68	8.94	5.96	7.13	43.38
5			0.99	25.19	3.49	5.82	9.52	10.83	7.71	5.22	9.89	23.22
6			3.87	35.93	1.98	5.25	10.60	7.04	9.47	6.57	4.26	9.08
7			94.65	12.31	2.66	7.31	7.21	5.43	6.60	7.52	3.99	2.49
8			49.73	6.32	2.46	4.63	6.36	8.32	7.71	6.64	10.88	1.65
9			58.90	7.63	2.47	3.94	7.20	40.00	7.49	9.41	8.65	0.00
10			30.51	10.39	3.39	3.81	5.66	17.60	11.21	5.88	4.61	0.01
11			5.06	3.73	6.38	4.33	3.16	11.22	8.44	16.24	5.20	2.48
12			2.40	3.97	3.29	2.97	2.69	10.97	5.80	22.13	6.43	1.99
13			3.33	2.00	3.31	2.83	4.78	12.20	13.32	10.49	6.87	0.71
14			1.95	2.38	4.65	3.60	4.32	14.18	13.02	6.19	3.50	1.54
15			2.49	2.52	2.86	2.92	5.09	9.95	12.17	3.57	7.88	5.04
16			2.24	3.51	2.70	7.28	5.32	15.64	9.14	0.67	5.20	5.94
17			3.08	2.45	1.42	4.16	8.74	11.77	11.55	0.82	2.20	5.47
18		4.51	2.08	2.46	1.14	4.12	7.35	6.64	4.14	2.00	1.99	6.73
19		13.21	2.48	5.28	1.76	5.09	11.04	4.75	6.25	2.03	6.98	5.75
20		11.90	1.98	2.59	1.98	6.25	8.93	5.32	3.65	2.71	4.14	6.36
21		4.64	1.66	8.73	1.98	8.47	8.27	4.29	5.55	2.33	6.86	5.23
22		2.62	1.99	15.46	2.93	5.87	7.48	3.59	6.34	4.81	10.12	4.32
23		2.66	6.54	7.70	3.40	3.44	5.82	7.13	6.75	6.29	6.12	5.07
24		7.04	5.02	5.13	8.57	3.83	3.77	6.35	7.72	9.76	3.98	4.67
25		4.51	4.37	3.81	9.26	5.05	6.24	6.12	8.89	9.12	1.98	4.09
26		7.54	5.67	4.52	5.08	3.84	8.07	6.92	10.57	5.95	2.42	3.88
27		8.11	4.80	9.28	4.62	3.56	5.08	7.24	15.78	5.95	1.55	1.98
28		27.95	7.37	5.72	4.17	4.84	4.73	8.16	9.96	5.12	1.98	3.27
29			6.21	7.13	2.56	2.46	35.56	8.59	9.09	3.11	2.28	3.10
30			4.32	2.75	1.98	2.34	44.96	20.36	10.05	2.85	2.97	2.27
31			5.15		1.98		22.07	12.95		4.19		2.29
Total		94.70	338.56	236.64	105.18	136.49	283.07	337.12	267.75	193.77	150.54	166.48
Count		11	31	30	31	30	31	31	30	31	30	30
Average		8.61	10.92	7.89	3.39	4.55	9.13	10.87	8.92	6.25	5.02	5.37
Maximum		27.95	94.65	35.93	9.26	8.47	44.96	40.00	15.78	22.13	10.88	43.38
Minimum		2.62	0.99	2.00	1.14	2.34	2.69	3.59	3.65	0.67	1.55	0.00

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2002
(units are in cubic feet per second)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.30	2.97	2.52	1.00	1.59							
2	2.30	2.55	3.46	0.66	4.79							
3	4.00	2.24	3.22	1.50	5.46							
4	6.26	2.29	2.20	3.40	2.33							
5	7.35	2.09	0.94	3.08	2.40							
6	5.08	1.71	1.67	2.46	1.71							
7	5.13	1.00	1.18	4.48	1.27							
8	3.87	1.34	3.64	1.93	4.15							
9	2.17	2.29	3.20	1.71	4.81							
10	3.40	0.69	1.74	2.25	195.33							
11	3.91	2.16	6.05	2.28	7.15							
12	3.61	4.60	7.69	2.92	8.23							
13	4.64	4.94	8.35	1.16	4.61							
14	3.93	6.43	6.99	0.15	3.26							
15	4.00	5.84	4.56	1.11	3.36							
16	3.20	3.73	3.45	5.67	3.98							
17	2.22	3.31	2.63	2.62	2.71							
18	1.91	2.50	3.94	1.11	1.84							
19	1.08	2.24	4.22	1.00	1.70							
20	1.11	2.89	1.67	1.40								
21	1.00	1.99	0.79	1.71								
22	0.76	2.17	1.59	1.50								
23	1.00	3.85	2.62	1.41								
24	0.61	2.95	2.83	1.00								
25	1.60	2.68	1.76	1.89								
26	5.03	2.80	2.08	3.00								
27	3.90	2.77	3.06	2.63								
28	5.56	1.90	3.92	2.61								
29	2.75		2.88	1.81								
30	4.96		1.99	1.49								
31	4.28		1.55									
Total	101.94	78.88	98.39	60.94	260.66							
Count	31	28	31	30	19							
Average	3.29	2.82	3.17	2.03	13.72							
Maximum	7.35	6.43	8.35	5.67	195.33							
Minimum	0.61	0.69	0.79	0.15	1.27							

Source: FCDMC Flow Records

PRICE DRAIN
DAILY FLOW RECORDS - 2002
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.59	5.88	5.00	1.98	3.15							
2	4.57	5.05	6.86	1.30	9.50							
3	7.94	4.43	6.38	2.97	10.82							
4	12.43	4.54	4.37	6.74	4.62							
5	14.58	4.15	1.86	6.11	4.76							
6	10.07	3.38	3.30	4.87	3.39							
7	10.17	1.98	2.34	8.89	2.51							
8	7.68	2.65	7.22	3.84	8.23							
9	4.31	4.54	6.35	3.39	9.54							
10	6.74	1.36	3.46	4.46	387.44							
11	7.76	4.29	12.00	4.53	14.19							
12	7.16	9.12	15.25	5.78	16.32							
13	9.21	9.81	16.56	2.30	9.14							
14	7.80	12.75	13.86	0.30	6.47							
15	7.93	11.59	9.05	2.20	6.67							
16	6.36	7.39	6.85	11.25	7.89							
17	4.40	6.56	5.22	5.19	5.37							
18	3.80	4.96	7.81	2.21	3.65							
19	2.13	4.45	8.38	1.98	3.38							
20	2.20	5.73	3.32	2.78								
21	1.98	3.95	1.57	3.39								
22	1.50	4.30	3.16	2.97								
23	1.98	7.64	5.20	2.80								
24	1.21	5.86	5.60	1.98								
25	3.17	5.31	3.48	3.76								
26	9.98	5.54	4.13	5.94								
27	7.74	5.49	6.07	5.22								
28	11.03	3.77	7.77	5.17								
29	5.46		5.71	3.59								
30	9.85		3.94	2.95								
31	8.48		3.07									
Total	202.19	156.46	195.15	120.86	517.01							
Count	31	28	31	30	19							
Average	6.52	5.59	6.30	4.03	27.21							
Maximum	14.58	12.75	16.56	11.25	387.44							
Minimum	1.21	1.36	1.57	0.30	2.51							

Source: FCDMC Flow Records

GROUNDWATER MODEL

Knight Piésold
CONSULTING

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

July 17, 2002

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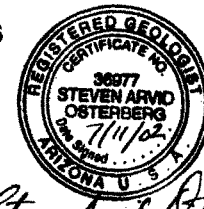

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Project 1889A/0130

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

Table of Contents

List of Figures ii
List of Appendices ii
1.0 Introduction 1
2.0 Hydrogeologic System 2
2.1 Geologic Framework 2
2.2 Conceptual Hydrogeologic Model 3
3.0 Numerical Model 4
3.1 Model Approach 4
3.2 Model Area 4
3.3 Model Selection 4
3.4 Model Grid and Layers 5
3.5 Aquifer Parameters 5
3.6 Aquifer Recharge 6
3.7 Wells 7
3.7.1 Groundwater Levels 7
3.7.2 Well Pumping Rates 8
3.8 Boundary Conditions 9
3.9 Other Model Considerations 9
4.0 Model Calibration 10
4.1 Steady-State Calibration 10
4.2 Sensitivity Analysis 11
4.3 Transient Calibration 11
5.0 Conclusions and Recommendations 14
References R-1

List of Figures

Figure	Title
1-1	Project Location Map
3-1	Flow Chart of Groundwater Modeling Approach
3-2	Refined Groundwater Model Area Finite Difference Grid, Boundary Conditions, Calibration Targets, and Wells
3-3	Refined Groundwater Model Area Recharge Zone Map
3-4	Depth to Groundwater Map
3-5	Hydrographs for Tri-Cities Landfill Monitoring Wells
3-6	Hydrographs for ADWR Monitoring Wells
4-1	Steady-State Potentiometric Surface in the Upper Alluvial Unit
4-2	Sensitivity Analysis for 50% Increase in Groundwater Model Input Parameters

List of Appendices

Appendix	Title
A	Water Level Records
B	Pumping Well Records

Va Shly'ay Akimel
Salt River Restoration Project
Feasibility Study
JAB.01J Groundwater Model
Final Report

1.0 Introduction

A numerical groundwater model[1] has been developed of the Salt River-Pima Maricopa Indian Community (the Community) for the Salt River Restoration Project (SRRP). The model is intended to guide development of habitat and riparian restoration along the Salt River and can be utilized by the Community for future groundwater-related investigations. It is also intended that the model be used by the U.S. Army Corps of Engineers (Corps) in their F3 analysis of options for ecosystem restoration along the Salt River. The project area is centered along the historic channel of the Salt River along the southern extent of the Community (Figure 1-1).

Specific objectives of this investigation include:

- To assess the depth to groundwater along the river channel for comparison to root zone depths
- To assess likely changes in groundwater depth in the future

The approach to the project includes an empirical analysis of the depth to groundwater along the river channel and development of a calibrated numerical groundwater model of the project area by refinement of the Arizona Department of Water Resources (ADWR) regional groundwater model (Corell and Corkhill, 1994). The model has been calibrated to steady-state conditions reflective of groundwater levels that have stabilized in response to long-term stresses on the hydrogeological system. In addition, a transient calibration was completed to evaluate the response of the aquifer to stresses prior to stabilization.

[1] The model represents a simplified description of the aquifer through a series of mathematical equations used to simulate groundwater position and movement. The model is designed to analyze natural conditions of the aquifer and to simulate the effects of groundwater recharge and discharge stresses.

2.0 Hydrogeologic System

2.1 Geologic Framework

Geologically, the project area is situated within the regional Basin and Range Physiographic Province. Within the province, extensional tectonics resulted in development of extensive basin-fill sedimentary deposits and uplifted north-northwest-trending bedrock ranges.

Bedrock exposed in the project area comprises Precambrian to Tertiary-aged crystalline and metamorphic rocks. These rocks crop out along the northeast edge of the project area and extend at depth to the southwest beneath extensive basin-fill sedimentary deposits. Basin-fill deposits range in thickness from 0 feet at the basin margins to several thousand feet within the project area. The deposits generally thicken to the southwest (Corkhill, et al., 1993). The sediments are largely unconsolidated clay, silt, sand, and gravel deposits that developed from erosion of the uplifted crystalline and metamorphic bedrock.

Corkhill, et al. (1993) subdivided the basin-fill deposits into three primary stratigraphic units including the following:

1. **Upper Alluvial Unit (UAU).** The UAU consists mainly of deposits of gravel, sand, and silt. The deposits typically range in thickness from 100 to 300 feet but thin out at contacts with exposed bedrock. Regionally, the UAU represents an unconfined aquifer for which hydraulic conductivity (K) is estimated to vary widely from approximately 20 to 250 ft/day and specific yield (S_y) from 8 to 22 percent.

2. **Middle Alluvial Unit (MAU).** The MAU is overlain by the UAU and comprises mainly clay, silt, and mudstone with some interbedded sand and gravel especially developed near margins of the basin. Within the refined model, the MAU ranges from 100 to approximately 600 feet in thickness and is a major aquifer from which groundwater is extracted. The aquifer has been regionally characterized as unconfined to leaky confined. Regional estimates of K range from 5 to 50 ft/day and S_y from 3 to 14 percent for the MAU.

3. **Lower Alluvial Unit (LAU).** The LAU underlies the MAU and consists mainly of conglomerate and sand near basin margins and mudstone and anhydrite distal from edges of the basin. Volcanic rocks are interbedded within the stratigraphic section. Within the refined model area, the LAU ranges in thickness from 0 feet at the basin margins to 2,000 feet within the basin. The LAU aquifer is described as leaky confined, and hydraulic properties are estimated to regionally be K = 5 to 60 ft/day and S_y = 3 to 15 percent.

Stratigraphically, the entire UAU-MAU-LAU sequence is underlain by crystalline bedrock. Hydrogeologically, the crystalline bedrock represents an impermeable boundary to groundwater within the alluvial sequence.

2.2 Conceptual Hydrogeologic Model

Groundwater flux through the project area is generally northeast to southwest as described by the ADWR (Corkhill, et al., 1993). Recharge of the groundwater comes from several sources including mountain front infiltration, alluvial underflow along the Salt River channel, urban and agricultural irrigation, and groundwater recharge projects at the Granite Reef Underground Storage Project (GRUSP) and Northwest Water Reclamation Plant (NWWRP) (Figure 1-1). As evapotranspiration rates are high (72.4 in/year [Cooley, 1970]) and precipitation relatively low (7.66 in/year [Schmidli, 1996]) within the project area, direct infiltration of precipitation does not contribute to aquifer recharge. Although rare in occurrence, flooding of the Salt River channel does provide some recharge but only on an isolated basis.

Aquifer discharge within the project area occurs by two primary methods. These include pumping wells used for domestic and agricultural purposes and groundwater discharge from the project area by aquifer flow.

3.0 Numerical Model

The ADWR developed a regional numerical (3D-MODFLOW) groundwater model (Corell and Corkhill, 1994) which covered an area of approximately 2,240 mi^2 within the Phoenix AMA including a major portion of the Salt River Valley. Its purpose was, in part, to provide a regional framework upon which groundwater management scenarios could be tested. The model contained grid-cells of 1 mi^2 and three layers corresponding to UAU, MAU, and LAU. For the SRRP, a refined groundwater model has been developed by modification of the regional ADWR model.

3.1 Model Approach

Development of the refined groundwater model includes modeling and calibration of steady-state and transient conditions. The calibrated model simulates the baseline conditions. In the future, when alternative project options are identified by the Corps, the model can be utilized to evaluate the effects on the depth of the water table. The modeling approach is schematically illustrated on Figure 3-1.

3.2 Model Area

The refined model encompasses approximately 85 mi^2 centered on the Salt River (Figure 3-2). The model area extends from approximately the Pima Freeway (the R4E-R5E boundary) on the west to approximately Powers Road on the east. The south edge of the model area occurs along Southern Avenue. At the north edge, the model area generally follows the north boundary of the Community. The model has been developed through refinement of the ADWR model grid, model layers, boundary conditions, recharge, and a compilation of wells as defined by the ADWR "55-series" well database.

3.3 Model Selection

As an initial step in development of a refined groundwater model in the project area, the ADWR 3D-MODFLOW regional groundwater model of the Salt River Valley was acquired. Groundwater Vistas (Environmental Simulations Inc., 2002) was utilized as the modeling pre-processing software to allow compatibility with the ADWR model and specialized capability for telescopic mesh refinement.

3.4 Model Grid and Layers

Using the telescopic mesh refinement tool of Groundwater Vistas, the ADWR regional 1-mi^2 model grid was refined within the present model area to comprise 96 rows, 112 columns, and three model layers to total 32,256 individual cells (Figure 3-2). This represents a subdivision of the regional grid in the area of interest into cells of 1/8- × 1/8-mile dimension. As in the ADWR model, each layer in the refined model corresponds to a single hydrostratigraphic unit representative of the UAU, MAU, and LAU (Corkhill, et al., 1993). The thickness of each layer was taken directly from the ADWR regional model. Within the refined model, the UAU, MAU, and LAU range in thickness from approximately 0 to 300 feet, 100 to 600 feet, and 500 to 2,000 feet, respectively. For simplicity, in the model the layers are not intermixed; however, each layer generally thins toward the east-northeast toward the basin margins and exposed bedrock.

Crystalline and metamorphic bedrock crops out at the east-northeast end of the refined model area. The exposed bedrock is modeled as inactive cells (Figure 3-2).

3.5 Aquifer Parameters

Aquifer properties selected for the refined model were based on calibration (Section 4.0) to existing groundwater level, pumping, and aquifer recharge rates and are generally comparable to those of the ADWR regional model (Corkhill, et al., 1993). Hydraulic conductivities have been modeled as single zones across the model area corresponding to each aquifer layer. The conductivities (K_x, K_y, K_z) and storage parameters (S_y, S) were defined as follows:

Layer	K_x (ft/day)	K_y (ft/day)	K_z (ft/day)	S_y	S
1 (UAU)	150	150	20	0.08	0.001
2 (MAU)	20	20	10	0.03	0.001
3 (LAU)	100	100	50	0.03	0.0001

In final development of the refined groundwater model since the 80 percent completion report (Knight Piésold, 2002), vertical leakage between layers was reconsidered as vertical hydraulic conductivity (K_z) within Groundwater Vistas. This allowed better model calibration to empirical data than the use of leakage factors.

3.6 Aquifer Recharge

As noted in the Conceptual Hydrogeologic Model (Section 2.2), aquifer recharge occurs within the study area at several sites and is considered within the refined model. Rates of recharge are related in the model to land use (Figure 3-3). Two primary sites of focused recharge include:

1. **Granite Reef Underground Storage Project (GRUSP).** GRUSP is an aquifer recharge system where canal surface water is recharged to the UAU aquifer through 216 acres of rapid infiltration basins operated by the Salt River Project (SRP).

2. **Northwest Water Reclamation Plant (NWWRP) Ponds.** Infiltration of treated wastewater effluent from the NWWRP occurs through percolation ponds or directly into the adjacent Salt River channel near the southwest end of the model area near the interchange between the Pima and Loop 202 Highways. Two sets of ponds occur including:

   a. Five ponds totaling 75 acres operated by the Community and located north of the Salt River

   b. Four ponds totaling 27 acres operated by Mesa and located south of the Salt River

A third site of focused recharge (wetlands below Granite Reef) was previously considered in the 80 percent completion report (Knight Piésold, 2002). In final modeling, for simplicity, this source was incorporated in a general head boundary along the Salt River (Section 3.8).

Based on available records (Haws, 2002; Lluria, pers. comm., 2002; Correll and Corkhill, 1994), the modeled rates of recharge at these two sites of focused recharge are as follows:

Site	Recharge Rate (ft/day)
GRUSP	1.17
NWWRP	0.40

In addition to sites of focused recharge, aquifer recharge in the model is also considered to occur as irrigation at varying rates dependent on land use. Three categories of land use are defined in the model as: (1) Urban, (2) Agricultural, and (3) Mixed Agricultural/Residential. Urbanized land use occurs primarily south of the Salt River channel and immediately west of the Community in the cities of Mesa, Tempe, and Scottsdale. Agricultural land with relatively heavy irrigation occurs in the southeast end of the model area and within the Community north of the Evergreen Canal. Land immediately north and south of the Salt River channel in the western

portion of the Community and at the far eastern and southeastern end of the model area is used primarily for mixed agricultural/residential use (Figure 3-3).

Based on the available ADWR records and the regional model (Corell and Corkhill, 1994), the rates of recharge used in the model are as follows:

Site	Recharge Rate (ft/day)
Urban	0.002
Agricultural	0.008
Mixed Agricultural/Residential	0.003

No recharge was considered to occur within the channel of the Salt River (except that associated with NWWRP) as flooding occurs only sporadically in relatively short-lived events. The impact of surface flooding on aquifer recharge is estimated to be relatively minor compared to other recharge sources.

Mountain front recharge is recognized to occur but is non-sensitive in the refined model. For simplicity, it was therefore not included as an input parameter. Also, no infiltration is considered within natural open space areas (Figure 3-3).

3.7 Wells

Groundwater level information from monitoring wells has been utilized within the model for steady-state and transient calibrations. In addition, information on pumping wells, including production rates and pumping periods, has been included.

3.7.1 Groundwater Levels

Water level data utilized in development of the refined model were taken from Community monitoring well records provided by Abel Ramirez (2002, pers. comm.) and from ADWR records (Appendix A). The Community wells are primarily located immediately adjacent to the channel of the Salt River (Figure 3-2). The records include potentiometric data generally from the period March-April of 2001. Based on these data, a depth to groundwater map (Figure 3-4) was constructed for the immediate area of the Salt River channel. The map indicates that groundwater depth ranges from approximately 50 feet near the GRUSP and NWWRP recharge sites to approximately 175 feet north of GRUSP.

Transient groundwater level data provided by Rameriz (2002) from eight monitoring wells that are located near the Tri-Cities Landfill (Appendix A) were also reviewed. ADWR water level records of five monitoring wells located off the Community were also examined. These wells are located within or in close proximity to the model area. For the Tri-Cities Landfill (Figure 1-1) wells, semi-continuous groundwater level records exist since 1990. In these records, a trend of steady increase is noted in all wells from 1994 through approximately early 1996 (Figure 3-5). Thereafter, the trends in water levels are generally stable except for apparent fluctuation related to inflow during 1997. The increase is approximately coincident with initiation of aquifer recharge at the GRUSP facility that is located approximately 2 to 3 miles upgradient of the landfill monitoring wells.

Water level records from the ADWR (Appendix A) of wells on or in the near vicinity of the refined model area were examined. These records are generally from the period 1998 through 2001 and were reviewed for relatively long-term trends. These wells are located greater than 4 miles from the GRUSP site, and some are slightly outside of the refined model area. Records for four of five wells indicate relatively stable trends (Figure 3-6). In a fifth well (No. 607702), the trend is stable to slightly increasing from early 1998 through 2000; no record exists after 2000. This well is located approximately 2 miles south of the Tri-Cities Landfill and approximately 5 miles southwest of the GRUSP site; the slight increasing trend may reflect the delayed effect of aquifer recharge at GRUSP. It is possible that a drop of approximately 25 feet in early 1998 that is evident on this well hydrograph may be reflective of an unidentified nearby pumping well or a mistaken water level measurement.

3.7.2 Well Pumping Rates

Groundwater pumping from wells was simulated in the refined model. One hundred and thirty-six wells for which locations and pumping rates were identified within the ADWR "55-series" database have been included in the refined groundwater model (Appendix B). These wells are located south and west of the Community. Within the refined model where more than one well exists per cell, pumpage was summed as a total per cell. Well depths vary with most wells penetrating all aquifer layers. As well screen information is not available in the ADWR database, pumping was estimated to be proportionally distributed to each aquifer unit intersected. Within the refined model area, wells of the Community were modeled as inactive (non-pumping) according to available records (Roche and Ramirez, 2002, pers. comm.).

3.8 Boundary Conditions

To define the hydrologic conditions at the margins of the model, two major types of boundary conditions were applied within Groundwater Vistas as follows (Figure 3-2):

1. **Constant Head.** Constant head conditions were applied to all boundary cells at the downgradient margins of the model. In Layer 1 (UAU), the head conditions as applied were derived or extrapolated from the potentiometric information (Appendix A) provided by the Community (Ramirez, 2002). For Layers 2 (MAU) and 3 (LAU), as no potentiometric maps were available, head values were set at levels deemed reasonable from 1988 year results in the ADWR regional model.

2. **General Head Boundaries (GHB).** A general head boundary was employed across the aquifer of the Salt River Valley near the upgradient margin of the model. In the model, the GHB accounts for alluvial underflow beneath the Salt River channel. The flux was initially estimated by completion of a flow net analysis utilizing hydraulic conductivity values consistent with the ADWR model for the UAU and an estimated aquifer thickness and width. The GHB was confirmed with mass balance calculations to ensure reasonable flux rates. The steady-state flux was estimated in the model at 4.1 million ft^3/day and is inclusive of a recharge zone at the base of Granite Reef. This value approximates that used in the ADWR regional model for alluvial underflow at the Salt River.

3.9 Other Model Considerations

Phreatophytic vegetation does not presently exist along the channel of the Salt River through the refined model area. As such, no evapotranspiration was considered within the refined model.

4.0 Model Calibration

The model was calibrated to measured water levels in a specific set of monitoring wells to ensure that the refined groundwater model for the Salt River area accurately simulates actual observed field conditions. In the calibration process, input parameters were adjusted to allow the simulated water levels to match the field data. A steady-state calibration of the refined numerical model was completed with the best available record of groundwater levels. These levels reflect relatively stable groundwater conditions at an approximate "snapshot" in time. In addition, a transient calibration has been completed utilizing limited available transient records of groundwater changes along the Salt River.

4.1 Steady-State Calibration

Groundwater levels have been approximately steady since 1998 as noted in hydrographs of the Tri-Cities Landfill monitoring wells (Figure 3-5). Hydrograph records of wells located more regionally (Figure 3-6) also indicate that the hydrogeologic system is in an approximate steady-state condition. As such, a steady-state calibration was completed to water levels in eight representative monitoring wells located primarily adjacent to the Salt River channel (Figures 3-3 and 4-1). The wells are generally distributed from the southwest to northeast extent of the model area.

The available record of stresses on the hydrogeological system and actual associated groundwater levels that best approximate steady-state conditions include the following:

Record	Data/Date	Source
Static Water Levels	Monitoring Well Potentiometric Data (Appendix A)/February-May 2001	Ramirez, 2002
Well Pumping Records	136 wells (Appendix B)/Monthly Average for Year 2000	ADWR database (2001)
GRUSP Recharge	1.17 feet/day / April 2001 record	SRP, pers. comm.. (2000)
NWWRP Recharge	0.40 feet/day (South Ponds and River Channel)/2000 record	Haws, 2002, Mesa report

Steady-state calibration has resulted in simulation of the water table reflecting a general northeast to southwest gradient with recharge mounds developed at the GRUSP and NWWRP sites (Figure 4-1). Comparison of the groundwater table elevations in the selected monitoring wells and elevations calculated in the model for each well are as follows:

Well No.	Groundwater Elevation: Model Observed (ft)	Groundwater Elevation: Model Calculation (ft)	Groundwater Elevation Difference (ft)
WGR-2	1,166	1,160	6
7cbd	1,129	1,124	5
8AAA	1,121	1,116	5
WGR-3	1,202	1,202	0
GW	1,200	1,199	1
MW-3TC	1,121	1,137	-16
MW-1	1,137	1,138	-1
MW-3	1,137	1,136	1

Calibration indicates an average absolute groundwater elevation difference of 4.38 feet between observed and modeled groundwater table levels. One well, MW-3TC, is notably poor in calibration. This may reflect an inaccurately observed or recorded groundwater level during the February-May record period or local, heterogeneous conditions.

If this well is discounted from the calibration well set, an average absolute difference of 2.7 feet occurs between observed and modeled groundwater levels. For a saturated thickness of 100 to 300 feet in the UAU, this represents an approximately 3 to 1 percent error.

4.2 Sensitivity Analysis

To evaluate the sensitivity of the refined model to various aquifer parameters, an analysis was completed of the steady-state model to the effects of variations in several aquifer parameters. These parameters included K; urban, agricultural, mixed agricultural/residential recharge; and GRUSP recharge. In the evaluation, each parameter was increased individually by 50 percent above the steady-state calibrated value. The model was executed after each parameter increase, and the overall change in absolute error was noted. Analysis indicates that the modeled groundwater levels are dominantly sensitive to changes in Layer 3 (LAU) horizontal K (K_x, K_y) and recharge rates at GRUSP (Figure 4-2).

4.3 Transient Calibration

To further test the refined numerical model for the Salt River area beyond the steady-state calibration, a calibration to limited available transient data was completed. This calibration was intended to document that the model responds to changes in stresses in the hydrogeologic system.

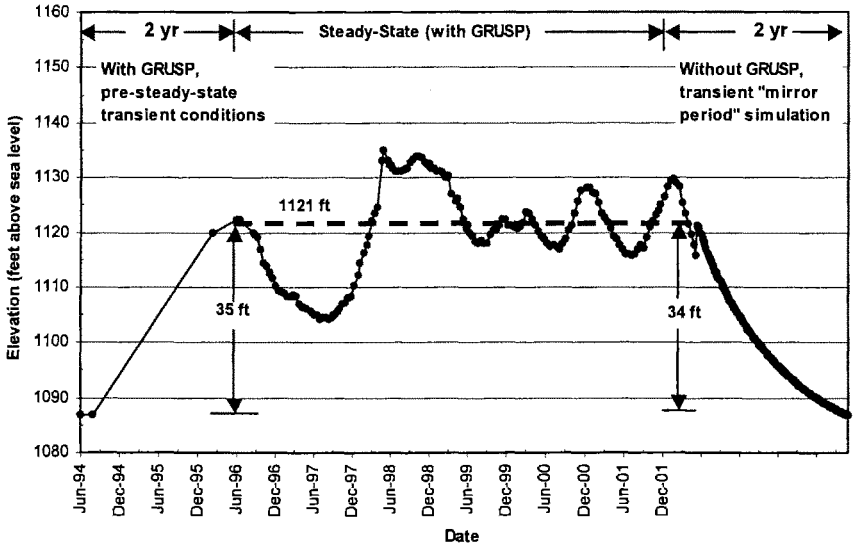
Available transient water level records for the model area are limited to eight Tri-Cities Landfill monitoring wells (Figure 3-5). These records indicate generally consistent trends of increasing water levels from mid-1994 through mid-1996, after which approximate steady-state conditions were reached. Well MW-3TC was chosen as representative of the eight wells as it was also used in steady-state calibration of the groundwater model. All of the eight wells are located in relative proximity to the landfill (within a 2.5-mile radius). Groundwater levels were observed to change in well MW-3TC from 1,087 feet in June 1994 to 1,122 feet in June 1996 for a total of 35 feet over the two-year period. The increased water levels in 1996 were in response to aquifer recharge at the nearby GRUSP site.

To test the reaction of the model to the GRUSP recharge, the model was run using steady-state (post-June 1996) groundwater levels as a baseline reference point for a two-year transient period simulation. This simulation was completed without the GRUSP recharge component. This was intended to simulate the "mirror opposite" reaction of the hydrogeologic system noted between mid-1994 and mid-1996 that resulted from GRUSP recharge. Several transient model trial calibrations were completed by changing the storativity (S) and S_y parameters. Optimum results were achieved for three model layers with the following values:

Layer	S_y	S
1	0.08	0.001
2	0.03	0.001
3	0.03	0.0001

After transient modeling of a two-year period "mirror opposite" simulation without GRUSP, water levels at MW-3TC were calibrated at 34 feet below steady-state levels as graphically shown below. This transient calibration resulted in an absolute error of one foot, indicating that the selected values of S and S_y are reasonable.

Well MW-3TC Hydrograph: Water Levels:
With GRUSP (Observed); Without GRUSP (Transient Model)



GRUSP Forward Trans MW-3TC.xls

5.0 Conclusions and Recommendations

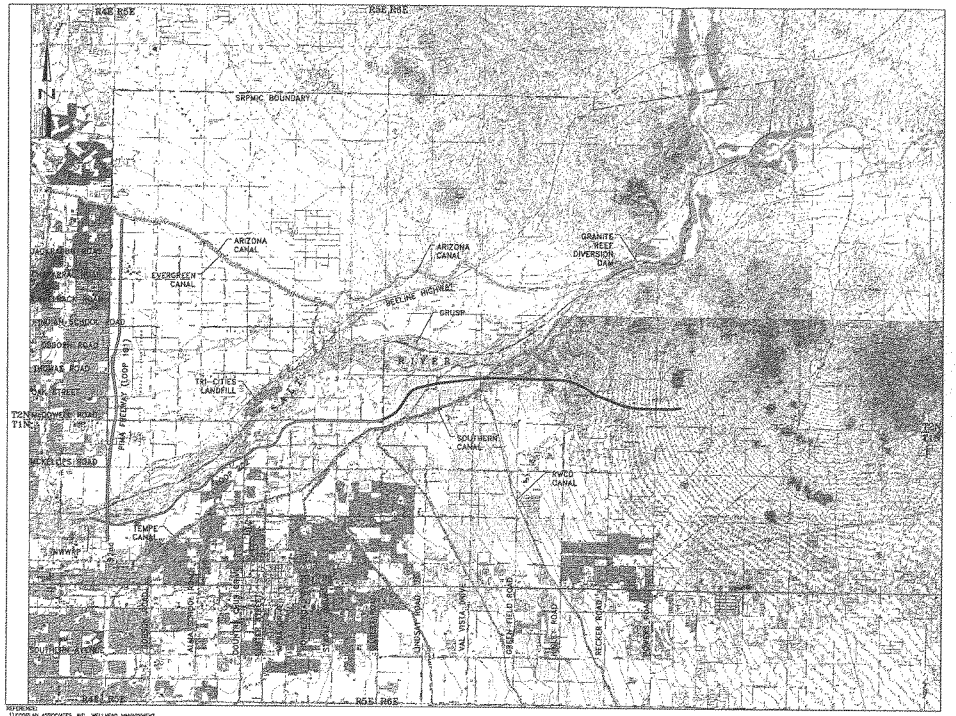
Four primary conclusions and recommendations are made based on the analysis of the Salt River aquifer in the vicinity of the Community. These include:

1. The depth to groundwater along the Salt River channel ranges from approximately 50 feet at GRUSP and NWWRP to 175 feet north of GRUSP based on empirical data. Hydrographs within the project area suggest that the water table has been relatively stable since approximately 1996.

2. A refined numerical groundwater model predicts a relatively stable water table if no additional major stresses are added to the hydrogeological system.

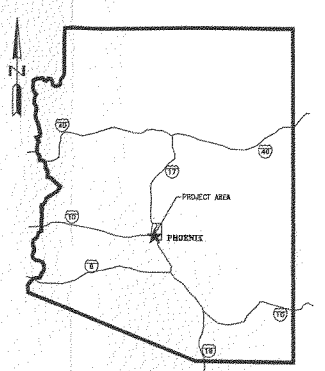
3. To further develop the refined numerical groundwater model, additional data should be systematically collected. Together with the ongoing collection of pumping and aquifer recharge records, these data should include seasonal records of groundwater levels in monitoring wells in the project area. Records from wells along the Salt River channel would be especially useful data.

4. As new stresses in the hydrogeological system such as "with Project Alternatives" are identified, the refined groundwater model can be run forward under transient conditions to evaluate changes in groundwater levels through the project period.



VICINITY MAP

5000 0 5000 10,000 FEET



LOCATION MAP

NTS

LEGEND:

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT
ADWR	ARIZONA DEPARTMENT OF WATER RESOURCES

REFERENCES:

1) DOUGLAS ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

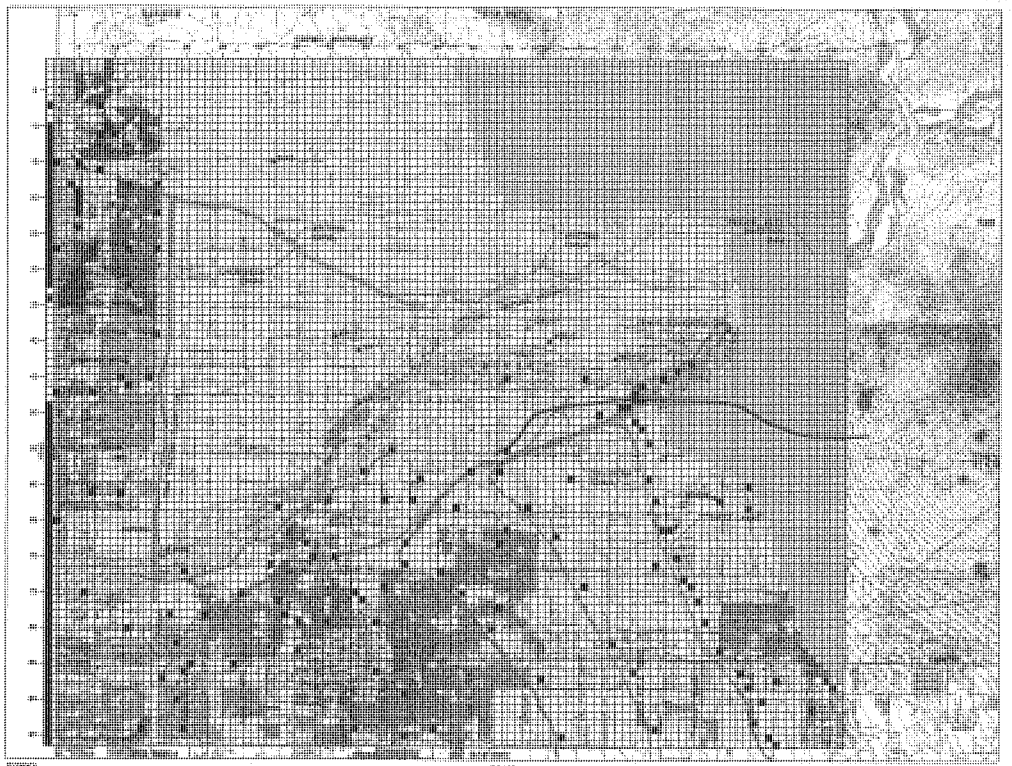
2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1995.

3) DOUGLAS ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

CLIENT	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
PROJECT	SALT RIVER RESTORATION FEASIBILITY STUDY
TITLE	PROJECT LOCATION MAP

Knight Piésold CONSULTING

DESIGNED BY	MDS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
DRAWN BY	WA	APPROVED BY	SAO	5/24/02	12889M10A	1-1	A



PLAN

4000 0 4000 8000 FEET

REFERENCES:

1) DOSPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1996.

3) DOSPLAN ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1993.

LEGEND:

- GENERAL HEAD
- CONSTANT HEAD
- PUMPING WELL
- REFINED GROUNDWATER MODEL AREA BOUNDARY
- FINITE DIFFERENCE GRID
- MW-3TC — COMMUNITY WELL CALIBRATION TARGET
- 628610 — ADWR MONITORING WELL CALIBRATION TARGET
- INACTIVE CELLS
- RWCD — ROOSEVELT WATER CONSERVATION DISTRICT
- GRUSP — GRANITE REEF UNDERGROUND STORAGE PROJECT
- SRPMIC — SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
- NWWRP — NORTH WEST WATER RECLAMATION PLANT
- SRP — SALT RIVER PROJECT
- ADWR — ARIZONA DEPARTMENT OF WATER RESOURCES

CLIENT	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
PROJECT	SALT RIVER RESTORATION FEASIBILITY STUDY
TITLE	REFINED GROUNDWATER MODEL AREA, FINITE DIFFERENCE GRID, BOUNDARY CONDITIONS, CALIBRATION TARGETS AND WELLS

Knight Piésold CONSULTING

DESIGNED BY	MJS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
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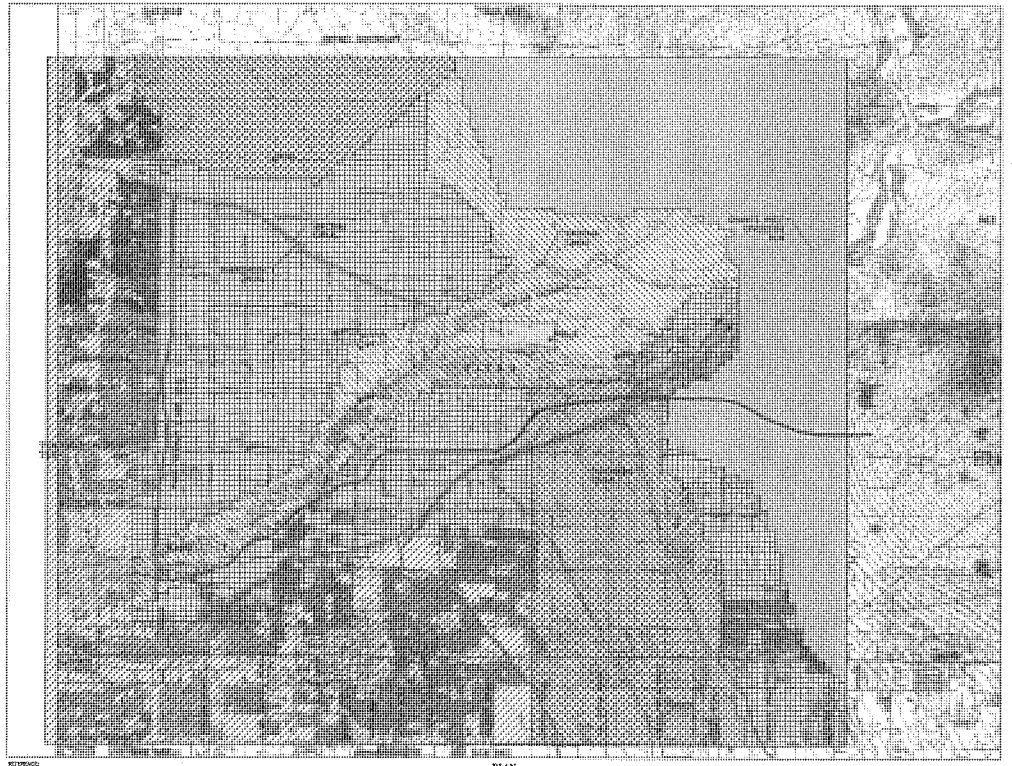

PLAN

4000 0 4000 8000 FEET

REFERENCES:
1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.

2) TERRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1995.

3) ECOPLAN ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.

LEGEND:

- REFINED GROUNDWATER MODEL AREA BOUNDARY
- URBAN
- OPEN SPACE -- NO RECHARGE
- MIXED AGRICULTURE/RESIDENTIAL
- AGRICULTURE
- GRUSP
- NWWRP
- INACTIVE CELLS

RWCD	ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP	CRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP	NORTH WEST WATER RECLAMATION PLANT
SRP	SALT RIVER PROJECT
MW-STC	COMMUNITY WELL CALIBRATION TARGET

CLIENT	SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
PROJECT	SALT RIVER RESTORATION FEASIBILITY STUDY
TITLE	REFINED GROUNDWATER MODEL AREA, RECHARGE ZONE MAP

Knight Piésold CONSULTING

DESIGNED BY	AGS	CHECKED BY		DATE	DRAWING No.	FIGURE No.	REV.
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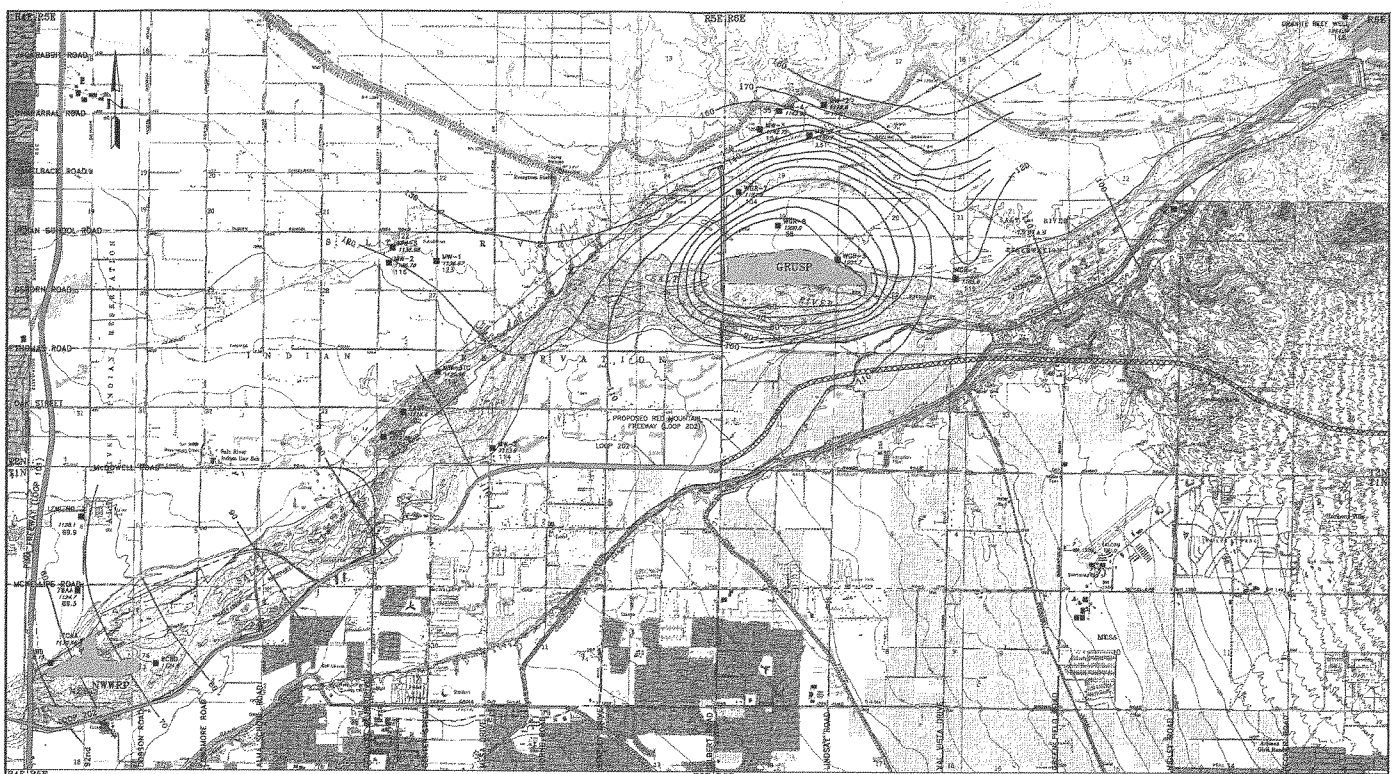
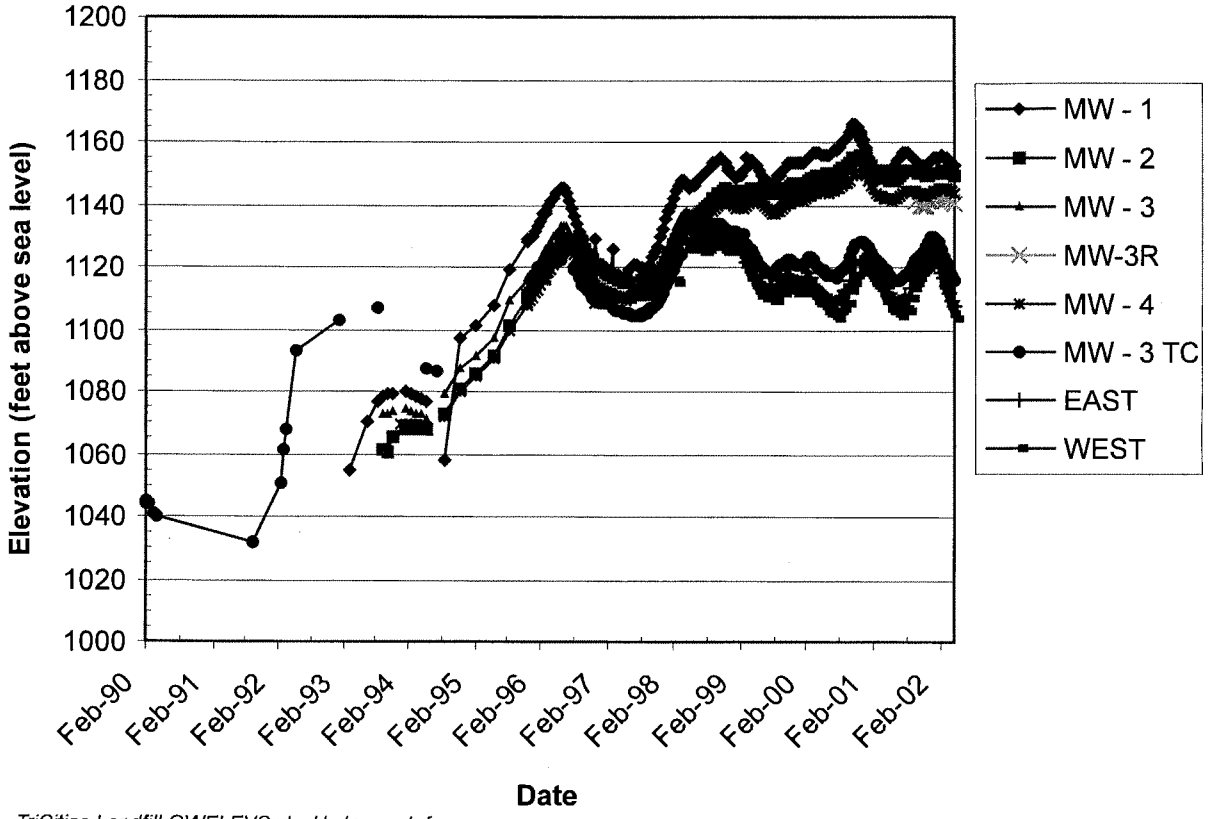

R4E R5E
R5E R6E
R4E R5E
R5E R6E
JACKRABBIT ROAD
CHAPARRAL ROAD
GILBLACK ROAD
INDIAN SCHOOL ROAD
GILBERT ROAD
THOMAS ROAD
OAK STREET
McDOWELL ROAD
McKELLIPS ROAD
GRANITE REEF WATER DELIVERY
GRUSP
SALT RIVER
SALT RIVER INDIAN RESERVATION
INDIAN RESERVATION
PROPOSED RED MOUNTAIN FREEWAY (LOOP 202)
LOOP 202
NWWRP
MESA
GILBERT ROAD
VAL VISTA DRIVE
LINDSAY ROAD
ELLSWORTH ROAD
SOUTHERN PACIFIC RAILROAD
SANTA FE RAILROAD
MOORE ROAD
PRIMROSE ROAD
LEGEND:
110 CONTOUR OF ESTIMATED DEPTH TO GROUNDWATER
MW-2 113.8 MONITORING WELL WITH DESIGNATION AND GROUNDWATER ELEVATION (FEET ABOVE SEA LEVEL)
69.9 DEPTH TO GROUNDWATER (FEET BELOW GROUND SURFACE)
RWCD ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP NORTH WEST WATER RECLAMATION PLANT
SRP SALT RIVER PROJECT
PLAN
2000 0 2000 4000 FEET
REFERENCE:
1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, PROJECTION OF LOW RISK AREAS FOR SITING IP WATER WELLS AND/OR MONITORING OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.
2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1999.
3) ECOPLAN ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1998.
CLIENT SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
PROJECT SALT RIVER RESTORATION FEASIBILITY STUDY
TITLE DEPTH TO GROUNDWATER MAP (MARCH - APRIL, 2001 DATA)
Knight Piésold CONSULTING
DESIGNED BY MDS CHECKED BY DATE
DRAWN BY WA APPROVED BY SAD 6/27/02
DRAWING No. 1889M018
FIGURE No. 3-4
REV. B

Figure 3-5. Hydrographs for Tri Cities Landfill Monitoring Wells



TriCities Landfill GWELEVS.xls Hydrograph form

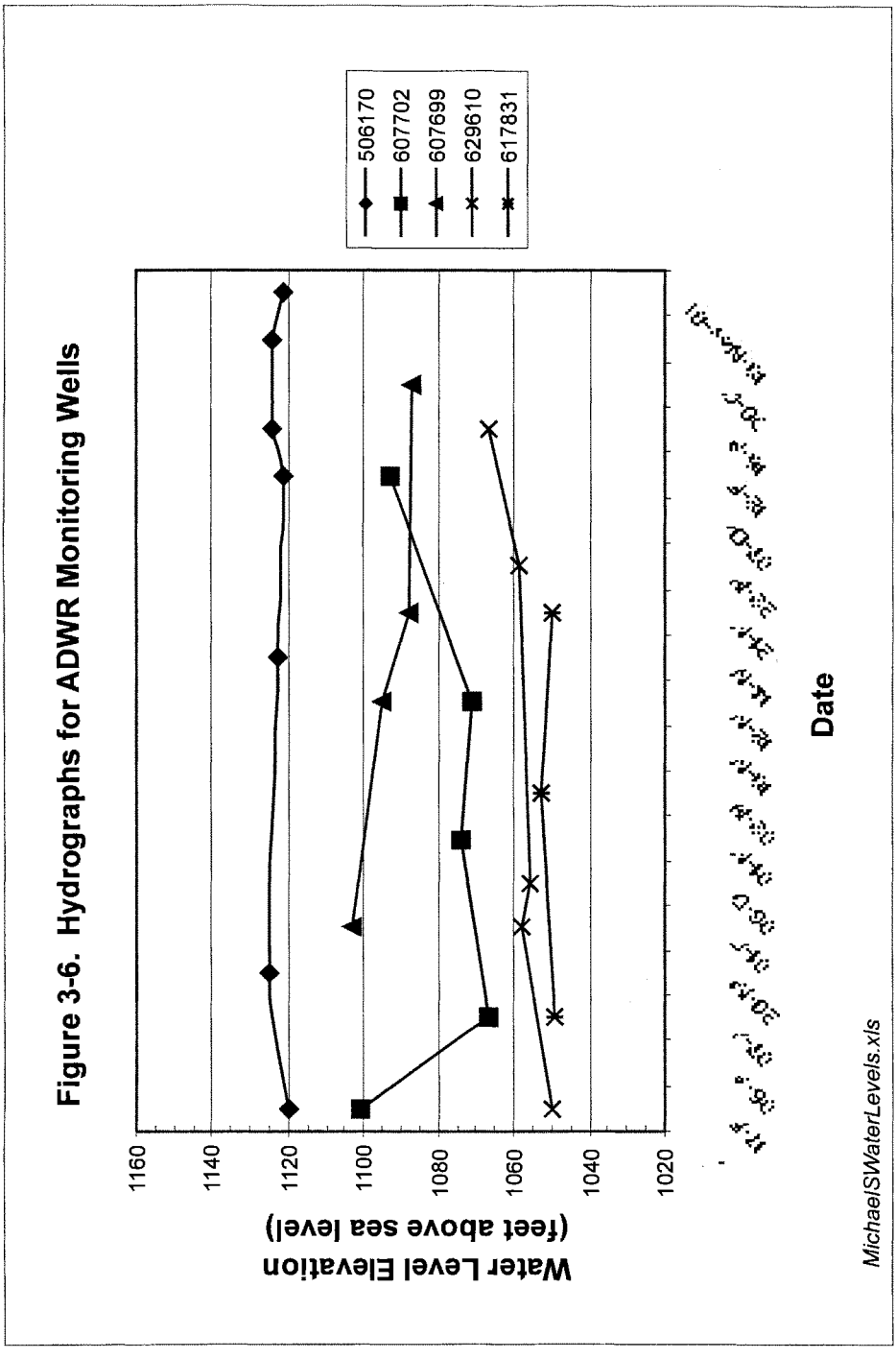


Figure 3-6. Hydrographs for ADWR Monitoring Wells
Water Level Elevation
(feet above sea level)
1160
1140
1120
1100
1080
1060
1040
1020
506170
607702
607699
629610
617831
Date
MichaelSWaterLevels.xls

LEGEND:
1120 POTENTIOMETRIC SURFACE CONTOURS IN UPPER ALLUVIAL UNIT (FEET ABOVE SEA LEVEL)
REFINED GROUNDWATER MODEL AREA BOUNDARY
CALIBRATION TARGET AND COMPUTED WATER LEVEL IN FEET
DRY CELLS
INACTIVE CELLS
RWCD ROOSEVELT WATER CONSERVATION DISTRICT
GRUSP GRANITE REEF UNDERGROUND STORAGE PROJECT
SRPMIC SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
NWWRP NORTH WEST WATER RECLAMATION PLANT
SRP SALT RIVER PROJECT
CLIENT SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
PROJECT SALT RIVER RESTORATION FEASIBILITY STUDY
TITLE STEADY-STATE POTENTIOMETRIC SURFACE IN UPPER ALLUVIAL UNIT
Knight Piésold CONSULTING
DESIGNED BY MDS
CHECKED BY
DRAWN BY WA
APPROVED BY SAO
DATE 5/24/02
DRAWING No. 1889M09A
FIGURE No. 4-1
REV. A
SRPMIC BOUNDARY
GRANITE REEF DIVERSION DAM
ARIZONA CANAL
BEELINE HIGHWAY
GRUSP
RIVER
SOUTHERN CANAL
EVERGREEN CANAL
PIMA FREEWAY (LOOP 101)
JACKRABBIT ROAD
CHAPARRAL ROAD
CAMELBACK ROAD
INDIAN SCHOOL ROAD
OSBORN ROAD
THOMAS ROAD
OAK STREET
McDOWELL ROAD
McKELLIPS ROAD
SOUTHERN AVENUE
POWERS ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
STAPLEY DRIVE
HORNE ROAD
MESA DRIVE
CENTER STREET
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
TEMPE CANAL
R4E R5E
R5E R6E
1200
1190
1180
1170
1160
1110
PLAN
4000 0 4000 8000 FEET
REFERENCES:
1) ECOPLAN ASSOCIATES, INC., WELLHEAD MANAGEMENT STRATEGY, IDENTIFICATION OF LOW RISK AREAS FOR SITING OF NEW WELLS AND/OR MODIFICATION OF EXISTING WELLS AS DOMESTIC WELLS, APRIL 2001.
2) TETRA TECH, INC., CITY OF MESA EXISTING AND CURRENTLY PROPOSED STORM DRAINAGE SYSTEM, SEPTEMBER 1996.
3) ECOPLAN ASSOCIATES, INC., SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY, WATER QUALITY MANAGEMENT PLAN, 1995.

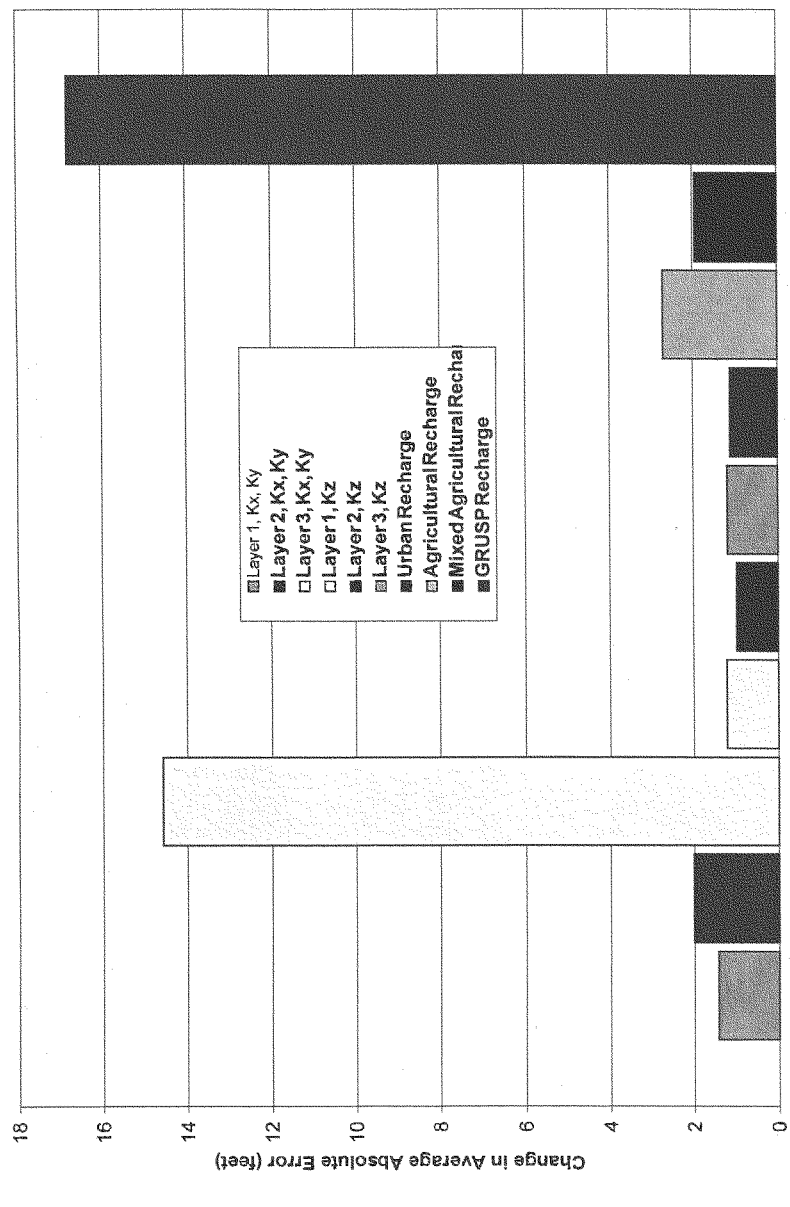


Figure 4-2. Sensitivity Analysis for 50% Increase in Groundwater Model Input Parameters

Appendix A

Water Level Records

Appendix A.
Monitoring Well Water Levels, SRPMIC*
(February-May, 2001 Record Period)

MONITORING WELL	EASTING	NORTHING	DATE:	ELEVATION (FT)	GROUND ELEVATION (FT)	GROUNDWATER DEPTH (FT)
WEST	723944	898612	5/29/2001	1112.75	1220	107
Lehi No.2	710107	894965	2/18/2001	1128.10	1198	70
7BAA	709951	891580	4/6/2001	1124.70	1194	69
7CAA	710211	889254	4/6/2001	1130.46	1195	65
7CBD	708723	888262	3/1/2001	1129.15	1180	51
8CBD	713584	888262	3/1/2001	1124.60	1201	76
MW-2 (North of River)	724145	906546	3/9/2001	1136.78	1253	116
MW-3	724313	907251	3/21/2001	1136.98	1259	122
MW-1	726321	906638	3/21/2001	1136.67	1260	123
MW-3TC	726398	901581	3/29/2001	1120.56	1235	114
EAST	724850	899744	3/29/2001	1115.60	1218	102
MW-2 (South of River)	728934	898127	3/9/2001	1113.60	1228	114
8AAA	721084	923884	3/21/2001	1120.75	1308	187
MW-2 (North of GRUSP)	744076	913871	3/01	1118.80	1295	176
MW-4 (GRUSP area)	742002	913562	3/01	1142.60	1298	155
MW-3 (GRUSP area)	741127	912713	3/01	1142.72	1297	154
MW-1 (GRUSP area)	743416	912471	3/01	1150.70	1282	131
WGR-7	740170	909832	3/01	1152.80	1257	104
WGR-6	741962	908338	3/29/2001	1200.00	1258	58
WGR-3	744722	906776	3/29/2001	1201.70	1262	60
WGR-2	750121	905905	3/29/2001	1165.60	1285	119
GRANITE-REEF-WELL	767967	917960	3/1/2001	1264.34	1380	116
Primate Foundation (GW)	760132	909113	3/01	1200.00	1296	96

* Data Souce: "March/April" 2001 Regional Groundwater Map of SRPMIC, from Abel Ramirez, May, 2002

Appendix A.

ADWR Monitoring Well Water Levels

	Well No.*				
Date:	506170	607702	607699	629610	617831
17-Feb-98	1120				
06-Apr-98				1050	
07-Apr-98		1101			
20-May-98	1125				
01-Dec-98		1067	1103		1055
08-Dec-98				1058	
01-Nov-99				1056	
02-Nov-99					1049
10-Nov-99		1074			
12-Nov-99			1095		
14-Nov-00	1123				
21-Nov-00		1071	1088		
22-Nov-00					1053
07-Dec-00				1059	
12-Feb-01	1121				
16-Aug-01	1124				
30-Oct-01		1093	1087	1067	1050
13-Nov-01	1124				
13-Feb-02	1121				

*Well Location

Well No.	Town	Range	Section	160	40	10
506170	1N	4E	1	NW	SE	NE
607702	1N	5E	9	SE	SW	SE
607699	1N	5E	26	SE	SE	SE
629610	1N	6E	3	NE	SE	SE
617831	1N	6E	21	NW	SW	SW

Appendix A.

Tri-Cities Landfill Monitoring Well Water Levels (Elevation-Feet)

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/22/1990						1044.00		
2/27/1990						1045.00		
3/1/1990						1043.80		
4/5/1990						1041.10		
4/17/1990						1040.20		
9/25/1991						1032.00		
3/4/1992						1050.70		
3/20/1992						1061.40		
3/30/1992						1067.90		
5/28/1992						1093.30		
2/2/1993						1102.60		
Apr-93	1054.45							
Jul-93	1070.57							
Sep-93	1076.53					1107.30		
Oct-93	1078.43	1061.40	1072.59					
Nov-93	1079.39	1060.66	1072.86					
Dec-93	1078.93	1065.58	1073.46					
Jan-94					1069.52			
Feb-94	1079.81	1067.59	1074.04		1069.40			
Mar-94	1079.15	1067.37	1073.66		1069.56			
Apr-94	1078.34	1067.56	1073.01		1069.33			
May-94	1077.67	1068.14	1072.61		1069.22			
Jun-94	1076.67	1067.81	1071.41		1068.47	1087.00		
Jul-94						1086.80		
Sep-94	1058.08	1072.90	1079.12		1072.16			
Dec-94	1097.46	1080.65	1087.62		1080.38			
Mar-95	1101.62	1086.04	1091.14		1085.05			
Jun-95	1107.56	1091.36	1097.52		1090.22			
Sep-95	1119.41	1100.91	1109.31		1099.42			
12/1/1995	1128.47	1109.93	1116.01		1107.50			
12/12/1995	1129.08	1110.96	1116.68		1108.31			
12/15/1996	1129.20	1111.12	1116.95		1108.66			
12/29/1995	1128.92	1112.12	1117.41		1109.54			
1/12/1996	1129.56	1113.09	1117.98		1110.45			
1/25/1996	1131.27	1114.38	1119.15		1111.58			
2/6/1996						1119.80		
2/9/1996	1133.03	1115.78	1120.67		1112.89			
2/23/1996	1134.80	1116.99	1122.11		1114.12			
3/8/1996	1136.82	1118.47	1124.04		1115.72			
3/12/1996	1137.08	1118.63	1124.47		1115.97			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
3/21/1996	1138.33	1119.50	1125.53		1116.89			
4/4/1996	1139.71	1120.72	1126.91		1118.10			
4/18/1996	1141.02	1122.03	1128.26		1119.43			
5/1/1996	1141.99	1123.28	1129.39		1120.45			
5/17/1996	1143.27	1124.74	1130.61		1121.87			
5/29/1996						1122.30		
5/31/1996	1144.32	1126.01	1131.66		1123.04			
6/13/1996	1145.02	1126.98	1132.49		1123.82			
6/14/1996	1145.24	1127.26	1132.69		1124.20			
6/18/1996						1122.20		
6/28/1996	1145.21	1128.27	1133.13		1125.05			
7/12/1996	1143.85	1128.98	1132.69		1125.63			
7/26/1996	1141.63	1129.21	1131.36		1125.65			
8/9/1996	1138.95	1129.07	1129.54		1125.05			
8/20/1996						1119.90		
8/23/1996	1136.41	1128.67	1127.55		1124.18	1119.56		
9/5/1996	1134.06	1128.14	1125.59		1123.10	1118.92		
9/20/1996	1131.21	1127.33	1123.46		1121.80	1116.92		
9/30/1996	1129.43	1126.57	1121.98		1119.06			
10/3/1996	1129.06	1126.58	1121.61		1120.63	1114.45		
10/17/1996	1126.80	1125.47	1119.64		1119.15	1113.95		
11/1/1996	1124.53	1124.28	1117.88		1117.75	1112.66		
11/5/1996						1112.50		
11/14/1996	1124.07	1123.69	1116.89		1116.69	1111.70		
11/27/1996	1121.55	1122.18	1115.26		1115.31	1110.35		
12/13/1996	1120.12	1120.93	1113.93		1114.12	1109.31		
12/26/1996	1120.61	1120.48	1113.78		1113.66	1109.18		
12/31/1996	1120.35	1119.84	1113.52		1113.09			
1/10/1997	1120.73	1119.61	1113.74		1113.07	1108.80		
1/24/1997	1120.13	1118.88	1113.32		1112.44	1108.45		
2/7/1997	1119.63	1118.33	1112.99		1112.20	1108.28		
2/21/1997	1119.04	1117.78	1112.51		1111.72	1108.18		
2/24/1997						1108.60		
3/7/1997	1118.65	1117.63	1112.38		1111.64	1108.21		
3/19/1997	1125.32	1116.93	1111.81		1111.07			
3/21/1997	1118.15	1117.13	1112.03		1111.25	1106.90		
4/3/1997	1117.65	1116.58	1111.54		1110.80	1106.29		
4/16/1997	1117.27	1116.20	1111.24		1110.50	1106.27		
4/30/1997	1117.04	1115.86	1110.99		1110.20	1106.25		
5/16/1997	1116.68	1115.38	1110.72		1109.80	1105.67		
5/22/1997						1105.17		
5/29/1997	1117.58	1115.26	1110.97		1109.76	1105.08		
6/11/1997	1118.99	1115.10	1111.72		1109.85			

700

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
6/13/1997	1119.23	1115.21	1111.89		1109.94	1105.07		
6/26/1997	1119.87	1115.03	1112.31		1110.05	1104.20		
7/11/1997	1120.60	1115.43	1113.09		1110.63	1104.34		
7/24/1997	1120.62	1115.49	1113.18		1110.71	1104.44		
8/8/1997	1120.34		1113.34		1111.11	1104.17		
8/21/1997	1119.75	1115.61	1112.66		1110.80	1104.60		
8/28/1997						1105.00		
9/5/1997	1119.45	1115.78	1112.51		1110.82	1104.98		
9/15/1997	1119.26	1115.73	1112.40		1114.90			
9/19/1997	1119.20	1115.86	1112.34		1110.91	1105.60		
10/2/1997	1119.22	1115.71	1112.09		1110.67	1106.00		
10/16/1997	1121.00	1116.08	1112.94		1111.03	1106.94		
10/30/1997	1123.20	1116.47	1114.16		1111.53	1107.30		
11/13/1997	1124.94	1117.20	1115.70		1112.47	1107.93		
11/25/1997	1126.85	1117.84	1117.12		1113.30	1108.36		
11/27/1996						1110.30		
12/11/1997	1129.57	1118.57	1119.11		1114.48			
12/11/1997	1129.56	1118.70	1119.22		1114.52	1110.15		
12/26/1997	1132.50	1120.38	1121.84		1116.56	1112.13		
1/8/1998	1135.40	1122.03	1124.34		1118.65	1114.30		
1/23/1998	1137.77	1123.73	1126.89		1120.51	1116.18		
2/6/1998	1139.80	1125.26	1128.73		1122.48	1117.70		
2/19/1998	1141.85	1127.14	1130.75		1124	1119.22		
3/3/1998						1121.72	1116.8	1115.4
3/5/1998	1144.67	1129.13	1133.2		1126.3	1122.15		
3/19/1998	1146.08	1130.4	1135.08		1127.68	1123.39		
4/1/1998	1147.6	1132.11	1136.73		1129.43	1124.40		
4/17/1998	1147.54	1133.17	1137.49		1130.76	1133.01		
4/30/1998	1147.05	1134.22	1137.81		1131.68	1134.85	1127.27	1125.55
5/15/1998	1145.47	1134.58	1136.85		1131.92	1133.15	1127.68	1126.2
5/29/1998	1145.9	1135.47	1137.06		1132.36	1132.25	1128.15	1126.04
6/2/1998						1132.10	1127.8	1126.7
6/11/1998	1146.19	1135.93	1137.12		1132.59			
6/12/1998	1146.4	1135.93	1137.09		1132.5	1131.55	1127.94	1125.75
6/26/1998	1147.42	1136.51	1137.74		1133.27	1131.20	1127.81	1126.53
7/10/1998	1148.6	1137.51	1138.61		1133.75	1131.14	1127.85	1125.42
7/24/1998	1149.2	1138.25	1139.34		1134.4	1131	1127.68	1125.27
8/7/1998	1149.9	1139.07	1140.02		1135.24	1131.51	1127.65	1125.24
8/14/1998						1131.7	1127.7	1126.6
8/21/1998	1150.75	1139.72	1140.74		1136.02	1131.77	1127.97	1125.6
9/4/1998	1151.77	1140.64	1141.72		1136.72	1132.77	1129.23	1126.82
9/16/1998	1152.36	1141.29	1142.32		1137.57	1133.4	1129.97	1127.53
9/23/1998	1153.18	1141.89	1142.9		1138.12			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
10/1/1998	1153.49	1142.23	1143.29		1138.45	1133.98	1130.47	1128
10/15/1998	1154.35	1143.37	1144.42		1139.4	1133.9	1130.51	1127.85
10/29/1998	1155.15	1143.74	1145.19		1140.13	1133.55	1129.43	1126.55
11/13/1998	1154.5	1144.28	1145.14		1140.7	1132.66	1128.58	1125.95
11/25/1998	1153.85	1144.93	1144.99		1141	1132.11	1127.78	1125.1
11/30/1998						1132.4	1127.6	1126.3
12/11/1998	1151.53	1144.74	1143.51		1140.38	1131.8	1127.68	1125.24
12/16/1998	1150.94	1144.68	1143.36		1140.51			
12/23/1998	1150.2	1144.43	1142.74		1140.3	1131.57	1128.11	1125.42
1/8/1999	1149.2	1144.04	1141.89		1139.85	1131.1	1127.98	1125.52
1/22/1999	1148.53	1143.64	1141.19		1139.12	1131.06	1127.97	1125.64
2/5/1999	1149.01	1143.8	1141.25		1139.28	1130.94	1128.23	1125.14
2/19/1999	1149.55	1144.13	1142.24		1139.43	1130.13	1127.13	1124.55
2/24/1999						1130.1	1125.4	1124.2
3/5/1999	1150.87	1143.97	1142.67		1139.16	1130.27	1124.17	1121.62
3/17/1999	1154.78	1144.1	1143.09		1139.83			
3/19/1999	1151.54	1143.87	1143.46		1139.78	1127	1121.69	1118.81
4/5/1999	1153	1144.61	1143.94		1140.36	1125.75	1119.99	1116.8
4/15/1999	1154.21	1145.24	1144.91		1141.11	1126.05	1120.28	1117.07
4/29/1999	1153.69	1145.63	1145.05		1141.51	1124.45	1117.93	1114.45
5/14/1999	1152.38	1145.68	1144.39		1141.56	1122.25	1116.33	1112.69
5/28/1999	1151.05	1145.58	1143.49		1140.92	1120.75	1114.23	1110.77
5/31/1999						1121.2	1115	1113.1
6/11/1999	1149.6	1145.33	1142.04		1140.17	1119.77	1114.35	1111.12
6/24/1999	1148.15	1144.73	1140.89		1139.58			
6/25/1999	1148.44	1145.08	1140.69		1139.9	1119.26	1113.78	1110.27
7/9/1999	1146.9	1143.94	1139.69		1138.75	1118.16	1112.98	1109.87
7/23/1999	1146.64	1143.6	1138.9		1137.98	1118.05	1113.16	1109.88
8/6/1999	1146.82	1143.6	1138.61		1137.51	1118.59	1114.29	1111.16
8/20/1999	1147	1143.42	1138.86		1137.26	1117.91	1112.84	1109.47
9/3/1999	1148.05	1143.36	1139.03		1137.48	1117.89	1112.95	1109.53
9/17/1999	1149.01	1143.59	1139.69		1138	1119.7	1115.57	1112.43
9/24/1999	1149.61	1143.86	1140.17		1138.09			
10/1/1999	1150.27	1143.99	1140.74		1138.14	1120.41	1115.68	1112.57
10/14/1999	1151.08	1144.26	1141.24		1138.71	1120.53	1115.53	1112.17
10/28/1999	1152.19	1144.97	1142.14		1139.35	1121.3	1116.78	1113.7
11/11/1999	1153.65	1145.63	1143.27		1140.12	1122.25	1117.48	1114.13
11/23/1999	1153.5	1145.74	1143.73		1140.53	1122.37	1117.59	1114.48
12/8/1999	1153.41	1146.48	1144.12		1141.15			
12/9/1999	1153.24	1146.67	1143.72		1140.98	1121.31	1116.11	1112.85
12/22/1999	1153.12	1146.48	1144.02		1141.19	1121.14	1115.19	1111.89
1/7/2000	1153.21	1146.91	1143.76		1141.5	1121.03	1115.39	1112.4
1/21/2000	1153.3	1147.03	1144.35		1141.65	1120.7	1115.21	1111.66

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/2/2000	1153.55	1146.88	1144.09		1141.49	1121	1115.18	1111.66
2/18/2000	1154	1147.17	1144.74		1141.79	1121.9	1116.36	1113.13
3/3/2000	1155.06	1147.53	1145.44		1142.52	1123.66	1118.37	1115.18
3/15/2000	1156.08	1148.46	1146.54		1143.3			
3/17/2000	1155.67	1148.13	1146.15		1143.05	1123.41	1117.13	1113.62
3/29/2000	1156.57	1148.73	1146.96		1143.57	1122.2	1114.68	1110.8
4/13/2000	1156.8	1149.15	1147.38		1144.03	1121.13	1113.28	1109.27
4/27/2000	1156.4	1149.45	1147.44		1144.3	1120.19	1112.25	1108.42
5/11/2000	1156.18	1149.48	1147.1		1144.32	1119.45	1112.08	1108.22
5/18/2000						1119	1110.6	1107.8
5/24/2000	1156.11	1149.66	1146.71		1144.28	1118.73	1111.34	1107.65
6/8/2000	1156.12	1149.92	1146.76		1144.25	1117.93	1109.96	1105.99
6/22/2000	1156.1	1149.77	1146.53		1144.06	1117.42	1109.47	1105.37
7/5/2000	1156.7	1150.08	1146.73		1144.3	1117.7	1109.74	1105.63
7/21/2000	1157.6	1150.38	1147.28		1144.6	1117.29	1108.68	1104.48
8/3/2000	1157.82	1150.28	1147.63		1144.94	1116.97	1108.28	1103.72
8/17/2000	1158.56	1151.08	1148.33		1145.11	1117.99	1110.08	1105.92
8/31/2000	1159.9	1151.5	1148.96		1145.83	1118.86	1110.93	1106.82
9/14/2000	1160.8	1151.88	1150.13		1146.6	1120.35	1112.51	1108.26
9/27/2000	1162.03	1152.35	1150.77		1147.1	1121.11	1112.98	1108.85
10/12/2000	1163.63	1153.52	1152.19		1148.09	1123.35	1116.08	1112.29
10/24/2000	1164.92							
10/25/2000	1165.25							
10/26/2000	1165.3	1154.7	1153.82		1149.67	1125.6	1118.61	1114.78
10/27/2000	1165.56							
10/30/2000	1165.6							
10/31/2000	1165.53							
11/1/2000	1165.3							
11/2/2000	1165.55							
11/3/2000	1165.59							
11/6/2000	1165.63							
11/7/2000	1165.45							
11/8/2000	1165.2	1155.15	1154.51		1150.1	1127.48	1120.98	1117.42
11/9/2000	1165.37							
11/10/2000	1165.46							
11/13/2000	1164.96							
11/14/2000	1165.1							
11/15/2000	1165							
11/16/2000	1164.82							
11/17/2000	1164.56							
11/20/2000	1164.51							
11/21/2000	1164.5							
11/22/2000	1164.38							

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
11/27/2000	1163.96							
11/28/2000	1163.8							
11/30/2000	1163.7							
12/1/2000	1163.36							
12/4/2000	1163.02							
12/5/2000	1163.12							
12/6/2000	1162.83							
12/7/2000	1162.78	1156.01	1153.57		1150.53	1128.05	1121.95	1118.61
12/8/2000	1162.73							
12/11/2000	1162.06							
12/14/2000	1161.61							
12/18/2000	1160.68							
12/21/2000	1160.75	1155.73	1152.28		1150.2	1128.03	1122.43	1119.18
12/21/2000	1160.6	1155.87	1155.56		1150.18			
12/28/2000	1159.28							
1/2/2001	1158.1							
1/4/2001	1158.05	1154.86	1150.44		1149.06	1127.35	1122.02	1118.9
1/8/2001	1157.43							
1/11/2001	1156.81							
1/15/2001	1156.15							
1/18/2001	1155.5	1153.69	1148.22		1147.69	1126.9	1122.05	1119.09
1/22/2001	1154.8							
1/25/2001	1154.12							
1/29/2001	1153.43							
2/1/2001	1152.9	1152.63	1146.26		1146.25	1125.27	1120.28	1117.01
2/8/2001	1151.73							
2/15/2001	1150.37	1151.08	1144.43		1144.94	1123.56	1118.22	1115
3/1/2001	1149.76	1150.21	1143.31		1143.86	1122.52	1117.39	1114.13
3/5/2001						1122.5	1116.6	1114.6
3/15/2001	1149.35	1149	1142.73		1142.83	1121.75	1116.81	1113.67
3/22/2001	1150.18	1148.98	1143.14		1142.75			
3/29/2001	1150.65	1148.73	1142.72		1142.55	1120.64	1115.69	1112.15
4/12/2001	1150.85	1148.4	1142.86		1142.28	1119.26	1113.23	1109.64
4/26/2001	1150.88	1148.32	1142.79		1142.22	1118.87	1113.33	1109.99
5/10/2001	1150.28	1148.31	1141.91		1141.79	1117.65	1111.49	1108.15
5/24/2001	1150.87	1148			1141.74	1116.81	1110.53	1106.88
6/7/2001	1151.43	1147.86			1141.49	1115.97	1110.07	1106.35
6/19/2001	1152.85	1148.42			1142.05			
6/21/2001	1152.53	1148			1141.72	1116.04	1109.49	1105.96
7/5/2001	1154.12	1148.53			1142.2	1115.8	1108.78	1105.07
7/19/2001	1155.38	1149.35			1142.97	1115.97	1108.93	1104.87
8/2/2001	1156.57	1150.06			1143.74	1116.77	1109.76	1105.82
8/16/2001	1156.99	1150.65			1144.41	1117.6	1110.79	1106.94

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
8/30/2001	1156.55	1151.23			1144.76	1117.2	1109.78	1106.02
9/13/2001	1155.62	1151.21			1144.76	1119.07	1113.65	1110.07
9/27/2001	1154.75	1151.08			1144.46	1120.86	1116.34	1113.17
10/3/2001	1154.5	1151.2		1140.84	1144.48			
10/11/2001	1153.91	1150.83			1144.1	1122.16	1118.31	1115.37
10/25/2001	1153.4	1150.41			1143.88	1123.1	1119.59	1116.4
11/8/2001	1152.94	1150.21		1139.66	1143.4	1124.1	1120.93	1118.07
11/20/2001	1152.53	1149.83		1139.7	1143.2	1125.2	1121.88	1119.22
12/6/2001	1152.6	1149.73		1139.86	1143.1	1126.48	1123.18	1120.27
12/20/2001	1153.56	1149.69		1140.83	1143.41	1128.37	1124.83	1121.9
12/31/2001	1154.3	1149.98		1141.61	1143.94			
1/3/2002	1154.35	1149.82		1141.62	1143.8	1129.47	1125.83	1123.12
1/17/2002	1154.81	1149.97		1142.26	1144.2	1129.82	1126.16	1123.37
1/31/2002	1154.82	1149.95		1142.56	1144.42	1128.8	1124.31	1121.17
2/14/2002	1155.39	1150.55		1143.26	1144.9	1128.45	1123.18	1119.94
2/28/2002	1155.55	1150.81		1143.52	1145.35	1125.34	1118.39	1114.59
3/14/2002	1155.16	1150.72		1143.26	1145.25	1123.46	1116.41	1112.62
3/28/2002	1154.71	1150.64		1142.83	1145.05	1121.53	1114.14	1110.24
4/11/2002	1154.12	1150.36		1142.27	1144.72	1119.55	1111.91	1107.92
4/25/2002	1153.51	1150.08		1141.45	1144.32	1117.55	1109.71	1105.55
5/9/2002	1152.85	1149.73		1140.71	1143.79	1115.64	1107.74	1103.62

Data Source: Ramirez, May, 2002

Appendix B

Pumping Well Records

Appendix A.

Tri-Cities Landfill Monitoring Well Water Levels (Elevation-Feet)

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/22/1990						1044.00		
2/27/1990						1045.00		
3/1/1990						1043.80		
4/5/1990						1041.10		
4/17/1990						1040.20		
9/25/1991						1032.00		
3/4/1992						1050.70		
3/20/1992						1061.40		
3/30/1992						1067.90		
5/28/1992						1093.30		
2/2/1993						1102.60		
Apr-93	1054.45							
Jul-93	1070.57							
Sep-93	1076.53					1107.30		
Oct-93	1078.43	1061.40	1072.59					
Nov-93	1079.39	1060.66	1072.86					
Dec-93	1078.93	1065.58	1073.46					
Jan-94					1069.52			
Feb-94	1079.81	1067.59	1074.04		1069.40			
Mar-94	1079.15	1067.37	1073.66		1069.56			
Apr-94	1078.34	1067.56	1073.01		1069.33			
May-94	1077.87	1068.14	1072.61		1069.22			
Jun-94	1076.67	1067.81	1071.41		1068.47	1087.00		
Jul-94						1086.80		
Sep-94	1058.08	1072.90	1079.12		1072.16			
Dec-94	1097.46	1080.65	1087.62		1080.38			
Mar-95	1101.62	1086.04	1091.14		1085.05			
Jun-95	1107.56	1091.36	1097.52		1090.22			
Sep-95	1119.41	1100.91	1109.31		1099.42			
12/1/1995	1128.47	1109.93	1116.01		1107.50			
12/12/1995	1129.08	1110.96	1116.68		1108.31			
12/15/1996	1129.20	1111.12	1116.95		1108.66			
12/29/1995	1128.92	1112.12	1117.41		1109.54			
1/12/1996	1129.56	1113.09	1117.98		1110.45			
1/25/1996	1131.27	1114.38	1119.15		1111.58			
2/6/1996						1119.80		
2/9/1996	1133.03	1115.78	1120.67		1112.89			
2/23/1996	1134.80	1116.99	1122.11		1114.12			
3/8/1996	1136.82	1118.47	1124.04		1115.72			
3/12/1996	1137.08	1118.63	1124.47		1115.97			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
3/21/1996	1138.33	1119.50	1125.53		1116.89			
4/4/1996	1139.71	1120.72	1126.91		1118.10			
4/18/1996	1141.02	1122.03	1128.26		1119.43			
5/1/1996	1141.99	1123.28	1129.39		1120.45			
5/17/1996	1143.27	1124.74	1130.61		1121.87			
5/29/1996						1122.30		
5/31/1996	1144.32	1126.01	1131.66		1123.04			
6/13/1996	1145.02	1126.98	1132.49		1123.82			
6/14/1996	1145.24	1127.26	1132.69		1124.20			
6/18/1996						1122.20		
6/28/1996	1145.21	1128.27	1133.13		1125.05			
7/12/1996	1143.85	1128.98	1132.69		1125.63			
7/26/1996	1141.63	1129.21	1131.36		1125.65			
8/9/1996	1138.95	1129.07	1129.54		1125.05			
8/20/1996						1119.90		
8/23/1996	1136.41	1128.67	1127.55		1124.18	1119.56		
9/5/1996	1134.06	1128.14	1125.59		1123.10	1118.92		
9/20/1996	1131.21	1127.33	1123.46		1121.80	1116.92		
9/30/1996	1129.43	1126.57	1121.98		1119.06			
10/3/1996	1129.06	1126.58	1121.61		1120.63	1114.45		
10/17/1996	1126.80	1125.47	1119.64		1119.15	1113.95		
11/1/1996	1124.53	1124.28	1117.88		1117.75	1112.66		
11/5/1996						1112.50		
11/14/1996	1124.07	1123.69	1116.89		1116.69	1111.70		
11/27/1996	1121.55	1122.18	1115.26		1115.31	1110.35		
12/13/1996	1120.12	1120.93	1113.93		1114.12	1109.31		
12/26/1996	1120.61	1120.48	1113.78		1113.66	1109.18		
12/31/1996	1120.35	1119.84	1113.52		1113.09			
1/10/1997	1120.73	1119.61	1113.74		1113.07	1108.80		
1/24/1997	1120.13	1118.88	1113.32		1112.44	1108.45		
2/7/1997	1119.63	1118.33	1112.99		1112.20	1108.28		
2/21/1997	1119.04	1117.78	1112.51		1111.72	1108.18		
2/24/1997						1108.60		
3/7/1997	1118.65	1117.63	1112.38		1111.64	1108.21		
3/19/1997	1125.32	1116.93	1111.81		1111.07			
3/21/1997	1118.15	1117.13	1112.03		1111.25	1106.90		
4/3/1997	1117.65	1116.58	1111.54		1110.80	1106.29		
4/16/1997	1117.27	1116.20	1111.24		1110.50	1106.27		
4/30/1997	1117.04	1115.86	1110.99		1110.20	1106.25		
5/16/1997	1116.68	1115.38	1110.72		1109.80	1105.67		
5/22/1997						1105.17		
5/29/1997	1117.58	1115.26	1110.97		1109.76	1105.08		
6/11/1997	1118.99	1115.10	1111.72		1109.85			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
6/13/1997	1119.23	1115.21	1111.89		1109.94	1105.07		
6/26/1997	1119.87	1115.03	1112.31		1110.05	1104.20		
7/11/1997	1120.60	1115.43	1113.09		1110.63	1104.34		
7/24/1997	1120.62	1115.49	1113.18		1110.71	1104.44		
8/8/1997	1120.34		1113.34		1111.11	1104.17		
8/21/1997	1119.75	1115.61	1112.66		1110.80	1104.60		
8/28/1997						1105.00		
9/5/1997	1119.45	1115.78	1112.51		1110.82	1104.98		
9/15/1997	1119.26	1115.73	1112.40		1114.90			
9/19/1997	1119.20	1115.86	1112.34		1110.91	1105.60		
10/2/1997	1119.22	1115.71	1112.09		1110.67	1106.00		
10/16/1997	1121.00	1116.08	1112.94		1111.03	1106.94		
10/30/1997	1123.20	1116.47	1114.16		1111.53	1107.30		
11/13/1997	1124.94	1117.20	1115.70		1112.47	1107.93		
11/25/1997	1126.85	1117.84	1117.12		1113.30	1108.36		
11/27/1996						1110.30		
12/11/1997	1129.57	1118.57	1119.11		1114.48			
12/11/1997	1129.56	1118.70	1119.22		1114.52	1110.15		
12/26/1997	1132.50	1120.38	1121.84		1116.56	1112.13		
1/8/1998	1135.40	1122.03	1124.34		1118.65	1114.30		
1/23/1998	1137.77	1123.73	1126.89		1120.51	1116.18		
2/6/1998	1139.80	1125.26	1128.73		1122.48	1117.70		
2/19/1998	1141.85	1127.14	1130.75		1124	1119.22		
3/3/1998						1121.72	1116.8	1115.4
3/5/1998	1144.67	1129.13	1133.2		1126.3	1122.15		
3/19/1998	1146.08	1130.4	1135.08		1127.68	1123.39		
4/1/1998	1147.6	1132.11	1136.73		1129.43	1124.40		
4/17/1998	1147.54	1133.17	1137.49		1130.76	1133.01		
4/30/1998	1147.05	1134.22	1137.81		1131.68	1134.85	1127.27	1125.55
5/15/1998	1145.47	1134.58	1136.85		1131.92	1133.15	1127.68	1126.2
5/29/1998	1145.9	1135.47	1137.06		1132.36	1132.25	1128.15	1126.04
6/2/1998						1132.10	1127.8	1126.7
6/11/1998	1146.19	1135.93	1137.12		1132.59			
6/12/1998	1146.4	1135.93	1137.09		1132.5	1131.55	1127.94	1125.75
6/26/1998	1147.42	1136.51	1137.74		1133.27	1131.20	1127.81	1126.53
7/10/1998	1148.6	1137.51	1138.61		1133.75	1131.14	1127.85	1125.42
7/24/1998	1149.2	1138.25	1139.34		1134.4	1131	1127.68	1125.27
8/7/1998	1149.9	1139.07	1140.02		1135.24	1131.51	1127.65	1125.24
8/14/1998						1131.7	1127.7	1126.6
8/21/1998	1150.75	1139.72	1140.74		1136.02	1131.77	1127.97	1125.6
9/4/1998	1151.77	1140.64	1141.72		1136.72	1132.77	1129.23	1126.82
9/16/1998	1152.36	1141.29	1142.32		1137.57	1133.4	1129.97	1127.53
9/23/1998	1153.18	1141.89	1142.9		1138.12			

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
10/1/1998	1153.49	1142.23	1143.29		1138.45	1133.98	1130.47	1128
10/15/1998	1154.35	1143.37	1144.42		1139.4	1133.9	1130.51	1127.85
10/29/1998	1155.15	1143.74	1145.19		1140.13	1133.55	1129.43	1126.55
11/13/1998	1154.5	1144.28	1145.14		1140.7	1132.66	1128.58	1125.95
11/25/1998	1153.85	1144.93	1144.99		1141	1132.11	1127.78	1125.1
11/30/1998						1132.4	1127.6	1126.3
12/11/1998	1151.53	1144.74	1143.51		1140.38	1131.8	1127.68	1125.24
12/16/1998	1150.94	1144.68	1143.36		1140.51			
12/23/1998	1150.2	1144.43	1142.74		1140.3	1131.57	1128.11	1125.42
1/8/1999	1149.2	1144.04	1141.89		1139.85	1131.1	1127.98	1125.52
1/22/1999	1148.53	1143.64	1141.19		1139.12	1131.06	1127.97	1125.64
2/5/1999	1149.01	1143.8	1141.25		1139.28	1130.94	1128.23	1125.14
2/19/1999	1149.55	1144.13	1142.24		1139.43	1130.13	1127.13	1124.55
2/24/1999						1130.1	1125.4	1124.2
3/5/1999	1150.87	1143.97	1142.67		1139.16	1130.27	1124.17	1121.62
3/17/1999	1154.78	1144.1	1143.09		1139.83			
3/19/1999	1151.54	1143.87	1143.46		1139.78	1127	1121.69	1118.81
4/5/1999	1153	1144.61	1143.94		1140.36	1125.75	1119.99	1116.8
4/15/1999	1154.21	1145.24	1144.91		1141.11	1126.05	1120.28	1117.07
4/29/1999	1153.69	1145.63	1145.05		1141.51	1124.45	1117.93	1114.45
5/14/1999	1152.38	1145.68	1144.39		1141.56	1122.25	1116.33	1112.69
5/28/1999	1151.05	1145.58	1143.49		1140.92	1120.75	1114.23	1110.77
5/31/1999						1121.2	1115	1113.1
6/11/1999	1149.6	1145.33	1142.04		1140.17	1119.77	1114.35	1111.12
6/24/1999	1148.15	1144.73	1140.89		1139.58			
6/25/1999	1148.44	1145.08	1140.69		1139.9	1119.26	1113.78	1110.27
7/9/1999	1146.9	1143.94	1139.69		1138.75	1118.16	1112.98	1109.87
7/23/1999	1146.64	1143.6	1138.9		1137.98	1118.05	1113.16	1109.88
8/6/1999	1146.82	1143.6	1138.61		1137.51	1118.59	1114.29	1111.16
8/20/1999	1147	1143.42	1138.86		1137.26	1117.91	1112.84	1109.47
9/3/1999	1148.05	1143.36	1139.03		1137.48	1117.89	1112.95	1109.53
9/17/1999	1149.01	1143.59	1139.69		1138	1119.7	1115.57	1112.43
9/24/1999	1149.61	1143.86	1140.17		1138.09			
10/1/1999	1150.27	1143.99	1140.74		1138.14	1120.41	1115.68	1112.57
10/14/1999	1151.08	1144.26	1141.24		1138.71	1120.53	1115.53	1112.17
10/28/1999	1152.19	1144.97	1142.14		1139.35	1121.3	1116.78	1113.7
11/11/1999	1153.65	1145.63	1143.27		1140.12	1122.25	1117.48	1114.13
11/23/1999	1153.5	1145.74	1143.73		1140.53	1122.37	1117.59	1114.48
12/8/1999	1153.41	1146.48	1144.12		1141.15			
12/9/1999	1153.24	1146.67	1143.72		1140.98	1121.31	1116.11	1112.85
12/22/1999	1153.12	1146.48	1144.02		1141.19	1121.14	1115.19	1111.89
1/7/2000	1153.21	1146.91	1143.76		1141.5	1121.03	1115.39	1112.4
1/21/2000	1153.3	1147.03	1144.35		1141.65	1120.7	1115.21	1111.66

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
2/2/2000	1153.55	1146.88	1144.09		1141.49	1121	1115.18	1111.66
2/18/2000	1154	1147.17	1144.74		1141.79	1121.9	1116.36	1113.13
3/3/2000	1155.06	1147.53	1145.44		1142.52	1123.66	1118.37	1115.18
3/15/2000	1156.08	1148.46	1146.54		1143.3			
3/17/2000	1155.67	1148.13	1146.15		1143.05	1123.41	1117.13	1113.62
3/29/2000	1156.57	1148.73	1146.96		1143.57	1122.2	1114.68	1110.8
4/13/2000	1156.8	1149.15	1147.38		1144.03	1121.13	1113.28	1109.27
4/27/2000	1156.4	1149.45	1147.44		1144.3	1120.19	1112.25	1108.42
5/11/2000	1156.18	1149.48	1147.1		1144.32	1119.45	1112.08	1108.22
5/18/2000						1119	1110.6	1107.8
5/24/2000	1156.11	1149.66	1146.71		1144.28	1118.73	1111.34	1107.65
6/8/2000	1156.12	1149.92	1146.76		1144.25	1117.93	1109.96	1105.99
6/22/2000	1156.1	1149.77	1146.53		1144.06	1117.42	1109.47	1105.37
7/5/2000	1156.7	1150.08	1146.73		1144.3	1117.7	1109.74	1105.63
7/21/2000	1157.6	1150.38	1147.28		1144.6	1117.29	1108.68	1104.48
8/3/2000	1157.82	1150.28	1147.63		1144.94	1116.97	1108.28	1103.72
8/17/2000	1158.56	1151.08	1148.33		1145.11	1117.99	1110.08	1105.92
8/31/2000	1159.9	1151.5	1148.96		1145.83	1118.86	1110.93	1106.82
9/14/2000	1160.8	1151.88	1150.13		1146.6	1120.35	1112.51	1108.26
9/27/2000	1162.03	1152.35	1150.77		1147.1	1121.11	1112.98	1108.85
10/12/2000	1163.63	1153.52	1152.19		1148.09	1123.35	1116.08	1112.29
10/24/2000	1164.92							
10/25/2000	1165.25							
10/26/2000	1165.3	1154.7	1153.82		1149.67	1125.6	1118.61	1114.78
10/27/2000	1165.56							
10/30/2000	1165.6							
10/31/2000	1165.53							
11/1/2000	1165.3							
11/2/2000	1165.55							
11/3/2000	1165.59							
11/6/2000	1165.63							
11/7/2000	1165.45							
11/8/2000	1165.2	1155.15	1154.51		1150.1	1127.48	1120.98	1117.42
11/9/2000	1165.37							
11/10/2000	1165.46							
11/13/2000	1164.96							
11/14/2000	1165.1							
11/15/2000	1165							
11/16/2000	1164.82							
11/17/2000	1164.56							
11/20/2000	1164.51							
11/21/2000	1164.5							
11/22/2000	1164.38							

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
11/27/2000	1163.96							
11/28/2000	1163.8							
11/30/2000	1163.7							
12/1/2000	1163.36							
12/4/2000	1163.02							
12/5/2000	1163.12							
12/6/2000	1162.83							
12/7/2000	1162.78	1156.01	1153.57		1150.53	1128.05	1121.95	1118.61
12/8/2000	1162.73							
12/11/2000	1162.06							
12/14/2000	1161.61							
12/18/2000	1160.68							
12/21/2000	1160.75	1155.73	1152.28		1150.2	1128.03	1122.43	1119.18
12/21/2000	1160.6	1155.87	1155.56		1150.18			
12/28/2000	1159.28							
1/2/2001	1158.1							
1/4/2001	1158.05	1154.86	1150.44		1149.06	1127.35	1122.02	1118.9
1/8/2001	1157.43							
1/11/2001	1156.81							
1/15/2001	1156.15							
1/18/2001	1155.5	1153.69	1148.22		1147.69	1126.9	1122.05	1119.09
1/22/2001	1154.8							
1/25/2001	1154.12							
1/29/2001	1153.43							
2/1/2001	1152.9	1152.63	1146.26		1146.25	1125.27	1120.28	1117.01
2/8/2001	1151.73							
2/15/2001	1150.37	1151.08	1144.43		1144.94	1123.56	1118.22	1115
3/1/2001	1149.76	1150.21	1143.31		1143.86	1122.52	1117.39	1114.13
3/5/2001						1122.5	1116.6	1114.6
3/15/2001	1149.35	1149	1142.73		1142.83	1121.75	1116.81	1113.67
3/22/2001	1150.18	1148.98	1143.14		1142.75			
3/29/2001	1150.65	1148.73	1142.72		1142.55	1120.64	1115.69	1112.15
4/12/2001	1150.85	1148.4	1142.86		1142.28	1119.26	1113.23	1109.64
4/26/2001	1150.88	1148.32	1142.79		1142.22	1118.87	1113.33	1109.99
5/10/2001	1150.28	1148.31	1141.91		1141.79	1117.65	1111.49	1108.15
5/24/2001	1150.87	1148			1141.74	1116.81	1110.53	1106.88
6/7/2001	1151.43	1147.86			1141.49	1115.97	1110.07	1106.35
6/19/2001	1152.85	1148.42			1142.05			
6/21/2001	1152.53	1148			1141.72	1116.04	1109.49	1105.96
7/5/2001	1154.12	1148.53			1142.2	1115.8	1108.78	1105.07
7/19/2001	1155.38	1149.35			1142.97	1115.97	1108.93	1104.87
8/2/2001	1156.57	1150.06			1143.74	1116.77	1109.76	1105.82
8/16/2001	1156.99	1150.65			1144.41	1117.6	1110.79	1106.94

	Well No.							
Date	MW - 1	MW - 2	MW - 3	MW-3R	MW - 4	MW - 3 TC	EAST	WEST
8/30/2001	1156.55	1151.23			1144.76	1117.2	1109.78	1106.02
9/13/2001	1155.62	1151.21			1144.76	1119.07	1113.65	1110.07
9/27/2001	1154.75	1151.08			1144.46	1120.86	1116.34	1113.17
10/3/2001	1154.5	1151.2		1140.84	1144.48			
10/11/2001	1153.91	1150.83			1144.1	1122.16	1118.31	1115.37
10/25/2001	1153.4	1150.41			1143.88	1123.1	1119.59	1116.4
11/8/2001	1152.94	1150.21		1139.66	1143.4	1124.1	1120.93	1118.07
11/20/2001	1152.53	1149.83		1139.7	1143.2	1125.2	1121.88	1119.22
12/6/2001	1152.6	1149.73		1139.86	1143.1	1126.48	1123.18	1120.27
12/20/2001	1153.56	1149.69		1140.83	1143.41	1128.37	1124.83	1121.9
12/31/2001	1154.3	1149.98		1141.61	1143.94			
1/3/2002	1154.35	1149.82		1141.62	1143.8	1129.47	1125.83	1123.12
1/17/2002	1154.81	1149.97		1142.26	1144.2	1129.82	1126.16	1123.37
1/31/2002	1154.82	1149.95		1142.56	1144.42	1128.8	1124.31	1121.17
2/14/2002	1155.39	1150.55		1143.26	1144.9	1128.45	1123.18	1119.94
2/28/2002	1155.55	1150.81		1143.52	1145.35	1125.34	1118.39	1114.59
3/14/2002	1155.16	1150.72		1143.26	1145.25	1123.46	1116.41	1112.62
3/28/2002	1154.71	1150.64		1142.83	1145.05	1121.53	1114.14	1110.24
4/11/2002	1154.12	1150.36		1142.27	1144.72	1119.55	1111.91	1107.92
4/25/2002	1153.51	1150.08		1141.45	1144.32	1117.55	1109.71	1105.55
5/9/2002	1152.85	1149.73		1140.71	1143.79	1115.64	1107.74	1103.62

Data Source: Ramirez, May, 2002

GEOTECHNICAL

Contents

Page

1.0 Study purpose ... 4
2.0 Location ... 4
3.0 Land Usage ... 4
4.0 Regional setting ... 6
4.1 Physiography ... 6
4.2 Geology ... 7
4.3 Faulting ... 7
5.0 Study area ... 9
5.1 Physiography and topography ... 9
5.2 Geomorphology ... 9
5.2.1 Slope features ... 9
5.2.2 Channel shifts ... 10
5.2.3 Sediment transport ... 10
5.2.4 Stream sinuosity ... 10
5.2.5 Gradient ... 10
5.2.6 Bed sediments ... 10
5.2.7 Channel types ... 11
5.2.8 Terrace deposits ... 11
5.3 Geology ... 13
5.3.1 Geologic units ... 13
5.3.2 Geologic structure ... 14
5.3.3 Depth and nature of alluvium ... 14
5.3.4 River sediments ... 16
5.3.5 Depth to bedrock ... 16
6.0 Soils ... 17
7.0 Geohydrology and groundwater ... 17
7.1 Basins ... 17
7.2 Aquifers ... 18
7.3 Bedrock ... 19
7.4 Gradient ... 19
7.5 Depth to groundwater ... 20
7.6 Contamination of groundwater ... 20
8.0 HTRW ... 22
8.1 Specific sites assessed beyond the Phase I EA level, with regard to potential environmental impact on the study area ... 23
8.1.1 Talley Defense Systems site ... 23
8.1.1.1 Potential contaminants of concern, releases, pathways ... 24
8.1.1.2 Releases ... 24
8.1.1.2.1 Heavy metals in soils and analysis of risk to groundwater ... 27
8.1.1.2.2 Perchlorate in soils and risk to groundwater ... 28
8.1.1.2.3 Halogenated solvents and other wastes ... 33
8.1.1.3 Proximity to the study area and planned restoration features ... 33
8.1.1.4 Conclusions by Geology & Investigations regarding potential risks from Talley Defense Systems operations ... 34
8.1.2 Landfills ... 36
8.1.2.1 Recommended groundwater equilibrium conditions modeling ... 41
8.1.2.2 Increased proclivity to overbank flooding ... 45
8.1.3 Drum dump site ... 45
8.1.4 VOCs in groundwater, including the Indian Bend Wash Superfund sites ... 45
8.1.5 DBCP in groundwater ... 47
8.1.6 LUSTs ... 47
8.1.7 Minor TSD issues ... 49
8.1.8 Regulated materials use ... 50
9.0 Non-hazardous wastes ... 50
9.1 Concrete, cement, and asphalt dumps ... 56
9.2 Illegal dumps ... 56
9.3 Analysis of non-hazardous waste sites ... 56
10.0 Geologic hazards ... 56
10.1 Faulting and seismicity ... 56
10.2 Subsidence ... 57
10.3 Slope stability ... 58

Contents, contin.

Page

10.4 Foundation conditions ... 58
11.0 Sources of construction materials ... 58
11.1 Concrete Materials ... 59
11.2 Cement ... 60
11.3 Pozzolan ... 60
11.4 Admixtures ... 60
11.5 Water ... 60
11.6 Soil Cement ... 60
12.0 References ... 61

Figures

Fig. 1. Location of the Va Shly'ay Akimel study area ... 5
Fig. 2. Location of USACE projects and study areas along the Salt River ... 6
Fig. 3. Geologic map of the Phoenix Basin ... 8
Fig. 4. Diagrammatic transverse profile of paired terraces on the lower Salt River Valley ... 12
Fig. 5. Terraces of the Lower Salt River in the Va Shly'ay Akimel study area ... 12
Fig. 6. Salt River Valley generalized hydrogeologic cross-section ... 15
Fig. 7. Depth to bedrock in the lower Salt River Valley ... 16
Fig. 8. Talley defense Systems location ... 25
Fig. 9. Detail map of the burn pits, Talley Defense Systems ... 26
Fig. 10. Lead in soil, Talley Defense Systems burn pits ... 29
Fig. 11. Copper in soil, Talley Defense Systems burn pits ... 30
Fig. 12. Lead in soil, adjacent to Talley Defense Systems burn pits ... 32
Fig. 14. Geologic map of the burn pits, Talley Defense Systems ... 35
Fig. 15. Exposed landfill debris on the south bank, Salt River, in the study area ... 37
Fig. 16. Cypress landfill ... 38
Fig. 17. GRUSP groundwater recharge mound ... 42
Fig. 18. Treated wastewater recharge ponds ... 43
Fig. 19. Irrigation canal outlets ... 44
Fig. 20. DBCP in groundwater ... 48
Fig. 21. Non-hazardous waste locations in the study area ... 53
Fig. 22. Additional non-hazardous waste locations in the study area ... 54
Fig. 23. Detail map of non-hazardous wastes in the vicinity of Cypress landfill ... 55
Fig. A-1 Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses ... 80

Tables

Table 1. Geologic units of the Phoenix Basin ... 8
Table 2. Other wastes produced at Talley Defense Systems site ... 33
Table 3. Summary data on landfills in the study area ... 39
Table 4. Non-hazardous wastes and debris catalog, Va Shly'ay Akimel study area ... 51
Table A-1. Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses ... 67

Attachment

Attachment A. Assessment of sites of potential HTRW and non-hazardous waste concerns, with regard to each of the 30 study area Alternatives ... 64
A-1.1 Background ... 64
A-1.2 Overall study concepts and objectives ... 66
A-1.3 Summary of environmental concerns ... 66
A-1.4 Assessment of each study Alternative, in relation to environmental concerns ... 81
A-1.5. Non-hazardous wastes impacts with the footprint of Alternative O ... 92

1.0 Study Purpose. The U.S. Army Corps of Engineers Los Angeles District (USACE LAD), the Salt River Pima-Maricopa Indian Community (SRPMIC), and the City of Mesa have initiated this study to assess the feasibility of ecosystem restoration along the Salt River from Granite Reef Dam downstream to the Pima Freeway (SR 101).

This Geotechnical Appendix for the Feasibility Phase, post AFB ("AFB" is "alternative formulation briefing"), represents the initial and subsequent input to the study by the Corps' Geotechnical Branch with contribution by the Salt River Pima-Maricopa Indian Community and presents the existing geologic conditions of the Va Shly'ay Akimel study area.

2.0 Location. The Va Shly'ay Akimel[1] study area is located on the Salt River Pima-Maricopa Indian Community (SRPMIC), adjacent to the City of Mesa in Maricopa County, Arizona, 18 miles east of the City of Phoenix (see Figure 1). The area is approximately 14 miles long and 2 miles wide, centered on the Salt River, and comprises approximately 17,435 acres. The upstream boundary of the Va Shly'ay Akimel study area is Granite Reef Dam. From here the study area extends southwest to the Pima Freeway (SR 101). The Rio Salado Phoenix environmental restoration project area lies downstream to the west, and extends to about one mile from the western limit of the study area.

3.0 Land Usage. The proposed Va Shly'ay Akimel project activities will occur mostly within the Salt River floodplain. However the study area encompasses overbank lands north and south of the river. The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands (USACE, 2002). The west and central portions of the study area south of the river are largely made up of very low density rural residential areas to higher density suburban residential areas. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern portion of the study area. Four gravel mining operations are located along the Salt River, with processing operations occurring along its banks. The river contains a large groundwater recharge basin in the central portion of the study area. Also along the banks of the river are located two closed landfills, a shooting range, a recreational vehicle park, private farms, and a commercial golf course. The land uses throughout the study area are within the boundaries of the following local government jurisdictions:

- County of Maricopa,
- City of Mesa, and
- Salt River Pima-Maricopa Indian Community (SRPMIC).

The land area north of the Salt River is within the SRPMIC. The SRPMIC lands extend to the south side of the river in places, but this area is mostly within the City's jurisdiction, along with several isolated areas of unincorporated Maricopa County. There are no Federally-owned lands within the study area.

[1] meaning, "the River People"

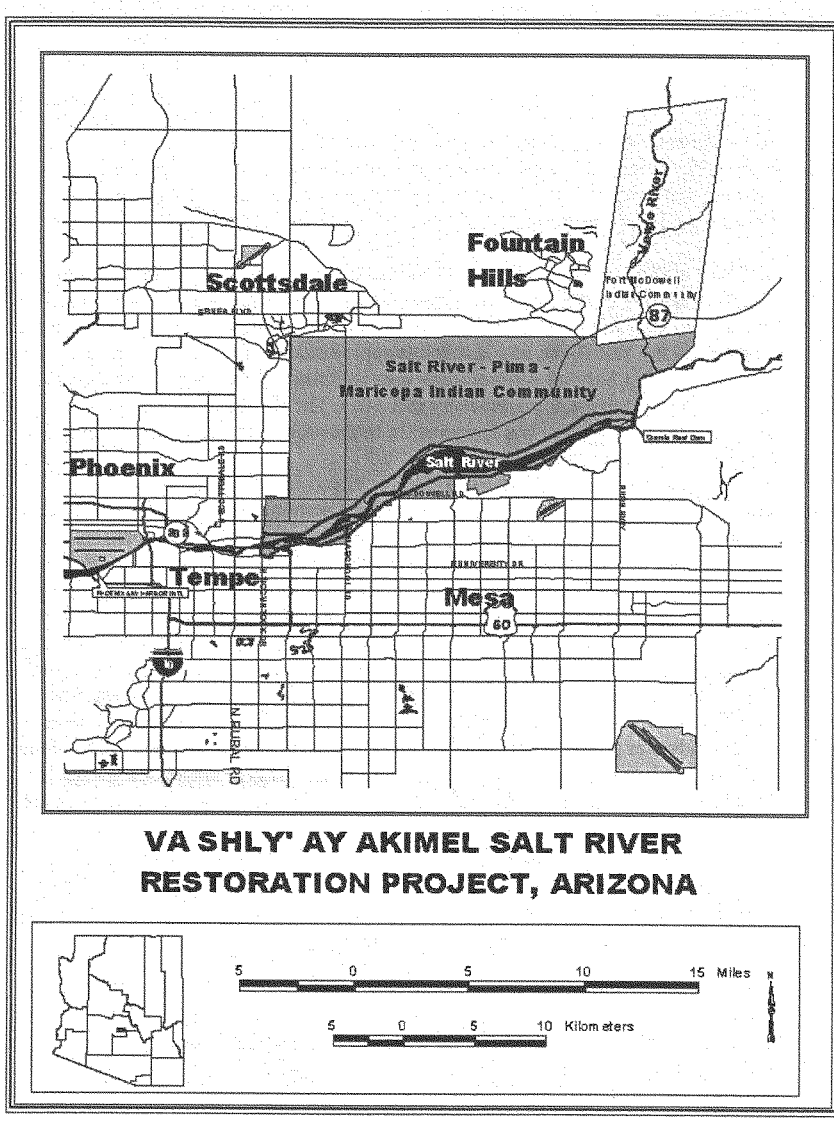


Figure 1. Location of the Va Shly'ay Akimel study area.

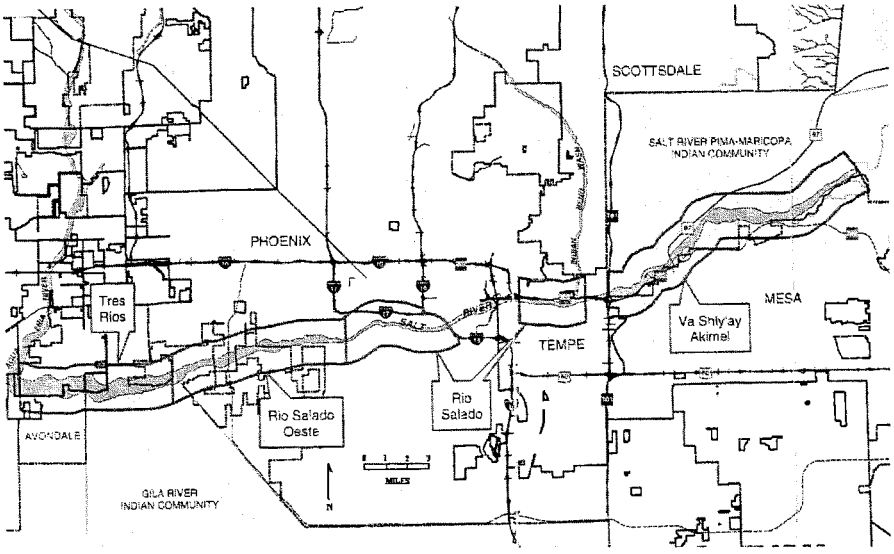


Figure 2. Location of USACE projects and study areas along the Salt River in the Phoenix Area.

4.0 Regional Setting

4.1 ***Physiography.*** The Va Shly'ay Akimel study area lies in the Salt River valley within the eastern part of the Phoenix Basin of south-central Arizona, and is located geomorphically within the Gila Lowland Section of the Sonoran Desert Subprovince, a part of the Southern Basin and Range physiographic province. This province is characterized by broad, gently sloping, interconnected alluvial basins bounded by generally northwest-southeast trending mountain ranges.

The Phoenix Basin is a term loosely applied to a series of topographical and structural basins bounded on the north and east by the Bradshaw-Mazatzal-Superstition Mountains, on the west by the Hassayampa River, on the southwest by the Buckeye Hills, and on the south by the Sierra Estrella and South Mountains (Salt River Mountains on some maps) (Péwé, 1978). Internally, the Phoenix Basin contains several small ranges, including the Phoenix, South, and White Tank Mountains. Several major rivers pass through the area, including the Salt, Gila, Verde, and Agua Fria Rivers. The Salt River enters the basin on the east side, flowing southwestward to its junction with the south-flowing Verde River near the west edge of the Mazatzal Mountains. From this junction near Mesa, the Salt River flows westward across the broad Salt River Valley to its confluence with the Gila River. This reach of the Salt River between the Verde and Gila confluences is herein referred to as the "lower" Salt River. The Gila River continues westward along the northern edge of the Buckeye Hills to its confluence with the Hassayampa River where it turns south toward Gila Bend and exits the basin on its way to the Colorado River. The Agua

Fria River enters the basin from the north near the Hieroglyphic Mountains, and flows south to its confluence with the Gila River near the center of the basin, 15 miles west of Phoenix and 28 miles west of the study area.

Elevations range from over 7,000 feet for the highest peaks of the Mazatzal Mountains, 4,500 feet in the Sierra Estrella, and 2,540 feet in the South Mountains, to a low of about 800 feet on the Gila Riverbed where it exits the basin on the southwest. Interbasin ranges range in height from 3,780 feet in the White Tank Mountains to 2,440 feet in the Phoenix Mountains, to 1,750 feet in the Buckeye Hills.

4.2 ***Geology.*** The study area lies within the East Salt River sub-basin, part of the larger Phoenix Basin of south-central Arizona, within the Southern Basin and Range Province (Figure 3). Geologic structure in the area is dominated by block faulting, which produces a topography of sharp contrasts, in which isolated, almost parallel mountain ranges rise in stark contrast above low-lying desert plains. In many cases, the basin areas are filled with thousands of feet of sediment and debris eroded from the adjacent mountains. However, some of the basin areas are pediments- erosional surfaces cut into the edges of nearby uplands.

The mountain ranges in the Phoenix Basin area consist mostly of Tertiary age sedimentary and volcanic rocks that lie unconformably upon an ancient Precambrian igneous and metamorphic basement complex.

The Precambrian complex is composed predominantly of schist, gneiss, metasedimentary and metavolcanic rocks intruded by granitic to granodioritic plutons. Widespread granitic intrusives were emplaced into this Precambrian basement during the late Cretaceous and early Tertiary Laramide orogeny. Middle Tertiary sedimentary and volcanic rocks rest unconformably on older rocks, and consist of sandstones, siltstones, tuffs, and cemented alluvial fanglomerates. The entire basement is cut by numerous middle Tertiary dikes ranging in composition from granite to diorite. These rocks are overlain and cut by a Miocene volcanic assemblage of basalt and andesite dikes, sills, and flows, latite and rhyolite flows and lithic tuffs, and volcaniclastic rocks.

Late Tertiary Basin-and-Range block faulting formed many of the present-day basins and ranges. Mountain ranges were deeply eroded and shed variably sized clastics into adjacent down-dropped basins. Valley fill reaches up to nearly 12,000 feet thick in the interior of the Phoenix valley. Numerous low-lying isolated hills (inselbergs) project above the valley surfaces. These hills represent peaks of former mountain ranges that are now almost completely buried by alluvial material. Valley fill consists mostly of poorly- to well-consolidated (cemented) and unconsolidated gravel, sand, silt, and clay, representing several environments and ages of deposition. In the Salt River valley area, the sediments were deposited in fluviatile and lacustrine environments and consist of clastic and evaporite sequences. The valley fills tend to be coarser near the mountain fronts, and finer in the interior of the valley. Calcium carbonate cementation is common, and considerable caliche is present near the mountain fronts. In the interior of the valley, most of the valley floor is covered by coarse to fine grained alluvium. This material has been continuously deposited and reworked by the shifting channels of streams draining the mountains.

4.3 ***Faulting.*** Geologic structure in the area is dominated by block faulting attributable to the late Tertiary Basin and Range tectonic event. This extensional event began between 13-10 Ma in

the southern Basin and Range Province, and resulted in formation of most of the present structural basins in southern and central Arizona (Pearthree and Scarborough, 1984). Major extension ceased in the area during the late Miocene or Pliocene.

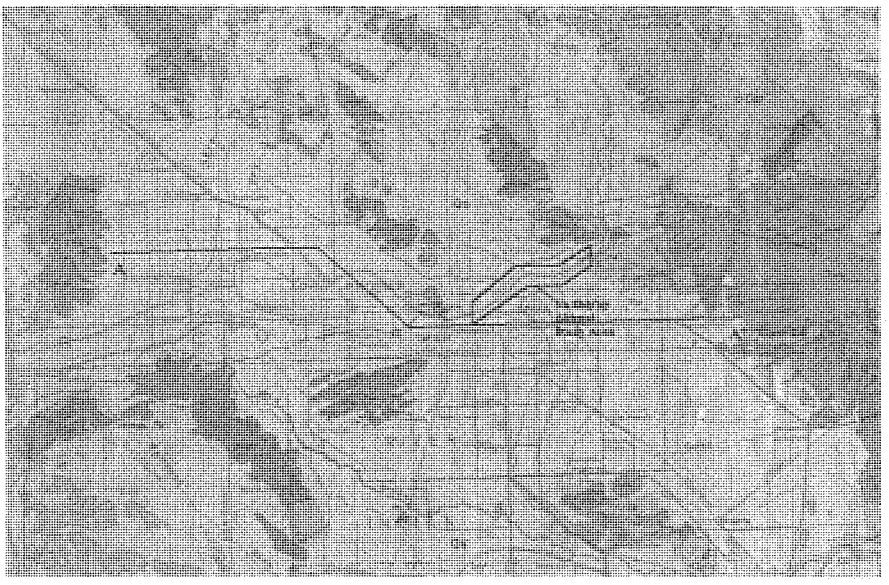


Figure 3. Geologic Map of the Phoenix Basin (from Wilson, et al., 1969). See Table 1 for explanation. See Figure 4 for Hydrogeologic Section A-A'.

Table 1. Geologic Units of the Phoenix Basin (from Wilson, et al., 1969)

Map Symbol	Geologic Time	Lithology
Qs	Quaternary	Alluvial gravel, sand, and silt in flood plains, terraces, fans, and pediment cappings.
QTb	Quaternary/Tertiary	Basaltic flows, agglomerate, tuff, and cinders.
Tvs	Tertiary	Silicic volcanic rocks.
Ti	Tertiary	Dikes, sills, and plugs of rhyolitic to basaltic composition.
TKs	Late Cretaceous Early Tertiary	Sedimentary rocks, and local volcanic rocks. Includes Cloudburst Formation in Pinal County.
TKg	Late Cretaceous Early Tertiary	Intrusive igneous rocks consisting of granite, quartz monzonite, granodiorite, quartz diorite, and porphyry equivalents. Laramide Orogeny.
pCgr	Precambrian	Intrusive igneous rocks consisting of granite, quartz monzonite, granodiorite, and quartz diorite.
pCm	Precambrian	Mazatzal Quartzite.
pCgs	Precambrian	Nonfoliated greenstone.
pCsc	Precambrian	Yavapai Series mica schist, phyllite, slate, and amphibolite.

pCgn	Precambrian	Gneiss.

Quaternary-age faulting in Arizona is mostly confined by a northwest-trending belt, which bisects the state, separating domains of little or no neotectonic faulting in the northeast (Colorado Plateau Province) and southwest (Southern Basin and Range Province) (Menges, 1984). Historically, the Phoenix area possesses a very low level of seismicity, and evidence of late Quaternary faulting is sparse (Pearthree and Scarborough, 1984). Quaternary faults in southern and central Arizona consistently show evidence of very long recurrence intervals, on the order of 100,000+ years, and displacement rates of <0.03mm/yr (Pearthree and Scarborough, 1984). The nearest mapped Quaternary faults are found to the north of the study area along the western flanks of the Mazatzal Mountains (Pearthree and Scarborough, 1984). These faults are composed of short northeast and north-south segments, the nearest of which is the Carefree Fault 20 miles due north of Mesa and 16-17 miles north and northwest of the study area.

5.0 Study area

5.1 ***Physiography and Topography.*** The study area includes river channel and overbank areas. The width of the Salt River floodplain in the study area ranges from 0.25 mile to 1.0 mile wide. Topographic relief is generally very low to flat, with 0-2% slopes, ranging from an elevation of 1,300 feet in the Salt River bed at Granite Reef Dam at the upstream (east) end of the area, gently sloping down to about 1,175 feet elev. at the downstream (west) end. In the eastern portion of the project, low hills of the Usury Mountains form the banks and uplands south of the Salt River, and rise to 50 to 150 feet above the riverbed. The highest of these, Schlechts Butte on the southeast side of Granite Reef Dam, rises to 1,798 feet elevation. The lower flanks of Mount McDowell extend into the northeast corner of the project area, where they rise about 100 feet above the riverbed at Granite Reef Dam.

The Va Shly'ay Akimel study area is located within Township 1 North, Range 5 East, Sections 3, 4, 7, 8, and 9, Township 2 North, Range 5 East, Sections 25, 26, 33, 34, and 35, and Township 2 North, Range 6 East, Sections 13, 14, 22, 23, 24, 27, 28, 29, and 30 of the Gila and Salt River Baseline and Meridian.

The study area is covered by the following topographic map sheets: Mesa, Arizona 1:250,000 sheet; Mesa, Ariz. 1:62,500 sheet; and Tempe, Mesa, Buckhorn, and Granite Reef Dam, Ariz. 1:24,000 sheets. The Flood Control District of Maricopa County possesses more detailed (4-foot contour interval) topographic maps of the Salt River channel areas and the overbank areas.

5.2 ***Geomorphology.*** A discussion of the geomorphology along the lower Salt River can be found in the 2000 Tres Rios Feasibility Study Environmental Impact Statement, Section 3.2 Geology and Geomorphology. Topics covered include slope features, channel shifts, sediment transport, sinuosity, gradient, bed sediments, and channel types. The following sections 5.2.1-5.2.7 are largely summarized from this report. Drosendahl (1988) provides a good overview of the terrace deposits along the Salt River, as well as other geomorphic features.

5.2.1 *Slope Features.* The lower Salt River is associated with three pediment-inselberg complexes in the surrounding terrain: the Spook, Papago, and Bush Pediments (Drosendahl, 1988). A pediment is a ramp-like erosional feature common in semiarid regions. Pediments form at the base of mountains or extend outward from the base of an inselberg (e.g. Papago Buttes). Pediments are characterized by: (1) a well-defined break in slope between the pediment surface and the inselberg hillslope of the same rock type, and (2) a bedrock surface, in some

cases covered with a layer of alluvium with a thickness that is no more than 1/100 of the width of the pediment.

5.2.2 *Channel Shifts*. The geomorphologic history of the lower Salt River is very complex. It is characterized by scour-and-fill events, floods, and channel shifts. Historically, the Salt River has been characterized by the meandering nature of the river system. However, more recently, urban development in the region has changed the lower Salt River from a meandering channel to a straight channel with high banks in several reaches downstream from the study area.

Comparative photographs show that the Salt River channel has shifted within the floodplain several times from the 1880s to the present, meandering on the north side of the floodplain during some periods and on the south side during others. Channel shifts have distributed alluvial material across the entire width of the floodplain. The alluvium deposited by the river consists of cobbles, sands, silts, and clays from numerous tributary streams within the watershed. Well log data show that this depositional history has been continuous over a long period of time.

5.2.3 *Sediment Transport*. The Salt River is dominated by scour-and-fill events, which degrade the river in some areas and aggrade it in others. The scour-and-fill transportation of sediment has produced numerous thick deposits within the fluvial system: cobble lag surfaces, sand sheets (macro-forms), channel side bars, midchannel bars, point bars, and overbank deposits. Many of these deposits have been disturbed by intensive mining for sand and gravel within the study area. Mining alters later transportation events by removing and compacting material, thereby reducing the amount of sediment transported, and loosening other sediments; also, sand pits serve as depositional traps for fine sediments.

Sediment transported in a scour-and-fill setting tends to move in waves or pulses, rather than at a constant rate through time. In essence, slugs of sediment are moving downstream periodically during flow events. The historical photography confirms that floodflows are probably the most important events in the transportation of sediment. Floodflows have the highest potential to move material. During a flood, the bulk of the sediment is moved as bedload, but there is also movement of sediment as washload, in solution and suspension. Prior to damming of the Salt River, smaller flow events moved sediment (fine sands, silts, and clays) by incising downward into the larger slugs of sediment found in the channel. However, the amount of sediment moved in these smaller events is small in comparison with the amount of material moved during a flood.

5.2.4 *Stream Sinuosity*. Despite notable location changes from time to time, the main channel of the lower Salt River has had a consistent sinuosity over the past century. Deviations in the sinuosity of the lower Salt River have been surprisingly small over the last 125 years. The channel may radically adjust its position, but overall it generally preserves the mean sinuosity-a meander eliminated in one location is almost always replaced by a meander in a different but nearby position.

5.2.5 *Gradient*. The average gradient of the lower Salt River between Granite Reef Dam and the confluence with the Gila River is about 9.5 feet of vertical drop per mile of horizontal distance, although there are numerous local variations. The gradient has decreased a small amount because of erosion in the upper reaches and deposition in the lower reaches.

5.2.6 *Bed Sediments*. Channel degradation in Mesa and Tempe has resulted in substantial changes in bed sediments in the Salt River in that area. As the channel cut downward, it exposed a series of well-defined strata. Numerous historical photographs show that the channel was sandy before 1978, except at a few locations where cobble bars were common, such as McDowell Crossing (about 2 miles east of Gilbert Road, below Granite Reef Dam). Downcutting during the 1978 floods removed this sandy layer and began exposing a cobble layer. The 1980 flood further excavated the channel bed, in some places cutting completely through the cobble layer and extending into a mixed sand and cobble zone beneath. Later, smaller flows continued the excavation, in some places down to still another cobble layer.

Part of the explanation of the downcutting of the Salt River channel in Tempe and Mesa is that upstream dams are storing sediments once carried by floodflows, so the relatively clear water entering the study area is capable of entraining sediments that are not replaced by materials from upstream. The 1978-1980 flows may also have been so large that degradation would have occurred in any case.

5.2.7 *Channel Types*. The channel of the lower Salt River exhibits a variety of geomorphologically defined segments, with each segment having distinctive characteristics. These channel segments fall into two broadly defined categories: braided and compound.

Those segments that are braided channels have more than one low flow channel, usually one that is clearly the thalweg and additional channels that are occupied only at moderate or high flows. These channels are separated from each other by sand bars, sand sheets, or "midchannel" bars. In general, the braided configuration is the natural product of four controlling factors, all of which occur in the study area channels. First, braided channels typically carry large amounts of sediment compared with the capacity of the stream, and the lower Salt River appears to be "overloaded" with sediment in the lower reaches (downstream of the study area). Second, such streams also have gradients that are relatively steep, or they generate high amounts of stream power. The lower Salt River has a relatively shallow gradient, but during floodflows, those discharges that shape the channel and accomplish sediment transport on a large scale, stream power is likely to be high. Third, braided channels have erodible banks, a condition common along parts of the lower Salt River. Finally, braiding usually results from highly variable discharges, such as those found dryland rivers such as the Salt River. For these reasons, braiding of at least parts of the lower Salt River channel is the natural tendency of the system.

The second general channel type found in the lower Salt River is the compound form (also referred to as "channel in channel"). Compound channels function with two modes of operation: one at low flow, when water occupies a single, meandering channel, and the other at high flow, when water occupies a much broader "braided" channel. Compound channels are common in dryland settings downstream from dams, irrigation areas, and urban areas because wastewater and occasional natural low flows maintain the low flow meandering channel. If this low flow channel has sufficient discharge, it becomes unstable and is an erosion hazard. When meanders are abandoned, they are known locally as sloughs or oxbows. They are the sites of standing water for a period and eventually fill with sediment during moderate floods. Upstream dams prevent moderate flows, but occasional catastrophic floods (perhaps accompanied by spills from the dam) form the broad, braided part of the channel.

5.2.8 *Terrace Deposits*. Prominent terraces of the Salt River are conspicuous upstream from Tempe (Péwé, 1978). The terraces represent episodic regional uplift of the ranges surrounding the Phoenix Basin during late Cenozoic time. The terraces consist of thick, well-cemented to non-cemented sand and gravel, and are considered older than the alluvium within the confines of the Salt River. The terraces form gently sloping (0-2%), undulatory surfaces of low relief. Four terraces are present rising eastward from Tempe to Stewart Mountain Dam (approximately 10 miles upstream from Granite Reef Dam). From oldest to youngest, these are the Sawik, Mesa, Blue Point, and Lehi Terraces (see Figure 4).

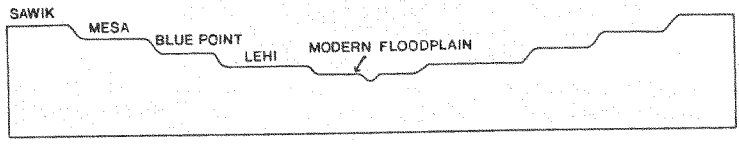


Figure 4. Diagrammatic transverse profile of paired terraces on the lower Salt River (after Péwé, 1978).

The Sawik Terrace is the oldest Salt River terrace, and ranges from 120 to 180 feet above the river from west to east across the greater study area. A 60 to 80 foot high scarp separates the Sawik Terrace from the younger Mesa Terrace. Highly dissected remnants of the Sawik Terrace can be found capping the foothills of Mount McDowell northwest of Granite Reef Dam, and in the hills southwest of the dam (Figure 5). Caliche is very strongly developed within Sawik alluvium, in layers up to 45 feet thick (Péwé, 1978), with lamellar caliche occurring at the surface locally.

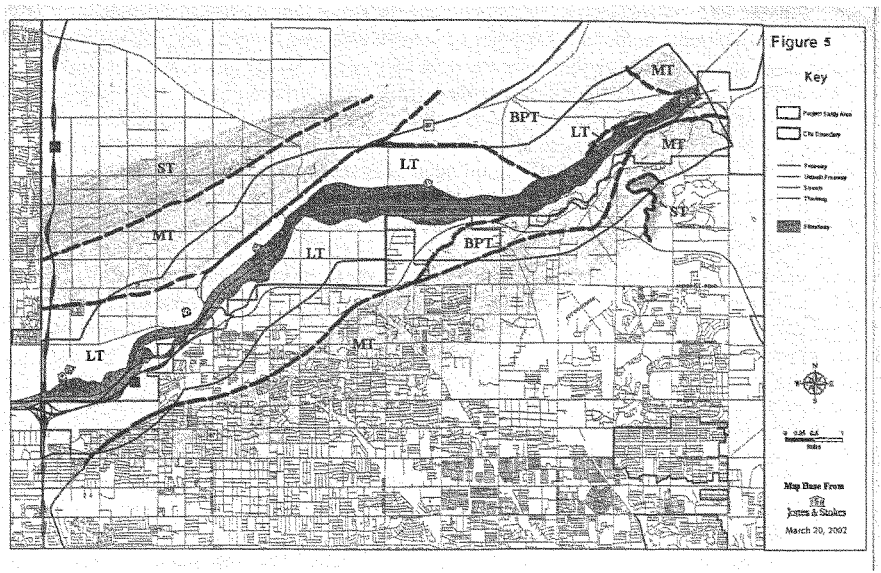


Figure 5. Terraces of the Lower Salt River in the Va Shly'ay Akimel study area (after Péwé, 1978). LT= Lehi Terrace, BPT= Blue Point Terrace, MT= Mesa Terrace, ST= Sawik Terrace.

Highly dissected remnants of the Mesa Terrace can be found in the central part of the study area on the north side of the Salt River, and on the north bank at Granite Reef Dam (Figure 5). The Mesa Terrace ranges from 80 feet to 160 feet above the present Salt River bed across the study area. Like the Sawik Terrace, caliche is extensively developed within Mesa Terrace alluvium, showing horizons with well-developed laminar layers up to many feet thick (Péwé, 1978). A 40 foot scarp separates the Mesa Terrace from the younger Blue Point Terrace.

The Blue Point Terrace is the second largest terrace of the Salt River. A 10 to 20 foot high scarp separates this terrace from the younger Lehi Terrace, and it is approximately 20 to 40 feet above the present river channel in the area (Drosendahl, 1988). Caliche development is weak. The largest remnants of the Blue Point Terrace in the study area are located on the north and south sides of the river in the eastern portion of study area, where they are covered by up to 60 feet of slope wash, alluvial, and eroded pediment material (Figure 5).

The Lehi Terrace is the youngest Salt River Terrace, and is actually part of the modern floodplain of the Salt River; however, it has not been inundated since the completion of the upstream dams. The terrace is approximately 5-10 feet above the river channel in the study area. The back scarp between this terrace and the older Blue Point Terrace marks the limit of flooding (Drosendahl, 1988). Lehi Terrace remnants form most of the terrace deposits in the study area can be found flanking the Salt River in the western ¾ of the study area (Figure 5). Only incipient caliche development is present within the terrace alluvium, which is covered by a deposit (up to 10 feet thick) of extremely fine-grained Salt River alluvial material.

5.3 ***Geology.*** The following geologic maps covering the study area were reviewed as part of this report: Cooley (1967), Arizona Highway Geologic Map, scale 1:1,000,000; Wilson, et al. (1969), Geologic Map of Arizona, scale 1:500,000; Pearthree, et al. (1997), Surficial Geologic Map of the Theodore Roosevelt Lake 30' x 60' Quadrangle, scale 1:100,000; Spencer, et al. (1996), Geologic Map of the Mesa Quadrangle, East-Central Arizona, scale 1:100,000; and Péwé and Drosendahl (1985), Rio Salado Development District – Eastern Part, Maricopa County, Arizona, scale 1:24,000.

A good summary of the geology of the Va Shly'ay Akimel study area and immediate surroundings can be found in Drosendahl (1988).

5.3.1. *Geologic Units*. The geology of the Va Shly'ay Akimel study area is dominated by valley fills and alluvium associated with the Salt River channel (Figure 3). On the extreme eastern edge of the project, at Granite Reef Dam, the southern tip of the McDowell Mountains, and the northwest tip of the Usury Mountains bound the Salt River on the north and south, respectively, and are composed of Precambrian granitic rocks.

The predominant surface materials within the Va Shly'ay Akimel study area consist of Quaternary age river sediment deposited as alluvium and to a lesser extent sheet wash deposited alluvium and slope deposited colluvium. Thick layers of alluvium have accumulated within the major streams, tributaries and flood plains of the Salt River. The alluvium thins in the direction of local mountains.

Sand and gravel, moderately well sorted and stratified, compose the bulk of the deposits left by the Salt River. These deposits consist of well-rounded clasts and are locally interbedded with irregular sand, silt, and clay lenses. The fine sediments are derived from overbank flows.

Colluvium is formed of loose to well-cemented gravel, sand, silt, and clay. The colluvium and alluvial deposits rest upon bedrock consisting of Tertiary sedimentary and volcanic rocks, as well as the Precambrian basement complex.

The bedrock exposures at the eastern margin of the study area are composed of Precambrian Camelback Granite (Péwé and Drosendahl, 1985). The Camelback Granite is composed of pink, coarse-grained to porphyritic granite locally cut by quartz veins, and aplite and greenstone dikes.

5.3.2 *Geologic Structure*. There are no mapped faults within the study area (Cooley, 1967; Péwé and Drosendahl, 1985; Spencer, et al., 1996; Wilson, et al., 1969). However, the northwest trending valley bounded on the east by the McDowell, Usery, and Superstition Mountains, and on the west by the Union Hills, Phoenix Mountains, Camelback Butte, and Tempe Butte, probably represents a graben, or downthrown block within the Central Arizona Basin of the Basin and Range Physiographic Province. The Basin and Range Province in the Phoenix area consists of a series of upthrown blocks, or horsts, composed of late Tertiary and Precambrian bedrock, and adjacent downthrown blocks, or grabens which form the topographic valleys, and contain deep accumulations of Quaternary and Late Tertiary unconsolidated sediments. It is probable that the west and east margins of this basin (the East Salt River structural basin) are controlled by Tertiary age basin and range normal faults lying concealed beneath alluvium of the Salt River.

5.3.3 *Depth and Nature of Alluvium*. Basin fill of the Salt River structural basin is the predominant sedimentary material in the Va Shly'ay Akimel study area. The basin fill is comprised of unconsolidated sediments composed of gravel, sand, silt, and clay. These sediments have been grouped into three major and one minor hydrogeological units. The U.S. Bureau of Reclamation, the U.S. Geological Survey, and the Arizona Department of Water Resources have independently identified the following units, although the descriptions and nomenclature used by these agencies differ slightly:

- Upper Alluvial Unit (UAU),
- Middle Alluvial Unit (MAU),
- Lower Alluvial Unit (LAU), and
- Red Sub-Unit

The following description of the units is mostly reproduced from ADWR (1994).

1) The UAU consists of mostly unconsolidated gravel, sand, and silt in stream channel, terrace, floodplain, and alluvial fan deposits. The unit was formed during the final stages of alluvial development of the Phoenix Basin, approximately late Pleistocene to recent (Holocene) time. Sediment within the unit was derived from the ancestral Salt and Gila Rivers and other streams, and from the surrounding mountains. Caliche cementation occurs locally in alluvial fan deposits and stream terrace deposits. The thickness of the UAU is relatively uniform, and is typically between 200 and 300 feet thick in the East Salt River Valley (see Figure 6). The unit is between

100 and 200 feet thick near the Salt River and becomes thinner near mountain fronts (ADWR, 1993).

2) The MAU underlies the UAU, and consists mainly of clay, silt, mudstone, and gypsiferous mudstone with some interbedded layers of sand and gravel. The finer grained sediments of silt and clay dominate the MAU; however, near the margins of the alluvial basins the MAU consists mainly of sand and gravel and is difficult or impossible to distinguish from the other units. The MAU is interpreted to consist of alluvial fan deposits near the mountain fronts grading into fluvial, playa, and evaporite deposits in the central areas of the basins.

The MAU generally thickens toward the center of the basins, and ranges from 0 feet along the edges of the basin fill areas nearer to the mountains, up to 1,600 feet in the deeper parts of the basins. In the East Salt River Valley, the MAU is thickest southeast of Gilbert, the deepest part of the basin. Where the MAU is not present, due to non-deposition, the LAU is directly beneath the UAU. The unit was formed during the middle stages of alluvial development of the Phoenix Basin, approximately late Tertiary to late Pleistocene time. The increasing thickness and decreasing particle size of the MAU toward the centers of the basins suggest that the alluvial basins were still closed and subsiding during deposition of the unit (ADWR, 1994).

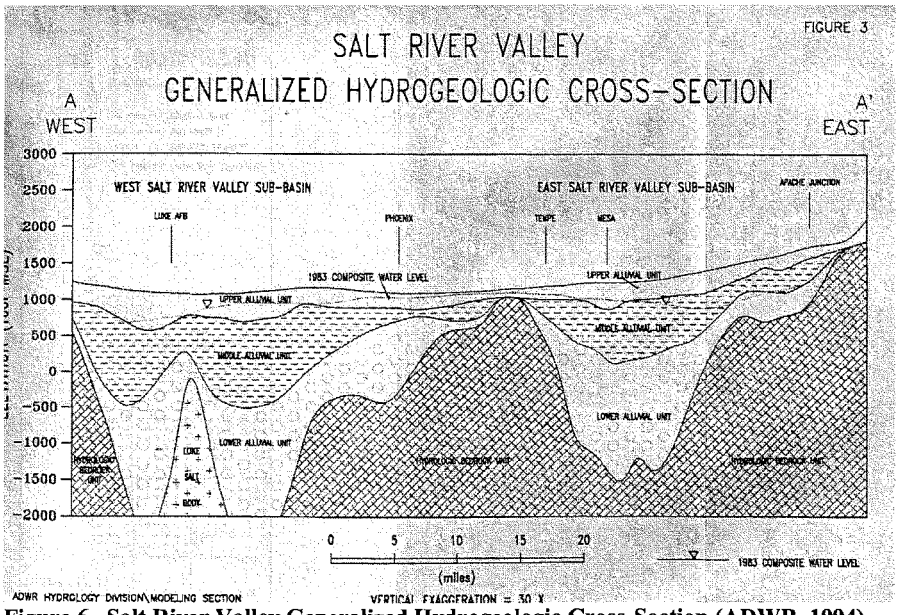


Figure 6. Salt River Valley Generalized Hydrogeologic Cross-Section (ADWR, 1994). Elevation in feet MSL. See Figure 3 for location.

The contact between the MAU and LAU is gradational, and differentiation is based on a number of factors, including bedding frequency, color, geophysical resistivity, and presence of gypsum. The unit is indistinguishable from the underlying LAU in some areas, indicating uninterrupted depositional processes.

3) The LAU underlies the MAU and overlies Tertiary and Precambrian basement rocks. This unit was formed during the early stages of alluvial development of the Phoenix Basin, approximately late to middle Tertiary time. Unit lithology consists of weakly to strongly cemented gravel and sand near the basin margins, grading into silt, mudstone, gypsum, and evaporates in the central areas of the basins. The LAU locally contains interbedded volcanic rocks. Like the overlying MAU, the LAU is interpreted to have been deposited as alluvial fan deposits near the mountain fronts grading into fluvial, playa, and evaporite deposits in the central areas of the basins. Radiometric dating of volcanic rocks within the LAU indicate that the unit may be as old as 16.6 million years (Brown and Pool, 1989 *in* ADWR, 1994). The LAU ranges from 0 feet thickness near the basin margins to several thousands of feet thick in the central areas of the basins. The increasing thickness and decreasing particle size of the MAU toward the centers of the basins suggest that the alluvial basins were closed and subsiding during deposition of the unit (ADWR, 1994).

4) The lowermost part of the LAU, the "Red Unit", is present locally, and is often described as a sub-unit. The Red Sub-Unit is in direct or fault contact with the overlying LAU at an unknown depth. The Red Sub-Unit was formed during the earliest stages of alluvial development of the Phoenix Basin, approximately late Miocene (Tertiary) time. The Red Unit lithology consists of debris flow materials comprised of reddish well-cemented breccia, conglomerate, sandstone and siltstone (ADWR 1993).

5.3.4 *River Sediments.* River sediments in the Salt River channel predominantly consist of moderately- to well-sorted, well-stratified sand and gravel, locally interbedded with silt in vegetated low flow areas near the river banks. The gravel is composed of well-rounded clasts (2-12 inches) of Precambrian metamorphic rocks (48.4%), Tertiary volcanic rocks (36.3%), and Precambrian granitic rocks (15.3%) (Drosendahl, 1988).

River bed materials are exposed in the cut banks of gravel mines. The materials form layers that range in thickness from 1 to 5 feet. Individual layers are discontinuous and thin and thicken along the mine walls. This is typical of river bed materials. The layers contain cobbles and sand, however the proportion of each vary within the individual layers. Some have a greater percentage of cobbles while others are primarily sand (Greeley and Hansen, 2001).

5.3.5 *Depth to Bedrock.* The alluvial, terrace, and colluvium deposits lie upon bedrock consisting of Tertiary sedimentary and volcanic rocks, as well as the Precambrian basement complex. The depth to bedrock in the project varies from 0 feet on the east end of the project site, deepening to over 9,000 feet north of Mesa, and rising to the west to about 1,000 feet on the west end of the project as shown on the depth to bedrock map in Figure 7. A bedrock shelf (pediment) overlain by a thin veneer of sedimentary materials extends downstream from Granite Reef Dam (USACE, 2002). The depth to bedrock rapidly increases at the basin border fault, located approximately 1.5 to 2.0 miles downstream.

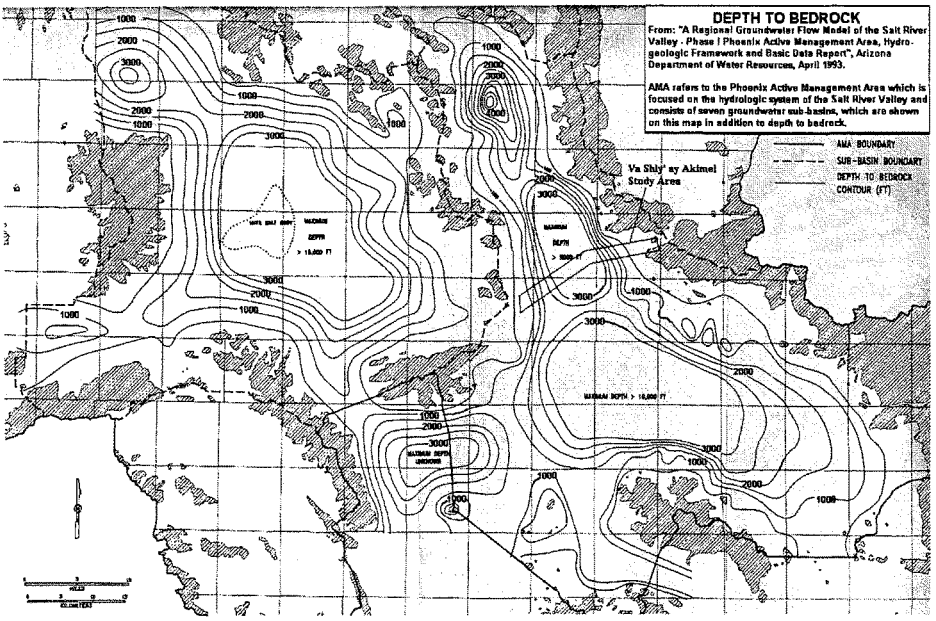


Figure 7. Depth to bedrock in the lower Salt River Valley, showing generalized location of the Va Shly'ay Akimel study area within the East Salt River structural sub-basin of the Phoenix Active Management Area (ADWR, 1993).

6.0 Soils. Soils in the study area have been mapped in great detail by the Natural Resources Conservation Service (NRCS) (formerly called the U.S. Soil Conservation Service) on aerial photographs at a scale of 1:20,000 (U.S. Soil Conservation Service, 1974). These maps provide a view of soil conditions in and near the river channels in the early 1970's. Since that time, conditions in the channels have changed in many areas, but the floodplain and terrace soils have remained generally unchanged. The soils in the vicinity of the river channels in the study area are of the hypothermic torrifluvents association, a group of soils that are well-drained to excessively well-drained on nearly level or gently sloping surfaces. The texture of the surface layer ranges from gravelly sand or very gravelly sand to fine sandy loam. The material beneath the surface layer is very gravelly sand to very fine sandy loam or loam. These soils are often redistributed by blowing wind and the shifting of stream channels, making mapping of individual areas as soil units unfeasible. Permeability ranges from very rapid to moderate, runoff is slow, and soil blowing is generally a hazard (U.S. Soil Conservation Service, 1974).

7.0 Geohydrology and Groundwater. The principal drainage through the Phoenix Basin is the Salt River. Dams located upstream from the study area (controlled and operated by the Salt River Project) prevent perennial flow in the river channel and limit natural recharge. The Salt River in this reach is ephemeral, flowing only in response to local flooding and releases from upstream reservoirs. Granite Reef Dam at the upstream boundary of the study area was constructed to divert Salt River water into the Arizona and Southern Canals. The dam is not a storage reservoir. Several irrigation run-off collection ponds and distribution ponds for mining

operations are present within the project boundaries. The study area receives stormwater runoff from hills on the undeveloped land on the north side of the Salt River from numerous small ephemeral drainage channels. The Buckhorn Mesa Project in the City of Mesa consolidates and directs stormwater drainage to the Salt River through a single discharge channel immediately downstream of Granite Reef Dam.

Regional groundwater pumping for irrigation has resulted in a general lowering of the water table throughout the area. Recharge to the groundwater basin is derived from seepage of irrigation waters, Salt River flows, rainfall, and underflow of groundwater. Recharge from stream flow and rainfall is minor, and the amount of recharge from irrigation seepage and underflow has not been high enough to offset progressive lowering of the water table.

Two groundwater recharge projects are located within the study area, the Granite Reef Underground Storage Project (GRUSP), and the Northwest Water Reclamation Plant (NWWRP).

7.1 ***Basins.*** Groundwater is regulated by the Arizona Department of Water Resources (ADWR). The groundwater basin underlying the lower Salt River Valley is identified as the Phoenix Active Management Area (see Figure 7). The Phoenix AMA comprises two distinct but interconnected alluvial groundwater basins: West Salt River Valley (WSRV) and East Salt River Valley (ESRV). These two units are separated by a mostly buried bedrock ridge located near Priest Road in Tempe (see Figure 4). Tempe Butte, south of the Salt River, and the Papago Buttes and Camelback Mountain north of the river are the outcropping expressions of this geologic feature.

The study area lies within the East Salt River Valley of the Central Arizona Basin, in the Basin and Range Physiographic Province. The Basin and Range Province in the Phoenix area consists of a series of upthrown blocks, or horsts, composed of late Tertiary and Precambrian bedrock, and adjacent downthrown blocks, or grabens which form the topographic valleys, and contain deep accumulations of Quaternary and Late Tertiary unconsolidated and semiconsolidated sediments. These depositional basins filled with unconsolidated sediments are referred to as alluvial basins. The ESRV alluvial basin represents a graben which trends north to northwest, and is bounded on the east by the McDowell, Usery, and Superstition Mountains, and on the west by the Union Hills, Phoenix Mountains, Camelback Butte, and Tempe Butte.

7.2 ***Aquifers.*** In the Salt River Valley groundwater occurs within three major and one minor hydrogeological units that are bounded below by impermeable Tertiary and Precambrian basement rocks which provide a physical boundary to the alluvial aquifer and to groundwater movement. These units are:

- The Upper Alluvial Unit (UAU),
- The Middle Alluvial Unit (MAU),
- The Lower Alluvial Unit (LAU), and
- The Red Sub-Unit

The amount of storage and flow within the units varies considerably with area and depth. The three hydrogeologic units are derived from Phoenix Basin alluvial materials. The geology of the units is described in Section 5.3.3. Hydrologic characteristics of the units are described as the following (their age increasing with descending order) (ADWR 1993):

1) The UAU comprises all alluvial materials at the ground surface, and extends to depths of 100 to 200 feet under the Salt River, and is thinnest near mountain fronts and bedrock outcrops. It consists of unconsolidated sand, gravel, cobble and boulders with local thin interlayered beds of clay and silt. The unit is a semi-perched to unconfined aquifer that is both saturated and unsaturated.

The Salt River flows over the UAU and was once the most important source of groundwater recharge for this unit. Water within the UAU is legally referred to as subflow to differentiate it from groundwater in the MAU and LAU. Historically, surface flows from streams and washes provided most water to recharge the UAU. Presently, the minor recharge sources-such as seepage from Granite Reef Dam, canals and irrigated land, underflow along major streams, and rainfall-have become more important. Approximately 25% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A very large portion of the groundwater is used for agriculture. Little or none of the water is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998).

2) The MAU underlies the UAU. At the project site the MAU's contact with the LAU varies from approximately 100 feet to 200 feet below ground surface. The thickness of tbe unit varies from 0 feet to approximately 1,600 feet. Unit lithology consists of weakly cemented interlayered beds of clay, silt, sand and gravel. This unit is a semi-confined saturated aquifer comprised of more than several discontinuous semi-confining layers that consist predominantly of silt and clay (USEPA 1993). Approximately 50% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A large portion of the groundwater is used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998).

3) The LAU underlies the MAU, and ranges in thickness within the study area from 0 feet along the mountain front at the eastern margin, to several thousand feet in the deepest part of the basin. Unit lithology consists of weakly to strongly cemented gravel, boulders, sand, sandy clay, silty sand and interlayered beds of clay. This unit is a semi-confined saturated aquifer comprised of more than several discontinuous semi-confining layers that consist predominantly of clay and mudstone. Approximately 25% of the groundwater pumpage in the Phoenix basin is directed towards this unit. A large portion of the groundwater is used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson, 1991, *in* USACE, 1998)

The LAU possesses a direct or fault contact with the Red Sub-Unit at an unknown depth. The Red Sub-Unit lithology consists of debris flow materials comprised of reddish well-cemented breccia, conglomerate, sandstone and siltstone. The Red Unit is a saturated aquifer and it is not know whether it is confined or unconfined. Aquifer characteristics for the Red Unit are unknown, except that it's groundwater likely originates from within faults and fracture zones within bedrock (ADWR 1993).

Groundwater movement and connection within the three principal alluvial units is mostly lateral and somewhat vertical. Vertical groundwater flow occurs through a combination of leakage through all three unit geologic contacts and through water wells that extend vertically across more than one unit.

7.3 *Bedrock.* In the Va Shly'ay Akimel area, bedrock is formed primarily by a Precambrian basement complex composed mainly of metamorphosed gneiss and granite. This material

possesses relatively low water storage and transmission characteristics and usually yields small quantities of water compared to the unconsolidated sediments in the basins. Bedrock does not form aquifer units and in fact forms a barrier that prevents or restricts the flow of groundwater.

The depth to bedrock influences groundwater movement in the overlying basin fill by constraining the geometry of the basin fill. The depth of the down-dropped bedrock graben controls the thickness of the unconsolidated basin fill materials in the graben. A greater thickness of basin fill occurs where bedrock is deep, and relatively thin basin fill overlies shallow bedrock. At Granite Reef Dam, granitic bedrock occurs near the surface, and extends downstream from the dam, covered by a thin veneer of alluvium, for 1.5 to 2.0 miles where the depth to bedrock rapidly increases at the basin border fault. Seepage from Granite Reef Dam into the thin alluvial sediments produces a continuous surface flow in this area. At the edge of the bedrock shelf, this water movement changes from surface flow and becomes subsurface flow.

7.4. *Gradient.* Groundwater at the Va Shly'ay Akimel project site varies in depth and flow direction by location. The direction of flow is highly variable, however groundwater flow is generally to the west-southwest (ADWR, 1993). Groundwater is being replenished at the Granite Reef Underground Storage Project (GRUSP). The GRUSP is a groundwater recharge area located approximately in the center of the study area. In addition, the City of Mesa recharges treated water at the west end of the study area. These two areas exhibit localized groundwater mounding. Groundwater flow around these two recharge areas is radially outward in each direction. Groundwater flow on the west side of the area is generally northwest toward Scottsdale which generates a cone of depression, except around recharge areas. Groundwater in the east Salt River valley flows towards two groundwater depressions. One is north of Scottsdale (7 miles northwest of the project) and one is east of Mesa (7 miles east-southeast of the project) (Jones and Stokes, 2002).

7.5 *Depth to Groundwater.* Long-term groundwater withdrawal for irrigation purposes has resulted in a general decline in water levels from 100 feet to 400+ feet throughout the Phoenix Basin. However, water-level declines have usually been less than 50 feet near the Salt River. From 1923 to 1976, groundwater levels have been lowered 340 feet near Luke Air Force Base, 28 miles west-northwest from the project area; 330 feet just north of Scottsdale, 7 miles northwest of the project; 370 feet east of Mesa, 7 miles east-southeast of the project; and up to 420 feet in the Queen Creek area, 20 miles southeast of the project (Laney, 1976).

According to the ADWR well registration database, dated July 2001, depth to groundwater in the project area varies from around 10 to 440 feet below the ground surface (Liesch, 2002), and is at approximately 260 feet depth (in crystalline bedrock) near Granite Reef Dam (Jones and Stokes, 2002). Beneath the Salt River, the general groundwater depth (within alluvium) ranges from 60 to 80 feet below the surface for the majority of the study area (Knight Piésold, 2000, *in* USACE, 2002). (A depth to groundwater map is included as Figure 6 of the main report.) Jones and Stokes (2002) report that depth to groundwater ranges from 120 feet below land surface near the Loop 101 Interchange to 350 feet below land surface near Power Road. For the period from 1987 to 1992, water levels fluctuated from year to year, on average 7-19 feet (Jones & Stokes, 2002). Local features affecting the groundwater depth and flow direction include: the NWWRP wastewater treatment recharge ponds, GRUSP, quarry operation distribution ponds, water well pumping, and canals.

The GRUSP, located near the center of the study area, recharges water into the upper alluvial unit from a series of ponds. The Salt River Project (SRP) permit requires it to limit water discharge to maintain the groundwater level at least 25 feet below the bottom of the Salt River Landfill on Gilbert Road and State Route 87, about 1 mile to the north (USACE, 2002, pp. IV-18 and IV-26). This results in a groundwater level that is 50 to 60 feet below the river channel in the immediate GRUSP area.

Effluent from the NWWRP (City of Mesa), located near the downstream end of the study area, is discharged into a series of recharge ponds where it is allowed to infiltrate the Salt River sediments. The groundwater mound that results from this recharge raises the local water table in this area to within 50 to 60 feet below the riverbed (USACE, 2002).

Perched water tables exist along the river at various depths. Seepage from the Granite Reef Dam forms a local perched water table near the surface (USACE, 2002). Wetland plants grow within this area just below the dam, and extend for about one mile downstream. A local red clay located along the western portion of the project area carries a perched water level at about 10 feet below the river bottom elevation, and recent measurements near the Verde and Salt River confluence, a few miles upstream from Granite Reef Dam, are about 20 feet below ground surface (SRPMIC, 2002).

7.6 ***Contamination of Groundwater.*** Long-term irrigation practices and landfills within the Salt River Valley have historically influenced water quality in the upper alluvial aquifer. High salinity, chloride, and nitrate concentrations were occasionally found in the shallow groundwater near irrigated or formerly irrigated areas (USACE, 2002). More recently the SRPMIC has developed a water quality management plan to protect and enhance surface and ground water quality. Since groundwater quality monitoring began in the 1980s, the water quality has significantly improved. Monitoring results from the first quarter of 2002 indicate that there were no exceedences of the maximum contaminant levels for volatile halocarbons in any of the sampled wells (Kenneth D. Schmidt and Associates, 2002). In addition, the concentrations of many volatile halocarbons were the lowest since monitoring commenced. It should be noted that there are no Superfund sites within the study area, however several of these sites are present downstream.

In the Environmental Impact Statement for the Va Shly'ay Akimel F-3 Study, Jones and Stokes (2002) summarized several surface and groundwater contaminants of concern in the area, including: volatile organic compounds (VOC's), metals, nutrients, ions, and total dissolved solids.

Jones and Stokes (2002) state that the most prevalent water contaminants in the lower Salt River are VOC's (e.g. from landfills, leaking underground storage tanks, high-tech, small, and large industries). The Arizona Department of Environmental Quality (ADEQ) records show the presence of VOC's in groundwater in areas near every reach of the lower Salt River, especially in the Central Phoenix area (Jones and Stokes, 2000).

Metals as contaminants (e.g. from landfills, mines, metal finishing, naturally occurring) have been detected in some Salt River Project groundwater wells, but their concentrations did not exceed their maximum allowable limits (Jones and Stokes, 2002).

Several ions and nutrients exceed maximum allowable levels in groundwater, surface water, and effluent in the study reach (Jones and Stokes, 2002). These include nitrates (e.g. runoff from agricultural fertilizer, animal feed-lot wastes, effluent from wastewater treatment plants, and subsurface septic leachate); bicarbonate, chloride, and boron (generally naturally occurring).

Jones and Stokes (2002) state that total dissolved solids (TDS) probably warrant the least concern among all contaminants, and that although TDS in surface waters and groundwater may cause problems for salt-sensitive plants, the present concentrations do not significantly differ from more natural conditions along the Salt River.

At present, all known groundwater HTRW contamination (see footnote 2, below) along the entire Salt River has been attributed to Volatile Organic Carbons (VOCs) leaching into the groundwater (USACE, 2000). VOC leaching has occurred from either mismanaged storage, pumping into ground water and/or improper dumping of VOC and related chemical compounds at Superfund sites located near the study area boundary. VOCs have been detected within the UAU and MAU, but not the LAU or Red Unit. There is no direct evidence that surface water recharge from the Salt River has contaminated the three alluvial aquifers with HTRW unless such recharge has been associated with the Superfund sites, downstream from the study area. The closest of these VOC sites is the Indian Bend Wash NPL site, discussed in more under the "HTRW" report sections, below.

8.0 HTRW[2]. The U.S. Army Corps of Engineers assesses risks and problems posed by potential HTRW (*h*azardous, *t*oxic, or *r*adioactive *w*aste) in study areas under the following criteria. If the conceptual or planned study area activities (i.e., the "construction of a project") would require moving or mobilizing HTRW-contaminated water or soil, this situation needs to be qualified and quantified as soon as possible in the study process. This is so that the associated costs can be estimated and a team decision made regarding whether or not it is viable to continue to include the suspect or contaminated zone in the overall study plan. General examples of conceptual activities that have to be considered are the increase of groundwater elevation or the directing of irrigation water in such a way that the water reaches and mobilizes some previously non-mobile contaminant. Actions that could mobilize contaminants in adjoining property also have to be considered.

A Phase I Environmental Site Assessment (*hereafter*, "Phase I EA") for this study was completed by Liesch (2002) under contract to SRPMIC, as an in-kind services product. By necessity, a Phase I EA is a generalized document when it addresses a study area of this size in the early stages of conceptual alternative evolution. Some of the perspective *30* specific study-area Alternatives under consideration (A_1 through O_1 and A_2 through O_2) had not been developed at the time Liesch (2002) did the Phase I EA research. This is the natural course of HTRW site identification and the developing of risk assessment: refining it further as the study evolves. The Liesch (2002) effort included database searches, aerial photo examination, interviews, a walk-over survey, visits to some of the businesses and quarries, a listing of all uses of land in the study area, and an assessment of the overall findings. Leisch (2002, p. i), in the Phase I EA, compiled a list of over 50 different sites of "development" and/or "utilization", apparently so as to completely document existing and known past land use and practices in the study area. That

[2] "HTRW" is "potentially *h*azardous, *t*oxic, or *r*adioactive *w*aste". There are no known or suspected radioactive sites in this study area.

listing by Leisch was assessed by the Corps' Geotechnical Branch, Geology & Investigations Section (*hereafter*, "Geology & Investigations"), site-by-site, with regard to perceived potential environmental risk to each of the 30 conceptual study Alternatives. This assessment was based solely on data presented in the Phase I EA, and the assessment was presented in the F-4 level feasibility study document (table A-1, figure A-1, in *Attachment A* of the 15 Oct. 2003 Geotechnical Appendix to the F-4 feasibility for this study). Leisch (2002, pp. ii, 30, 31) had concluded that 14 specific businesses or landfills were "environmental issues", and that an unspecified number of unspecified properties also had "environmental issues" regarding ASTs[3], USTs[4], and potential TSD[5] issues; plus environmental issues at unspecified locations throughout the study area regarding debris dumping, other illegal dumping, and the potential interactions between study area activities and existing irrigation runoff water, wastewater recharge ponds, water wells, septic tanks, water wells. Geology & Investigations cut through the Phase I EA data in a different manner, having the advantage of knowing all the nuances of all 30 Alternatives under consideration. Geology & Investigations did not think that several properties on the Leisch final list of environmental issues actually presented potential risk to the study area, but, on the other hand, Geology & Investigations added several other items to a list of sites that required additional research and assessment.

The conclusion presented in the Oct. 2003 F-4 feasibility report by Geology & Investigations was that additional information on several specific properties must be gathered, assessed, and folded into the overall environmental assessment in the geotechnical appendix for the final iteration of the feasibility report, and that by doing so, it likely could be deduced that many of the sites offer no risk to the environmental restoration activities planned for this study area. It fell to the local sponsor to gather this information as part of their on-going role as provider of environmental data as an in-kind-services product. In the interim months since Oct. 2003, all ITR and internal review feedback regarding HTRW reasserted what Geology & Investigations already had called for in the F-4 feasibility report: get the additional environmental data on the sites specified previously. As of mid-January 2004, Geology & Investigations teamed with the local sponsor's Environmental Services staff to collect the data, then prepared an independent assessment of the data. Results are presented below. Issues regarding debris dumping are covered in a new, separate section, under the heading of "non-hazardous waste", on pages below.

8.1. *Specific sites assessed beyond the Phase I EA level, with regard to potential environmental impact on the study area.*

8.1.1. *Talley Defense Systems site.* **[Draft Feasibility Note: Shortly before publication time for this document, late-March 2004, the footprint of Alternative O was changed, ELIMINATING all the features of Alternative O shown on fig. 8, below; that change includes ELIMINATION of the only planned constructed wetland near the Talley Defense site. This change serves to ELIMINATE any chance of impact on the *current* Alternative O features by the Talley Defense site. Nevertheless, this assessment is presented as is, because future Alternative iterations may change, possibly once again encompassing lands near Talley Defense. Since the time already has been spent to find the actual locations of the Talley Defense facilities of concern (unknown at the F-4 phase), and collect and analyze all**

[3] AST is "above ground storage tank".
[4] UST is "underground storage tank".
[5] TSD is "treatment, storage and disposal".

the existing data on the site, and to assess the potential risk to the study area, this assessment is presented intact. Remember there are 28 other Alternatives besides Alternative O, all, technically, still "in-play" with regard to final conceptual planning. Until all 28 are officially eliminated from the planning process, this assessment has pertinence, and the Talley Defense site presents some element of risk, as qualified, below—the author, 23 March 2004].

Talley Defense Systems[6] received mention in the 2002 Phase I EA report for its testing of rocket propellants and its history of numerous (unspecified) TSD (*t*reatment, *s*torage, and *d*isposal) violations. No precise location for the facility was provided in that Phase I EA. These facts prompted Geology & Investigations to collect and assess the following additional information about the Talley Defense Systems site.

As of Jan. 1988, the facility comprised nearly 37,000 square feet of industrial space, separated into five, non-contiguous plants and a waste propellant burn pit area (SAIC, 1994, pp. 2-1 and 2-3), all shown on figs. 8, 9. All are south of the Salt River and outside of the study area, but all are upgradient from the study area; the waste propellant burn pits adjoin SRPMIC land. Since 1965 or 1966, the firm has been manufacturing solid-phase rocket propellants on location, including: ammonium perchlorate (AP), ammonium nitrate (AN), NaN (a component of sodium azide), and magnesium Teflon (Smith Consultants, 2000-a, p. 1; SAIC, 1994, p. 2-3). The main effort at the facility is the design, development, and manufacture of aircraft escape rocket motors and catapults, including the propellants, but sodium azide (NaN_3) propellants for automobile airbags also have been manufactured there (SAIC, 1994, p. 2-2).

Beginning in 1980, the facility was regulated under various EPA and Arizona Dept. of Environmental Quality hazardous waste oversights, and since the 1990s has received various ADEQ air quality permits for the open burning of waste propellants (SAIC, 1994, pp. 3-1 through 3-7). As of Aug. 30, 1991, a Consent Judgment limited this burning to 1,000 lbs of waste propellants per burn event and to one burn event per day, and also required submittal of a plan for removal of any hazardous waste release that may be discovered as a result of the burning. Documentation that provides a rough scope of the scale of burning that had been intended prior to the 1991 Consent Judgment includes: a 1980 permit application for burning 32,000 lbs/year of solid composite propellants; a 1985 application for burning 500,000 lbs per year of hazardous waste. In the history of regulatory oversight, "[Talley Defense Systems] generally demonstrated improper handling of hazardous wastes in the majority of the inspections," (SAIC, 1994, p. 3-7). Among the documented TSD problems is a May 10, 1989 "fire and explosion" at the facility (SAIC, 1994, p. 3-8).

The objective is to assess the potential risk that the study area has been impacted by releases of wastes from any of the Talley Defense Systems operations. To assess this risk, factors considered were: 1) potential contaminants of concern; 2) documented and possible releases of those contaminants of concern; 3) potential contaminant pathways to the study area; 4) the type of hazard associated with the potential contaminant of concern; and 5) proximity to the study area.

[6] The firm operated under the name Talley Industries of Arizona, Inc., until June 1984, when it became Talley Defense Systems (SAIC, 1994, p. 2-2).

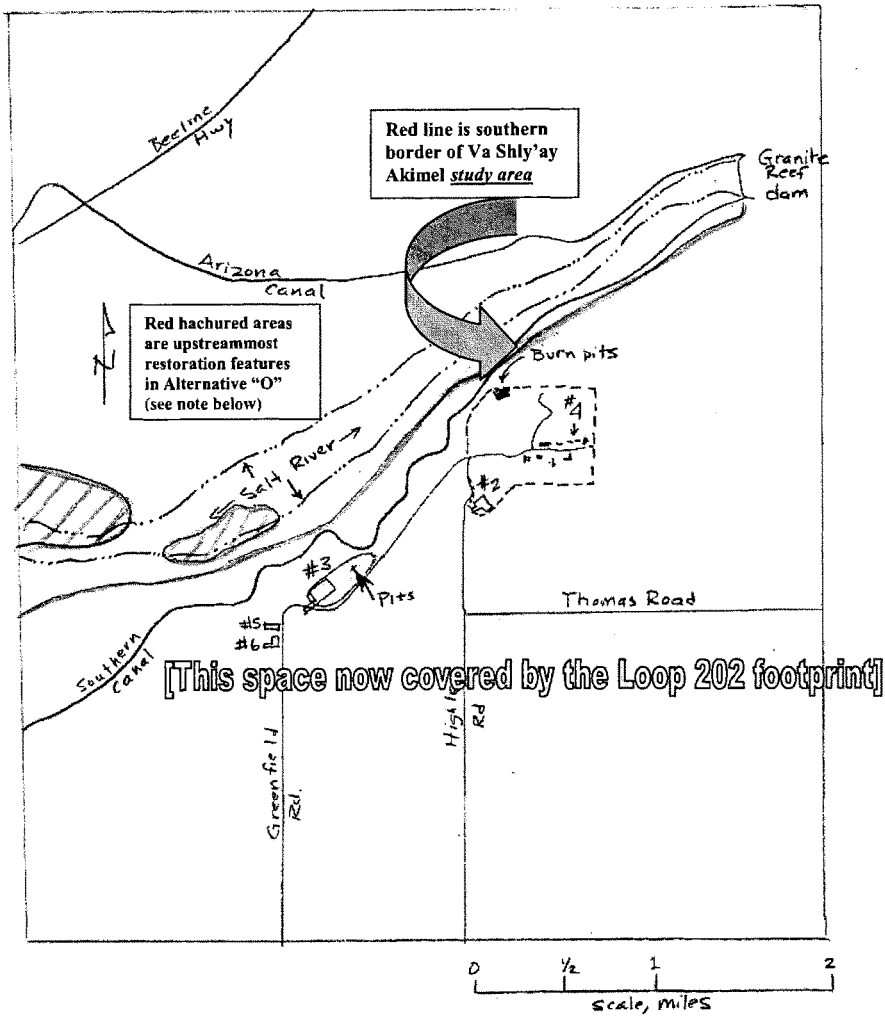


Figure 8.--Relative locations of the Talley Defense System facilities (plants #2, 3, 4, 5, 6), note the "burn pits", another pit area (by plant #3); the Salt River; the Va Shly'ay Akimel study area; and upstreammost environmental restoration features of Alternative "O". Data from Basin and Range Hydrogeologists, 1997, exhibit 2. "Pits" at plant #3 are washwater evaporation and percolation pits. Plant #1 is 3 miles away from this view and was never considered to be in need of environmental oversight. Plant #5 is comprised of administrative buildings (SAIC, 1994, pp. 2-1 and 2-2). Note detail of burn pits in fig. 9. Both hachured areas shown were eliminated from Alternative O's footprint shortly before this document was to be released for publication.

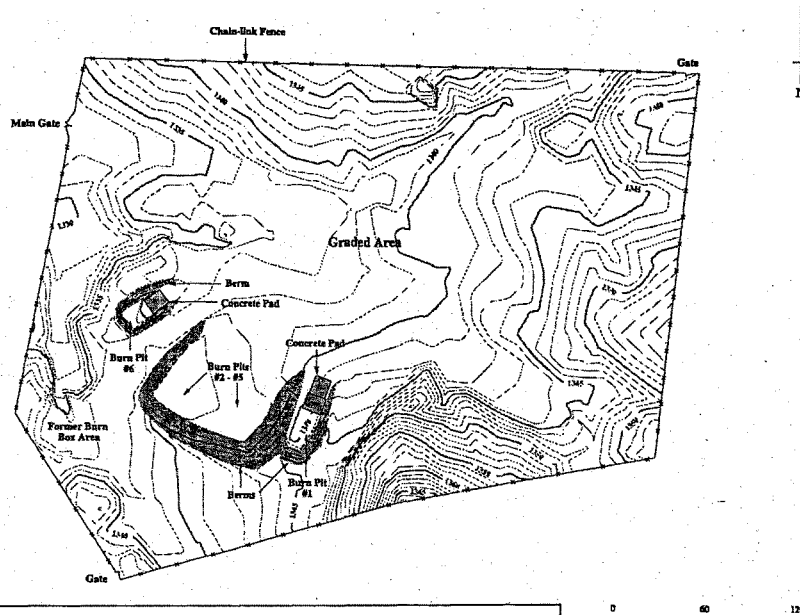


Fig. 9.--Detail map of the burn pits at Talley Defense Systems (map scanned from Basin and Range Hydrogeologists, 1997, exhibit 3). See fig. 8 for larger area view.

8.1.1.1. Potential contaminants of concern, releases, pathways. The facility[7] has been documented to have used the following potential contaminants of concern in operations:

- halogenated and non-halogenated solvents, which are RCRA-listed wastes (SAIC, 1994, p. 4-2);
- chromium-containing paint (SAIC, 1994);
- perchlorate and other propellants, including sodium-azide, a RCRA-listed waste;
- other heavy metals (lead, copper).

8.1.1.2. Releases. There have been at least four different studies of the contamination situation from 1994 to 2000, all of which require some judgment with regard to what has impacted and what may impact the study area in the future. There are no "final answers" at this point, as there has been little to no testing beyond the known release points, and none of the studies were carried out with regard to determining whether *this study area* is or is not impacted by releases. Releases of perchlorate, chromium, copper, and lead have been documented as occurring from Talley Defense System operations, and release of halogenated and non-halogenated spent solvents was assigned a "high potential" to have occurred in past, but assigned a very low potential to have occurred in recent operations due to improved handling of the solvents. Details, and cited references to these facts, are listed below.

Releases of the heavy metals has been proven by analyzing sludge in open, unlined, evaporation-and-percolation pits at plant #3 (see fig. 8 for location). The wash-water with the sludge was allowed to percolate directly into local soils from those pits, and to evaporate. The pit sludge originated in the high-pressure washing of spent rocket housings, which was then directed to the pits. As needed, that propellant-containing sludge was burned off, in the open, on location in the pits when propellant concentrations in the sludge became too high. The other documented release relates to the past practice of Talley Defense Systems of burning (and sometimes exploding) waste propellants in open pits at the boundary of the SRPMIC lands, an action possibly dating back to the mid 1960s (see fig. 8 for location of burn pits). A private-industry investigation relayed that the waste propellants are a source of heavy metals and perchlorate and that they are hazardous waste due to their reactivity (Basin & Range Hydrogeologists, 1997, cited in Smith Consultants, 2000-a, p. 1, and Smith Consultants, 2000-b, p. 1). These releases are discussed below, in detail.

8.1.1.2.1. *Heavy metals in soil and analysis of risk to groundwater.* A 1994 investigation by private industry, which was based on the statistical use (kriged) of previously gathered[8], substantial soil testing, concluded that the primary point of release of contaminants (the company's propellant burn pits--see fig. 9) *likely* has been the source of storm-runoff-borne soil-lead contamination that spread at least 250 northwestward into SRPMIC lands, and *likely* has been the source of both storm-runoff-borne and fugitive-dust-borne copper contamination that spread more than 600 ft northward, over 250 ft northwestward, and more than 600 ft eastward into SRPMIC lands, and roughly 100 ft into the study area (see figs. 10, 11, 12). The uncertainty is based on the facts that concentrations encountered for each of these metals in the testing is *close* to exceeding background levels in soil for those metals, plus these determinations were made by kriging and there are limitations to interpretation of kriging. The cited investigators

[7] see figs. 8, 9, and location with relation to the entire study area on fig. A-1, site 26

[8] By Basin and Range Hydrogeologists, Inc, presented in a March 3, 1997 report entitled, *Site assessment report, Thermal Treatment Unit, Talley Defense Systems*, a consultation report done for Talley Defense Systems.

based their conclusion that the pits were a source of release because high concentrations of the metals were found in areas most affected by surface runoff and ponding. Their analysis also indicated elevated beryllium, nickel, and zinc in soils. Chromium also is mentioned as a released metal. Their study concluded five things:

- The propellant burn pits, which occupy 2.5 acres of surface area, do not comply with Federal regulations;
- Future metals releases from these burn pits will occur because the surface soils are erodible and have high metal concentrations;
- Runoff of surface water has been the primary transport route of contaminants into land adjoining the burn pits, *possibly* bringing with it beryllium, chromium, copper, nickel, and zinc;
- Lead dispersed by surface runoff into lands adjoining the pits exceeds residential PRGs (*preliminary remediation guidelines*) then in effect (in 2000);
- Heavy metals in the soils probably do not affect groundwater, based on the facts that underlying bedrock has a low hydraulic conductivity, the groundwater surface is deep (200 ft), vertical mobility of metals in Arizona soils traditionally is limited[9], and sampling suggests attenuation of heavy metal concentrations at shallow depth (Smith Consultants, 2000-b, pp. 2, 9, 12, and maps 1, 7, and 8).

Not investigated in the Smith Consultants' study were open waste evaporation/percolation pits at plant #3 (see "pits" on fig. 8). At plant #3, solid rocket propellant was washed from the insides of spent rocket motor casings at high pressures. The wash water, after being screened twice to remove large pieces of solid propellant, then flowed into the two 15-by-40 ft, 3-ft-deep pits, where it percolated into the ground and evaporated. As needed, propellant residues were burned in the open at the pits to reduce rocket propellant residue that accumulated. These processes took place for twenty years, ending in 1990 (SAIC, 1994, pp. 6-35 through 6-37). Tests revealed cadmium, chromium, and lead in soil at these pits, all below draft ADEQ guidance levels for soil in effect at the time (<100 mg/kg Cd, <2,000 mg/kg Cr, <400 mg/kg Pb) (SAIC, 1994, p. 6-37). Geology & Investigations considered that possible sources of the heavy metals in those wash evaporation pits may be these: chromium may have come from the paint used on rocket assemblies; cadmium may be from the casings; lead was thought possibly to be from a lead-containing propellant (but Talley Defense stated no such propellants were burned there (SAIC, 1994, p. 6-37)). The propellant concentration level in these same residues was high (discussed below, under *perchlorate*).

8.1.1.2.2. *Perchlorate in soils and risk to groundwater.* The situation regarding potential perchlorate release from the burn pits area is perhaps less completely studied than the metals situation, based on the presence of only a "draft" report on the subject, again by Smith Consultants (2000-a), but this time using new soil samples to test for perchlorate, collected by Smith Consultants in 2000. No water samples were taken, but some speculation on risk to groundwater was made by Smith Consultants, nevertheless. The perchlorate was identified as a component of the propellants burned at the pits (Basin & Range Hydrogeologists, 1997, cited in Smith Consultants 2000-a, p. 1). The soil samples revealed perchlorate in 19 of the 23 soil samples collected *in the runoff-impacted area west of the burn pits*; it had migrated at least 250 ft northeastward into SRPMIC lands (see fig. 13). Concentrations in that entire test

[9] Heavy metals are cations (positively charged particles) with a low solubility and are readily adsorbed by clay particles in soil (Smith Consultants, 2000-a, p. 5).

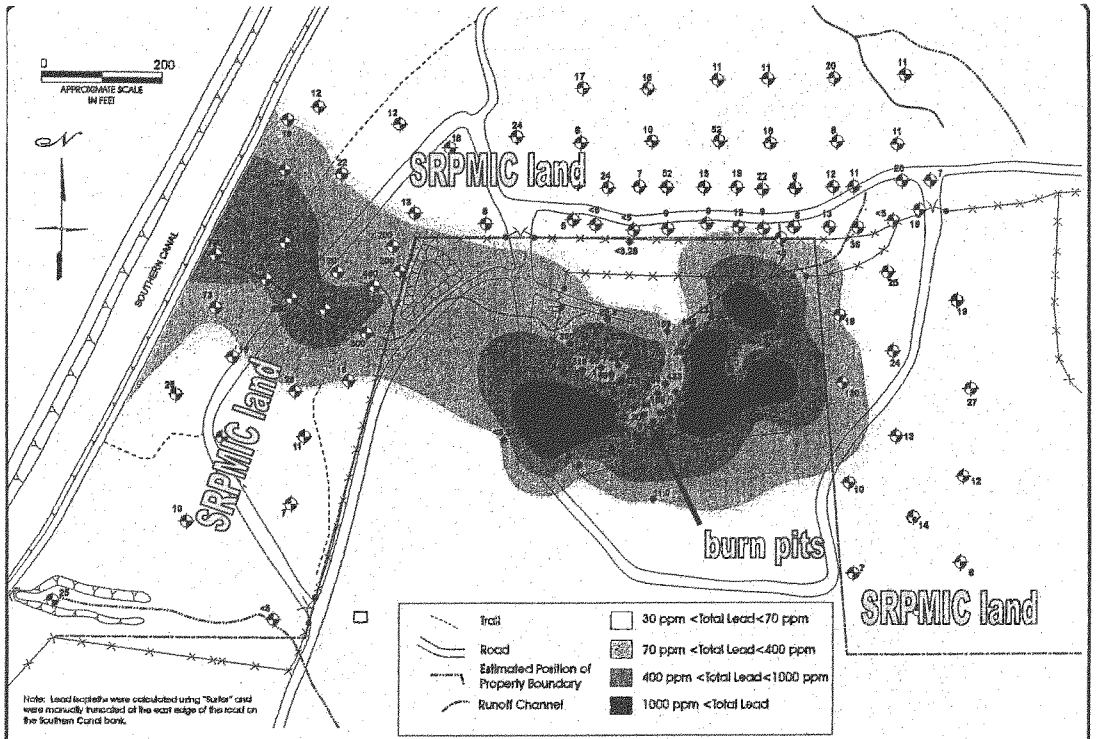


Fig. 10.--Distribution of lead in soil adjacent the burn pits (shown on fig. 8). This map was fig. 7 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands and burn pits highlighted).

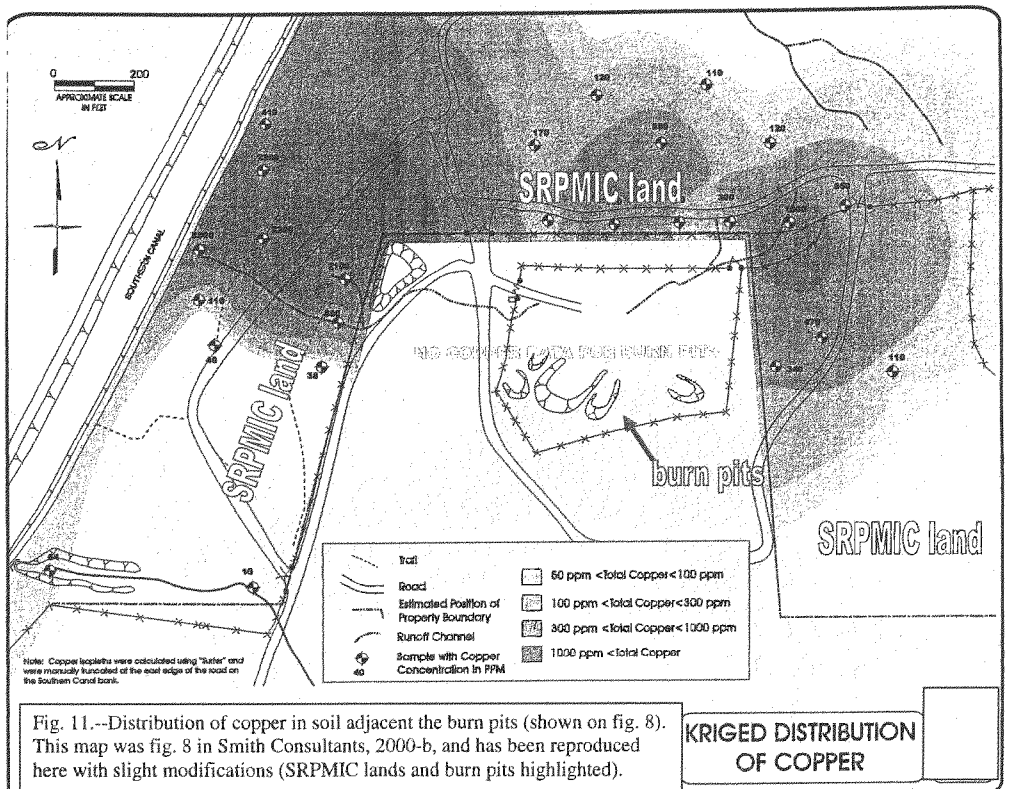


Fig. 11.--Distribution of copper in soil adjacent the burn pits (shown on fig. 8). This map was fig. 8 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands and burn pits highlighted).

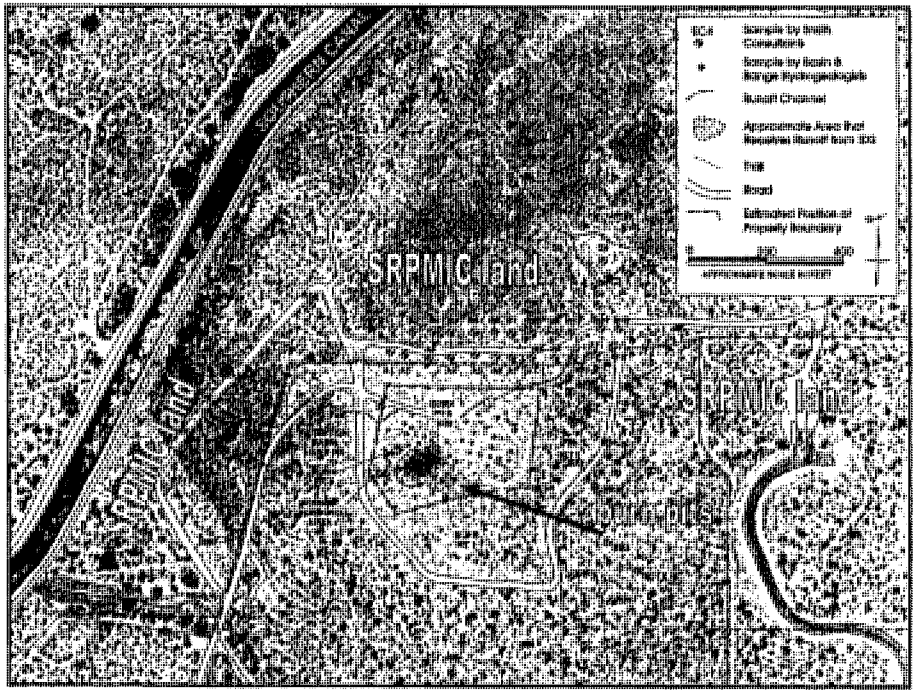


Fig. 12.--Distribution of lead in soil adjacent the burn pits (shown on fig. 8). This map was fig. 2 in Smith Consultants, 2000-b, and has been reproduced here with slight modifications (SRPMIC lands, runoff-receiving area, and burn pits highlighted).

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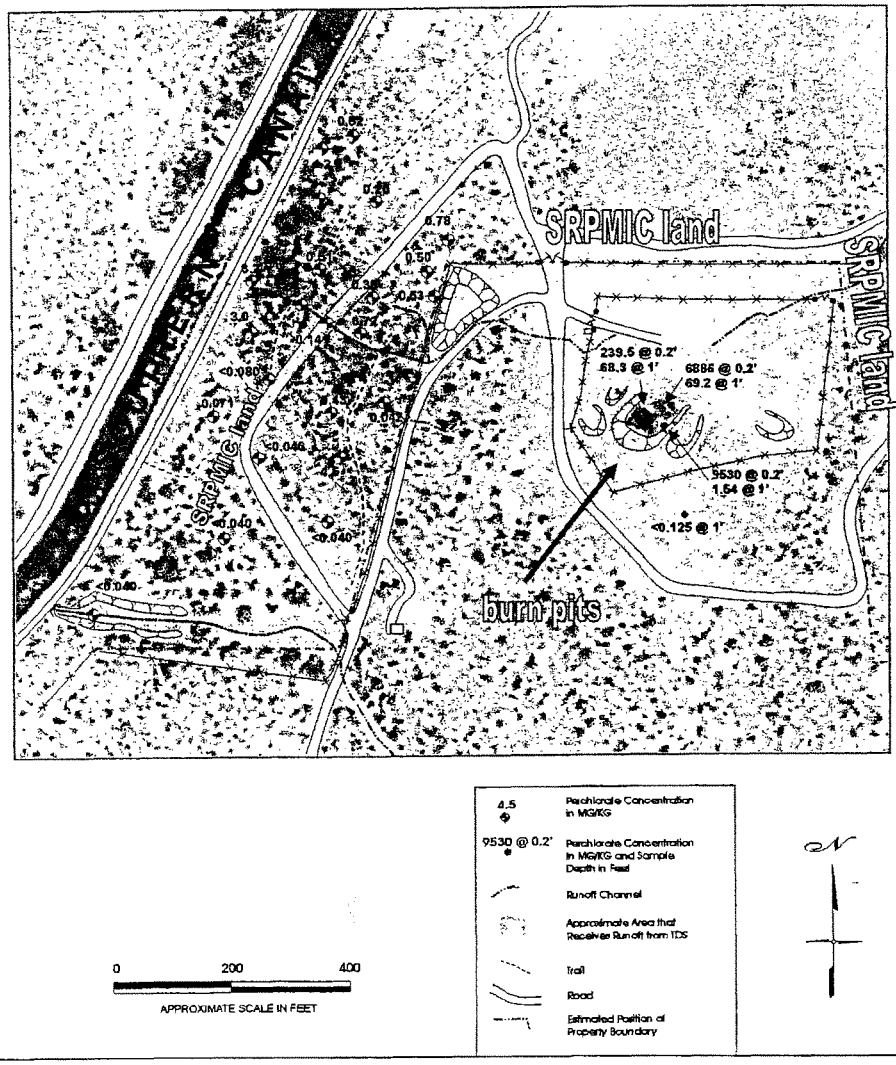


Fig. 13.--Distribution of perchlorate in soil adjacent the burn pits (shown on fig. 8). This map was fig. 3 in Smith Consultants, 2000-a, and has been reproduced here with slight modifications (SRPMIC lands, runoff-receiving area, and burn pits highlighted). A background perchlorate-in-soil sample, collected approximately 2,000 ft northeast of the burn pits for the Smith Consultants study contained <0.040 mg/kg perchlorate (Smith Consultants, 2000-a, fig. 4).

suite (samples outside the burn pits) were 0.042 to 4.5 mg/kg perchlorate, none of which exceed the PRGs in effect as of mid 2000. Perhaps most importantly, the conclusion by the Smith Consultants investigators is essentially that much of the highly mobile perchlorate probably was *missed* by the sampling technique, having migrated readily to soil horizons deeper in the soil profile than were caught up in the shallow soil sampling program (Smith Consultants, 2000-a, pp. 3-4, and maps 2, 3). This correlates to some degree with the seeming paradox: perchlorate concentrations showed an increase at the maximum distances sampled, away from the burn pits. Possibly the perchlorate reached a less permeable layer at depth or thinner soils away from the burn pits, and in response was closer to the surface when laterally more distant from the burn pits, where it could be more readily captured in the shallow soil samples. Smith Consultants assign risk of groundwater contamination to SRPMIC lands, *and to the Salt River in particular*, due to perchlorate migration, citing that the alluvial soils in the release area have high hydraulic conductivity and the general absence of vertical migration barriers (Smith Consultants, 2000-a, p. 6).

8.1.1.2.3. *Halogenated solvents and other wastes.* Other documented wastes produced at Talley Defense Systems include:

- the halogenated solvent 1,1,1-TCA[10], which is a RCRA-listed waste (type F001);
- type F002 and F003 non-halogenated solvents, which are RCRA-listed wastes, and, in the case of F003, are ignitable wastes;
- and type P105 (sodium azide), a RCRA-listed, hazardous waste.

Locations where each was produced or used in the facility are pertinent, shown in table 2.

Table 2.—Other wastes from Talley Defense Systems, Mesa, AZ.

Plant	Type waste	Name of waste	Description	Uses
At Plant #2	F001	1,1,1-TCA	A halogenated solvent	Used in degreasing
At Plant #2	F002	Could be any of several spent halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992	Uncertain	Non-specific source
At Plant#2	P105	NaN_3 (sodium azide)	Hazardous waste; RCRA-listed waste	Automobile safety air-bag propellant
At Plants #3 and #6	F001	1,1,1-TCA	RCRA-listed waste	Metal working at plant #3, non-specific source, plant #6; probably used in degreasing
At Plants #3	F002	Could be any of several spent halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992		
At Plant #6	F003	Could be any of several spent non-halogenated solvents listed in 40 CFR §261.31, Jul 1, 1992	RCRA-listed waste; Ignitable waste	

Source: SAIC, 1994, pp. 4-2, 6-18.

[10] Trichloroethane, phased out of use by 1995 due to risk for ozone depletion, according to: PACIFIC NW POLLUTION PREVENTION RESEARCH CENTER POLLUTION PREVENTION RESEARCH PROJECTS DATABASE, at website http://www.pprc.org/pprc/rpd/statefnd/sce/recyclab.html.

Assessment of the release potential of these wastes, according to SAIC (1994) is that release potential was low at the time of the study, but may have been high in the past for TCA at plant #2, and for liquid wastes at plant #3 due to past practices. What that past, speculative high potential may translate into, as far as actual contamination in the study area, has not been determined. There has been no testing.

8.1.1.3. *Proximity to the study area and planned environmental restoration features*. Talley Defense Systems plants are spread along a more than 2-mile-long line (fig. 8), all upgradient from the study area. No part of Talley Defense Systems facilities is any closer to any Alternative "O" environmental restoration feature than ½ mile. That point includes the washwater perc pits at plant #3. The waste propellant burn pits are farther away from Alternative O--no closer than 1-¾ mile--but these burn pits are in part *adjacent* to SRPMIC *lands*, and are just 500 ft outside the Va Shly'ay Akimel *study area* boundary.

8.1.1.4. *Conclusions by Geology & Investigations regarding potential risks from Talley Defense Systems operations*. Available data are highly *in*conclusive regarding whether or not any released contaminants from Talley Defense Systems operations have impacted the currently (early 2004) planned environmental restoration features of the Va Shly'ay Akimel study area, or any other parts of the study area that are downstream of Talley Defense Systems burn pits.

As a result, it must be assumed that there is risk for some perchlorate contamination in the study area, where excavation, construction, and groundwater level manipulation are planned via Alternative O. The two potential sources of contaminant release (based on available data) have to be assumed as the washwater pits at plant #3, and the burn pits. Due to the high mobility of perchlorate, no greater or lesser risk is assigned to one source or the other. The burn pits, while farther away from the Alternative O features, probably saw more total release than did the washwater pits. To a lesser degree than assigned to perchlorate, a risk of contamination of the from heavy metals has to be considered as possible for the study area, foremost from cadmium, chromium, and lead from the washwater pits, and to a lesser degree (due to greater distance) from copper, lead, and possibly cadmium from the burn pits. Unless or until direct sampling of soil and groundwater for these contaminants is undertaken in a manner that will determine contaminant concentrations (or the absence of contaminant) in the study area and in and near planned features for Alternative O, the presence or absence of contaminants will remain an unknown. None of the previous sampling, testing, and numerical analysis by others was designed to answer this question, nor did it answer this question. Precautionary sampling and testing of soil to be moved and groundwater to be dewatered, for perchlorate and these heavy metals, should be a part of the construction of features most upstream in Alternative O**[no longer needed as long as the late March 2004 decrease in the footprint of Alternative O remains in effect, as per the fig. on the last page of this document, and as long as Alternative O remains the likely direction this study will take]**. A line of exploratory borings immediately upstream of the upstreammost wetlands and/or constructed features of Alternative O would be a wise investment, at the nearest opportunity **[no longer needed as long as the late March 2004 decrease in the footprint of Alternative O remains in effect, as per the fig. on the last page of this document, and as long as Alternative O remains the likely direction this study will take]**. Such work *could* serve to remove most all of this potential risk with regard to the study at hand, by proving that contaminant migration did not proceed far enough downstream to impact the study.

Distance, barriers, and geochemical reactions will work together to allow any contaminants that may be migrating to either migrate to the study area or be stopped prior to reaching the study

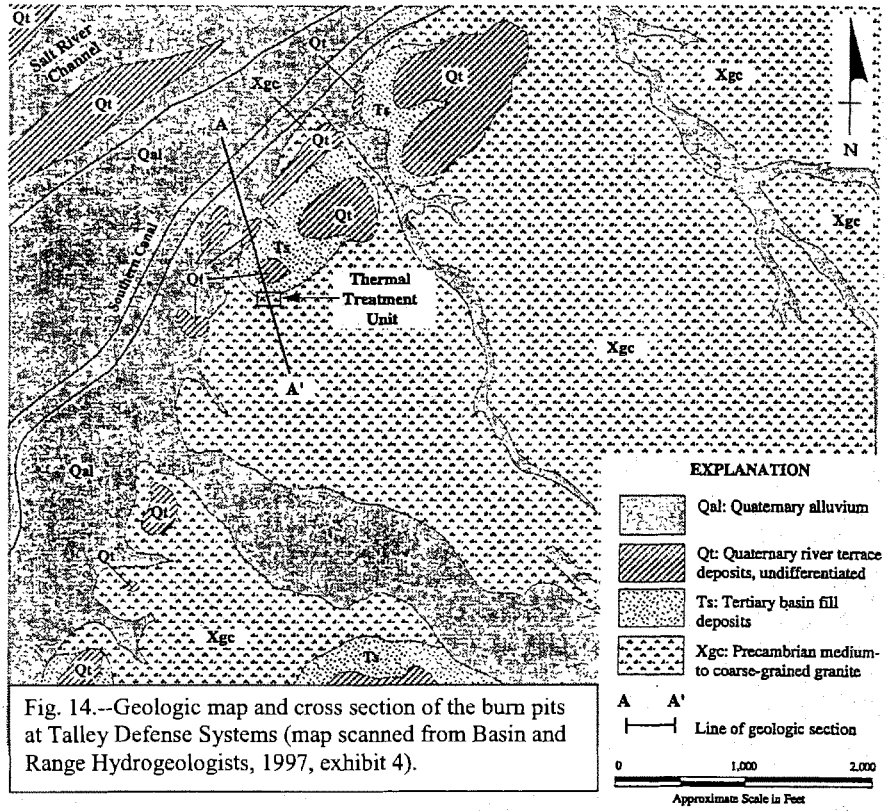
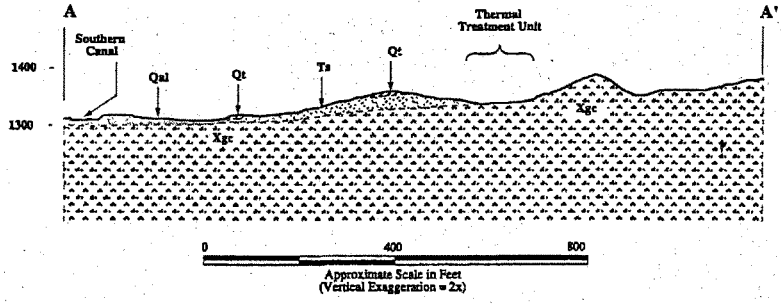


Fig. 14.--Geologic map and cross section of the burn pits at Talley Defense Systems (map scanned from Basin and Range Hydrogeologists, 1997, exhibit 4).



area. Groundwater[11] is about 450 feet deep and flows southeast (away from the study area) at 13.83 ft/day (SAIC, 1994, pp. 5-2 through 5-4). But the fact that all Alternative O features are down-gradient of surface runoff from the plant and are downgradient from the two known release areas has to be considered as increasing the risk to the study area, as the contaminants likely would travel such a route. The presence of Talley Defense's runoff retention basin shown on figs. 10 and 11, which was new as of June 2000 (Smith Consultants, 2000-a, p. 4), should be expected to provide some manner of barrier to contaminant migration, especially the metals. The observed attenuation in copper and lead contamination at depth coincides with what is known about the geochemistry of those metals and suggests that the soil between the burn pits and the study area probably serves to some degree as a barrier to metals migration. The potential mitigation feature of soil stabilization, discussed by Smith Consultants (2000-b, p. 10) is worthy of additional consideration. The location of the Southern Canal (fig. 8) between the Salt River and the contamination also may serve as a partial barrier to mitigation of contaminants to the study area. That canal's depth, lining type, etc., were not determined for this assessment. It is unclear whether the local geology (see fig. 14) would contribute to or impede contaminant migration. Smith Consultants report that the hydraulic conductivity of granitic, Precambrian-age basement bedrock below the alluvial soils at the burn pits is many magnitudes of order less than that of the thin, overlying soils developed from weathering of the granitic bedrock (Smith Consultants, 2000-a, p. 6). This rock, if unfractured, *may* represent a sort of lower, partial, containment to migration; if fractured, it could provide addition, faster routes of migration to the study area.

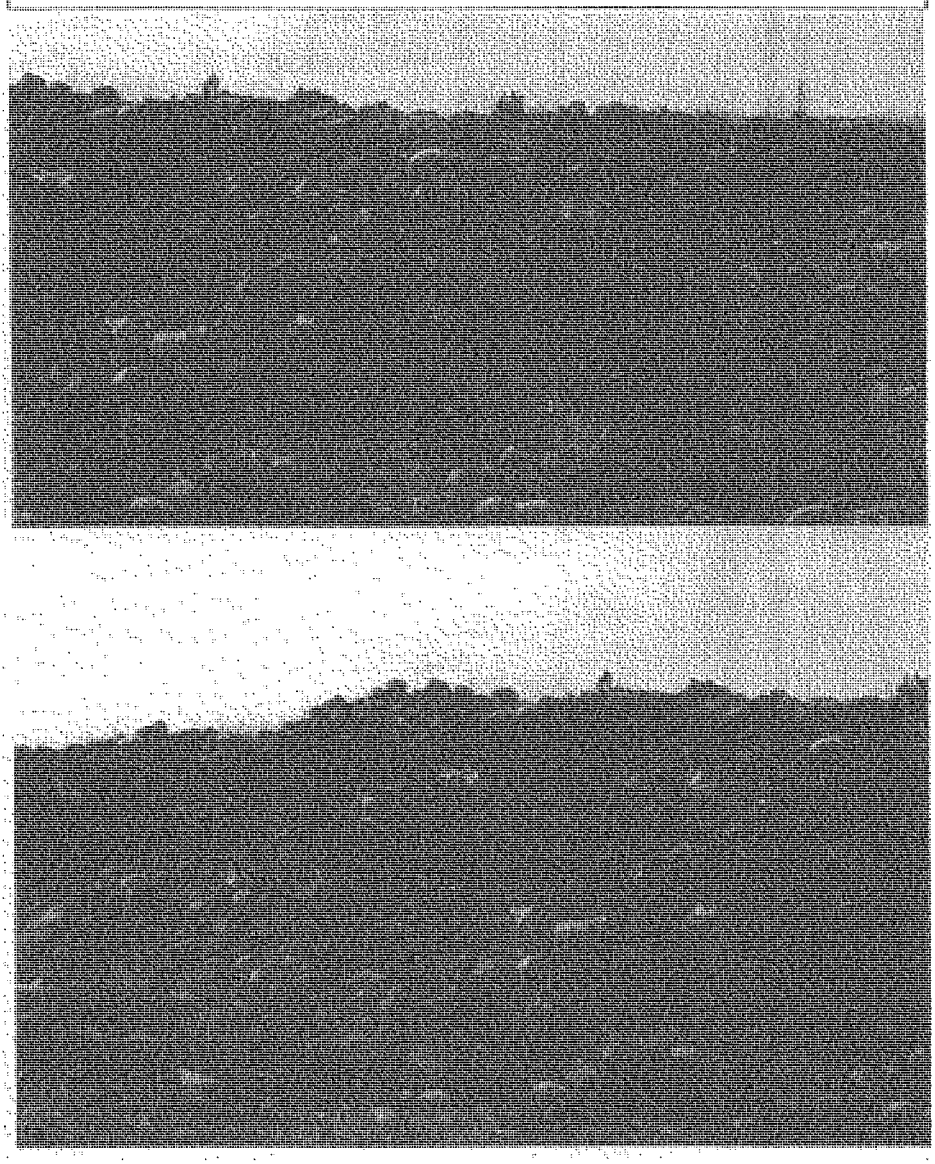
The Talley Defense Systems facility is within both the 50-year and 100-year flood plains (SAIC, 1994, p. 5-5), so a risk exists of contaminant movement to the study area via surface inundation of the burn and washwater pits, and other facilities as well.

The risk from halogenated and non-halogenated solvents probably should be considered a very low potential risk at this point, not worthy of follow-up at this time, based on available data about past practice at the facility. This should be tempered with the fact that no testing was done in any of the past studies for these potential contaminants of concern.

8.1.2 *Landfills* (sites 8, 15, 18, 30, 31, 32C, on fig. A-1). Five landfills are within the study area; all are near the current array of conceptual environmental features of Alternative O. See the summary of these landfills, below, in table 3. All landfill sites for which there is any information are unlined, so there is concern regarding what might be leached from them if they are inundated as part of the conceptual environmental restoration. Potential riverbank erosion and breach of landfill contents deserves consideration as an issue. Only the Tri-Cities landfill has bank protection. A reported debris pile at site 2 on fig. A-1 (Salt River Sand and Rock quarry) is the load from one such breach. The risk of others to breach is not known. USACE, 2002 (p. III-4) notes two of the landfills (unspecified) were improved with bank hardening under a FEMA program subsequent to 1992-93 flood breaches. The river bank segment that is essentially composed of Cypress landfill trash (figs. 15, 16) is evidence that is has been breached in the past and is susceptible in the future.

[11] As of the time of the research (1994), there were 22 groundwater withdrawal wells within a 1.5-mile radius of the burn pits, with the closest downgradient well, one mile to the southeast from plant #3, extending to –731 ft below ground surface. There were no injection wells (SAIC, 1994, p. 5-4).

Fig. 15.—Top and bottom frames. Exposed landfill debris comprising the north bank, Salt River, at the perimeter of the Cypress landfill. Note tires, plastic garbage bags, construction debris. Photo, looking north, of the toe of the bank, by Geology & Investigations, 31 Oct. 2001.



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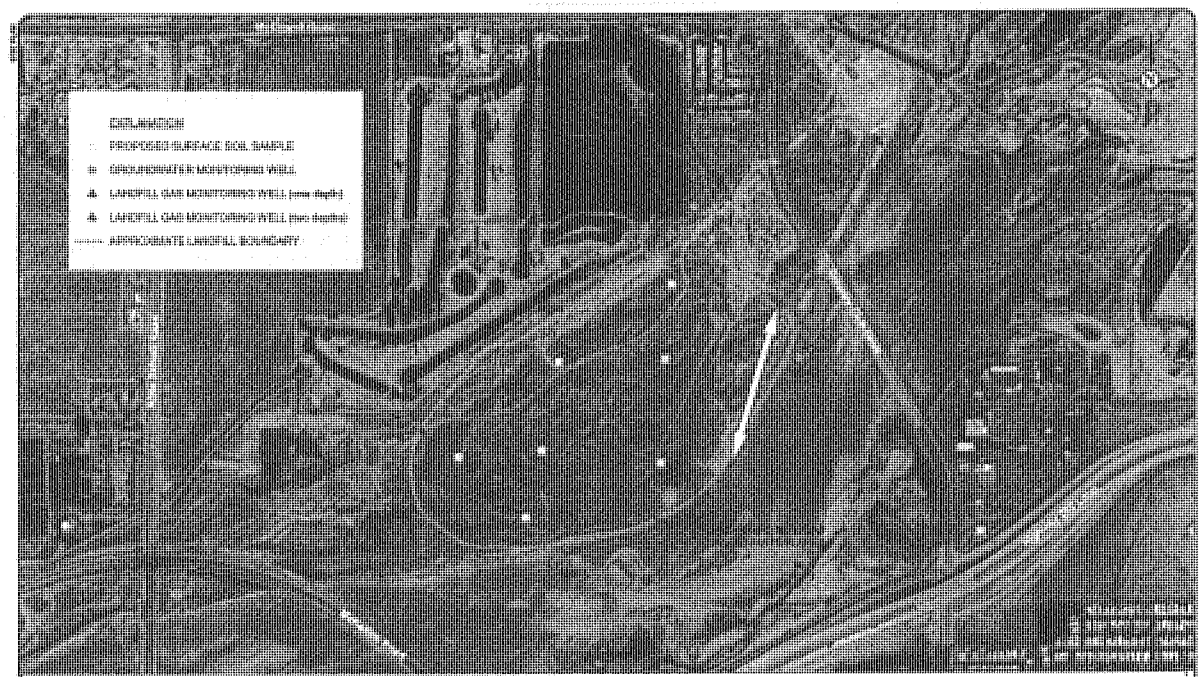

Fig. 16.—Aerial photo of the Cypress landfill (yellow circle) supplied by SRPMIC staff. The white arrow is the approximate area along the north bank o Salt River where Cypress landfill contents comprised the river bank (refer to photos, fig. 15). The red circle is the approximate area where an underground ignition is thought to have occurred within the landfill.

Table 3.—Summary data on landfills in the study area			
Name	Status	Actions	Contents, pollutants (if any)
Tri-Cities, forms the north bank of Salt River in the study area Site 15, fig. A-1	Closed, operated from 1972-1993	Reclaimed, unlined, possibly capped. A soil cement barrier was constructed along the side facing Salt River so as to prevent bank erosion if the river flows. That toe is reportedly 15 ft deep (SRPMIC staff, 2003)	40-million cu yds of waste including demolition debris and residential waste. VOCs in groundwater were a problem until methane collection system installed; then VOCs dropped and no longer exceed MCLs. (Liesch 2002).
Cypress (informally known as "old Tri-Cities" or "Country Club" landfill and many older references will use those terms Site 8, fig. A-1	Operated from early 1960's to about 1980	No closure procedures undertaken; never permitted. Reportedly will receive brownfield funding for cleanup, according to SRPMIC staff, Jan. 2004. Contains wildcat barrel dumping, on top of the landfill after it ceased to be a landfill; this has been partially cleanup up by ADEQ (just the liquid-containing drums), and the rest of the drum cleanup will be covered under the brownfield funding, according to SRPMIC staff, Jan. 2004. More on this barrel site under "wildcat dumping".	Precise boundaries / depth of the landfill not specified and likely unknown. Contains an underground fire (Erroll L. Montgomery & Associates, 2002, p. fig. 1), probably in the waste, near the toe of the north bank of the Salt River channel. The waste forms at least a ¼ mile segment of the north bank of Salt River (see photo, fig. 15), including the toe of the bank, as observed by Geology & Investigations, 31 Oct. 2003. Two VOCs (TCE, 0.6 ppb, and PCE, 0.8 ppb) were detected in groundwater from a well (4ddd) located downgradient of this landfill, but the location is such that the readings could have been from any of three landfills (data excerpted from a 1986 K.D. Schmidt & Assoc. report that we have not been able to obtain). Acetone (dimethylketone) detected in 2002 groundwater sampling in two monitoring wells. There is no EPA MCL for acetone. Its source could be in-laboratory contamination of instruments (Erroll L. Montgomery & Associates, 2002, p. 11)
North Center St. landfill (informally known as "Tri-Cities, south side" or "Salt River" landfill Site 30, fig. A-1	Operated from early 1979s to 1980 by SRPMIC; also used in 1981	A 1994 closure report exists for the Tri-Cities landfill and shows this site on its maps (as "south side"), but all data available suggest no bank stabilization or cap was ever constructed for this landfill	3 million cu yds of waste deposited, incl. asphalt, demolition materials and residential waste. Bank has not been breached Groundwater contamination and methane migration are two risks suggested (Liesch, 2002, p. iii, 10). See note about TCE and PCE in groundwater for the "Cypress" landfill, above; the same applies to this site.
Vulcan demolition debris landfill	No data	Liesch (2002, p. 11, iii) lists no details and suggests no data are available	The size and contents are unknown.

Table 3.—Summary data on landfills in the study area			
Name	Status	Actions	Contents, pollutants (if any)
Site 31, fig. A-1			
"Old Mesa", North Center Street landfill (under the police firing range) Site 32C, fig. A-1	Inactive, dates back to at least the 1960's (Liesch, 2002, pp. 9)		Contents unknown
Salt River landfill Site 18, fig. A-1	Active	An active landfill (Liesch, 2002, p. 14); approx. location from SRPMIC staff, May 2003. Probably the same site as the Salt River landfill at Gilbert Rd. and State Rte. 87, mentioned in USACE, 2002 (p. IV-26).	None known or suspected.

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EPA rules governing the remediation and stability of existing landfills (Criteria for Municipal Solid Waste Landfills (40 CFR part 258)), particularly with regard to the necessity that they be stabilized so as to not wash out, do not apply to landfills that were not active after 1991, nor to those closed after 1991 that were installed with a final cover prior to 1994 (§258.1) (Source of data: http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/techman/subpartb.pdf). Thus, this regulation applies only to the Tri-Cities landfill, the one landfill that is in relatively good condition and the one landfill that has been armored against washout.

There is an informal, non-regulatory agreement between the operators of the GRUSP and the operators of the active Salt River landfill (see table 3 for data), such that the local groundwater recharge mound created by the GRUSP recharge activities will in no case be raised to an elevation closer than 25 feet below the bottom of the Salt River landfill. The objective is to assure that no leaching of Salt River landfill contents will occur due to inundation from below by groundwater. The agreement never has been formalized. The above is according to staff of the SRPMIC, as of mid-January 2004.

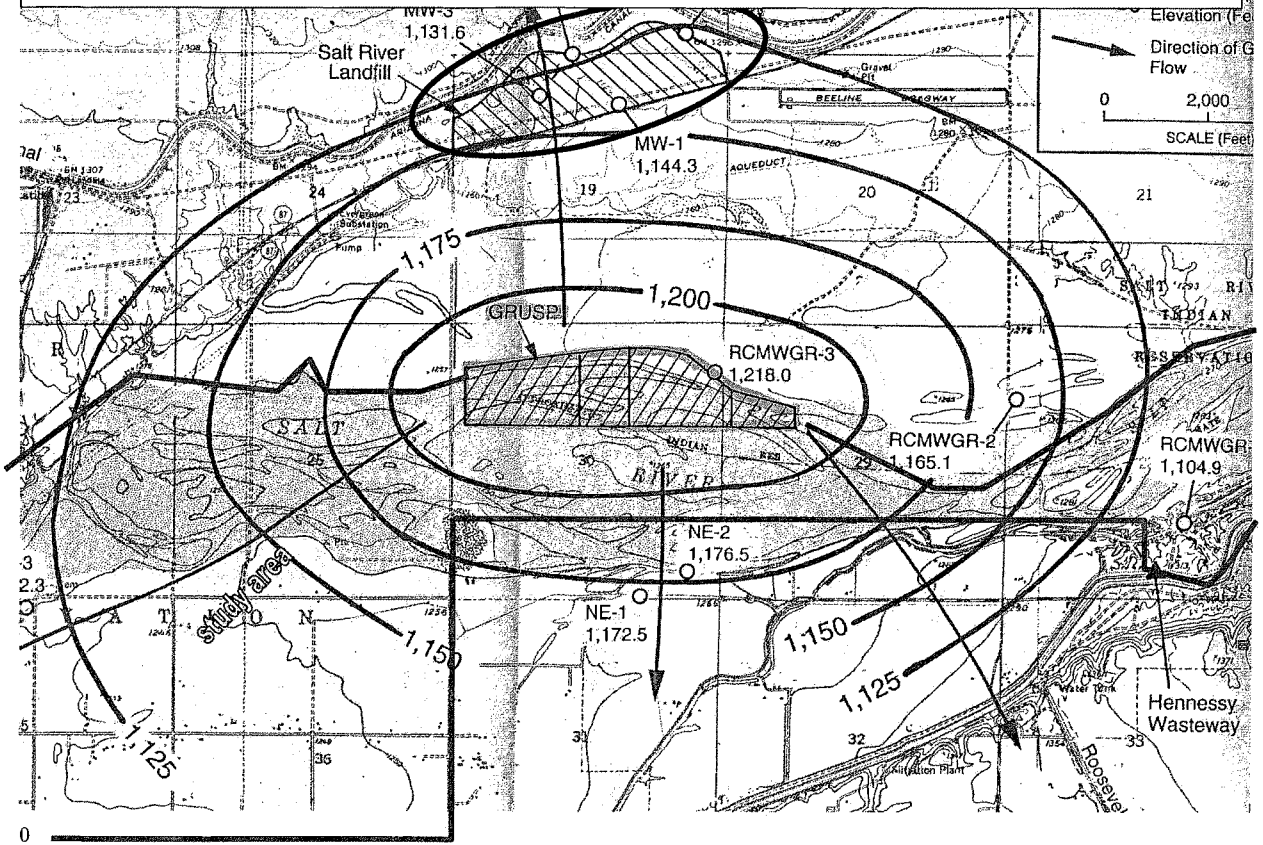
8.1.2.1 *Recommended groundwater equilibrium conditions modeling*. Throughout the feasibility process, the Geology & Investigations recommendation concerning the unlined landfills has been that infiltrating groundwater equilibrium conditions and zone of influence of that water be modeled for all features that will be irrigated and for wetlands that will be created as a part of this conceptual environmental restoration. The objective should be to avoid any inundation of landfill contents so as to avoid the risk of creating any landfill effluent. It was the opinion of previous researchers of two of those landfills that the one reason effluent from all the landfills in this vicinity is not a problem is that the landfills *do not receive any water*. Most environmental restoration features of this study are based on irrigation throughout project life.

The recommended task of modeling is complicated by the fact that the boundaries of the landfills are imprecisely known. The following data are provided as some background data that should help any effort to model the infiltrating groundwater equilibrium conditions and zone of influence. Since all the conceptual Alternatives include irrigation, many for the entire project life, there likely will be interaction between on-going groundwater recharge of other projects and irrigation of the Va Shly'ay Akimel study area. As long as the groundwater interaction remains undefined, mobilization of HTRW, most likely landfill leachate, has to be considered as a possibility.

A map of groundwater recharge mound from the GRUSP (location 17 on fig. A-1), as provided by SRPMIC Environmental Services, is reproduced here as fig. 17. Note the active Salt River landfill, the closest landfill to the GRUSP, which has an existing agreement that groundwater recharge due to the GRUSP will not inundate the landfill (see text section 8.2.2, above). Locations of the Mesa/SRPMIC groundwater recharge ponds (locations 53 and 4, respectively, on fig. A-1), which recharge treated wastewater, are shown on fig. 18. There are not any study area landfills downstream of them, but it should be documented that there will be no combined influence that will adversely impact existing situations, such as the South Indian Bend Wash Superfund groundwater contamination site (detailed below under section 8.2.4).

In the F-4 feasibility report, Geology & Investigations recommended including potential cumulative impacts from irrigation runoff ponds in the groundwater modeling. None of the pond locations were known at that time, although they were in general discussed in the Phase I EA.

Fig. 17.--GRUSP area (pink), and groundwater table elevation contours outward from the GRUSP, which, collectively, connote the groundwater mounding from the GRUSP. Note red lines (in between is the study area;; and blue circle (Salt River landfill—active). Note scale, and arrows (direction of groundwater flow). Data from SRPMIC Environmental Services files.



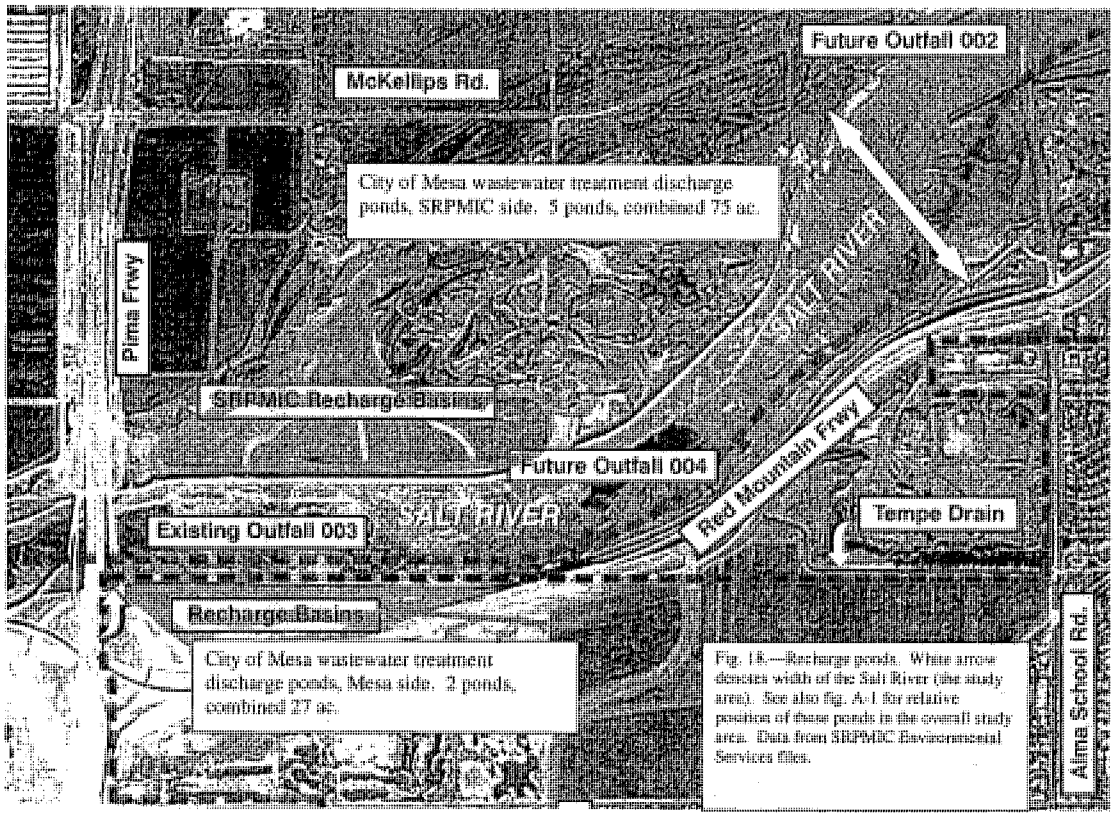


Fig. 18.—Recharge ponds. White arrow denotes width of the Salt River (the study area). See also fig. A-1 for relative position of these ponds in the overall study area. Data from SRPMIC Environmental Services files.

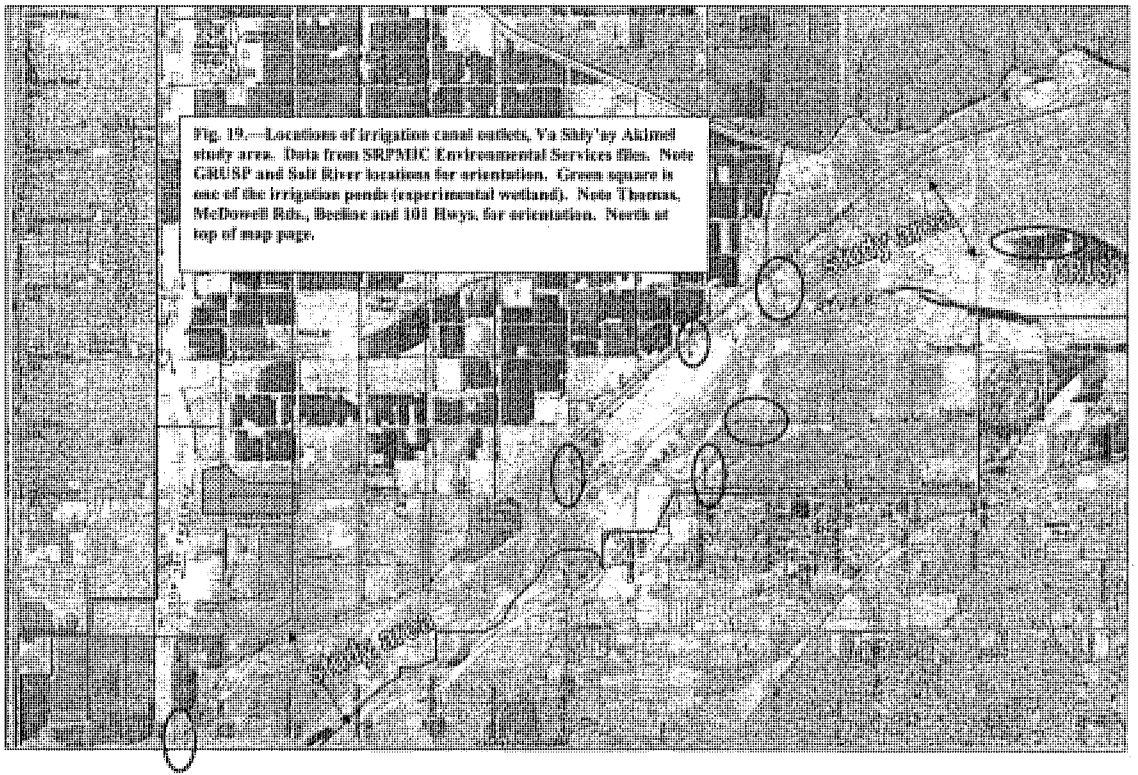


Fig. 19.—Locations of irrigation canal outlets, Va Shly'ay Akimel study area. Data from SRPMIC Environmental Services files. Note CAIISP and Salt River locations for orientation. Green square is one of the irrigation ponds (experimental wetland). Note Thomas, McDowell Rds., Beeline and 101 Hwys. for orientation. North at top of map page.

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The locations of most have been determined since: one pond, operated as an experimental wetland, adjoins the study area near the downstream end (see fig. 19); no acreage for that pond was discovered in research. Five others (including one yet to be built) are no closer than 3,500 ft from the study area; the next closest is 6,000 feet away from the study area. With such distances involved, impact from any of those five is unlikely. SRPMIC Environmental Services file data suggest one other pond exists; no location for it has been determined. Geology & Investigations has been recommending that the cumulative impact of irrigation drainage outlets also be factored into the groundwater modeling. Locations have been determined since the F-4 level geotechnical appendix was prepared and are shown on fig. 19. There are seven such outlets that drain into the Salt River within the study area; 21 others drain into the Arizona Canal and are not considered pertinent and were not counted.

8.1.2.2 *Increase in proclivity to overbank flooding*. For the same reasons applied to the issue of modeling of groundwater infiltration equilibrium conditions and zone of influence, Geology & Investigations recommends that consideration be given to any potential that may exist for this study's conceptual irrigation to decrease the capacity for infiltration during high flow events on the Salt River, and thus possibly exacerbate the risk of overbank flooding. Overbank flooding could increase the risk of mobilization of HTRW discussed in sections both in preceding and following sections.

8.1.3 *Drum dump site*. Some 60 to 65 metal drums with various liquid and solid wastes were illegally dumped on top of the Cypress landfill at some unknown time (site 11, fig. A-1), although some probably were dumped after that landfill was closed, which was in 1979. The dump location has received partial cleanup under RCRA[12] with the work done by ADEQ[13] in May 1990, when approximately 14 drums with liquid wastes that registered organic vapors in tests were removed from the site; it was speculated they were drums of recently dumped waste solvents. Other drums, badly deteriorated and breached in some cases already in 1990, had solid wastes, observed (and reinforced by testing) probably to be paint residues, resins, and possibly smelter slag (Benson (1990(?)). They remain as they were, exposed to the surface, some now spilled or completely decomposed. SRPMIC Environmental Services staff reports they are counting on the future brownfield cleanup of the underlying Cypress landfill to address this drum dump.

8.1.4 *VOCs in groundwater, including the Indian Bend Wash Superfund sites*. The North Indian Bend Wash and South Indian Bend Wash Superfund sites (no. 1, shown as the large blue rectangle on fig. A-1), are contaminated with TCE[14] in both soil and groundwater. The official, outer perimeter of these sites adjoins the downstreammost point of the study area (it is the large blue rectangle shown on fig. A-1, this report), but it has been verified that neither the soil contamination nor the groundwater contamination from North Indian Bend Wash site actually adjoins the study area, and the same likely is true of the South Indian Bend Wash site. Remediation is underway at these sites. The Superfund goal is to remove industrial solvents containing volatile organic compounds (VOCs) that were typically disposed of directly onto the ground or in dry wells. These disposal practices, along with other releases, resulted in the present groundwater contamination, all occurring prior to the existence of current, applicable

[12] "RCRA" is "Resource Conservation and Recovery Act".
[13] "ADEQ" is "Arizona Dept. of Environmental Quality".
[14] "TCE" is "trichloroethylene", also called trichloroethene, a volatile organic compound.

environmental regulations, which date from the 1970's. All three aquifers in the vicinity of these sites, the Upper, Middle, and Lower Alluvial Units, are contaminated, a situation that has been known since 1981 when elevated levels of VOCs including trichloroethylene (TCE), tetrachloroethylene (PCE) and chloroform were found in several Scottsdale-area drinking water wells (local water providers stopped using those wells for drinking water, in response). The entire site was placed on EPA's National Priorities List (NPL) in 1983. The southern area was administratively separated by EPA into a *South* Indian Bend Wash Superfund Site, which then took on a separate cleanup track from the *North* Indian Bend Wash site.

The North Indian Bend Wash groundwater contaminant plumes (which also contains PCE) are no closer than 8,000 ft from the Va Shly'ay Akimel study area boundary. This includes contamination in the UAU (Upper Alluvial Unit, essentially the uppermost aquifer (unconfined) present in the Phoenix area. Upgradient soil contamination at the site (exclusively from TCE) is no closer to the study area than 7,000 ft (EPA, 2001). **Monitoring of clean-up activities and monitor well test data by SRPMIC Environmental Services has led them to conclude that this site has not impacted the study area and likely will not in the future; pollutants are contained by current efforts and have not crossed into the study area** (Ramirez, 2004, p. 2).

At South Indian Bend Wash, Solvent Vapor Extraction (SVE) is the method being used for soil cleanup. The risk due to soil contamination is low, except in cases where direct contact with the soil may occur. Groundwater contamination is decidedly more serious, according to the EPA and is being studied further via monitoring wells, and with at least some focus still on PRP (potentially responsible party) identification (EPA website section on Superfund properties, March 22, 2004). There is no map of either the soil or the groundwater contamination areas posted anywhere on the EPA website, so a groundwater contaminant plume map from in a 1986 report attributed to K.D. Schmidt and Associates must be utilized to close the data gap (Geology & Investigations has not been able to acquire a copy of this report, only a copy of some data that were excerpted from the report). This data source shows the VOC groundwater contaminant plume to be in the Salt River but 1,350 ft down river from the downstreammost edge of the study area. That position places the groundwater contaminant plume from this Superfund site outside of the study area and, in the opinion of Geology & Investigations, should remove any potential risk of it contaminating the study area, based on the logic that groundwater beneath the Salt River is not going to travel in the upstream direction under any imaginable circumstance. The location of the soil contamination related to this Superfund site is not known and is not presented on the EPA website as of March 22, 2004. (EPA website data source, March 22, 2004: http://yosemite.epa.gov/r9/sfund/overview.nsf/507c94f730e0ebf488256958005cda5f/5128cd5fa52005aa88256dd3006a75c0.) **SRPMIC Environmental Services has concluded that this site has not impacted the study area and cannot, due to the downgradient location of all known pollutants** (Ramirez, 2004, p. 4).

Two other VOC-groundwater contamination sites are in the general vicinity of the Va Shly'ay Akimel study area. Neither appear to have impacted the study area or pose any foreseeable risk of doing so, primarily due to their distance and their position downgradient of the study area, with regard to groundwater flow direction. The South Mesa WQARF[15] site is successfully contained for the time being, via in-place remediation activities, according to data in the WQARF section on the ADEQ website as of March 19, 2004. The groundwater contaminant

[15] WQARF is "water quality assurance revolving fund", essentially a State "Superfund" site.

plume remains generally in the position shown in 1986 data attributed to K.D. Schmidt and Associates. That data suggest the plume is no closer to the study area than 23,000 ft to the southeast of the study area (about 4.3 miles). A second VOC-in-groundwater site is much closer to the southeast of the study area: the "Motorola Mesa WQARF" site, again according to data excerpted from the K.D. Schmidt & and Associates report mentioned above, is about 8,000 ft (1.5 miles) from the study area boundary. No such listing can be found as of March 2004 on the ADEQ website listing of WQARF locations, even under an alternative name, nor under any NPL locations in Phoenix. It has not been ascertained whether this site may have been completely cleaned up, and possibly dropped from the WQARF listings. Regardless, its distance and location downgradient of known groundwater flow removes this site from being a potential risk to the study area.

8.1.5 *DBCP contamination in groundwater*. DBCP[16] (which is, "dibromochloropropane") has been detected in groundwater over a large area south of the Salt River (fig. 20), and this area is as close as 1,700 ft south of the study area boundary, directly south of the GRUSP. The location once was known as the "Mesa DBCP WQARF Site", but no such listing can be found as of March 2004 on the ADEQ website listing of WQARF locations, nor can any be found in listings of all NPL locations in Phoenix. It was not ascertained whether this site may have been completely cleaned up, and possibly dropped from the WQARF listings. Favorable information that is available is the following. According to data from a 1986 report by K.D. Schmidt and Associates, the DBCP-contaminated groundwater apparently remains south of the Salt River and the study area; data suggest that groundwater flow is southeastward, away from the study area. Unfortunately, depths of the wells and of the contaminated samples is not in the excerpted K.D. Schmidt & Associates data available to Geology & Investigations, but this is the most logical conclusion that can be reached by evaluating the available data. Geology & Investigations has not been able to acquire a copy of this report, only a copy of some well test data that were excerpted from the report. The cited report data show that DBCP, measured to 0.2 ppb and lower, had not reached the study area or the Salt River. The 0.2 ppb concentration is the EPA's MCL (maximum contaminant level for drinking water) and was set at that level because "EPA believes, given present technology and resources, this is the lowest level to which water systems can reasonably be required to remove this contaminant should it occur in drinking water." (http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html). Web-based data sources used to prepare this section are: http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html and http://www.safetyinfo.com/safetyinfo/html/osha/Standards/z/1910_1044_APP_A.html.

8.1.6 *LUSTs*[17]. In the Phase I EA, eleven LUST properties are listed, including five clustered in a commercial business district along Country Club Dr. at the 202 highway, and along McKellips Rd. near Country Club Dr.; and two others along Alma School Rd. All of those are outside of the study area or at the study area periphery. Four others are in or adjacent the Salt River

[16] DBCP is a soil fumigant, applied to control nematodes and applied to crops such as cotton, soybeans, fruits, nuts, vegetables (cucumbers, summer squash, cabbage, cauliflower, carrots, snap beans, okra), plus aster, shasta daisy, lawn grasses and ornamental shrubs. Formerly heavily used in the agriculture industry, its use was stopped in 1979 except for application to pineapple crops in Hawaii (stopped in 1985). EPA lists the following as the health effects related to exposure: when people are exposed to it at levels above the MCL for relatively short periods of time: kidney and liver damage and atrophy of the testes.

Sources: http://www.epa.gov/OGWDW/dwh/c-soc/dibromoc.html;
http://www.safetyinfo.com/safetyinfo/html/osha/Standards/z/1910_1044_APP_A.html

[17] "LUST" is the acronym for "*L*eaking *U*nderground *S*torage *T*ank".

bottom, associated with the sand and gravel quarry or batch plant operations, and those are considered probably more important, as they are inside the study area. According to the

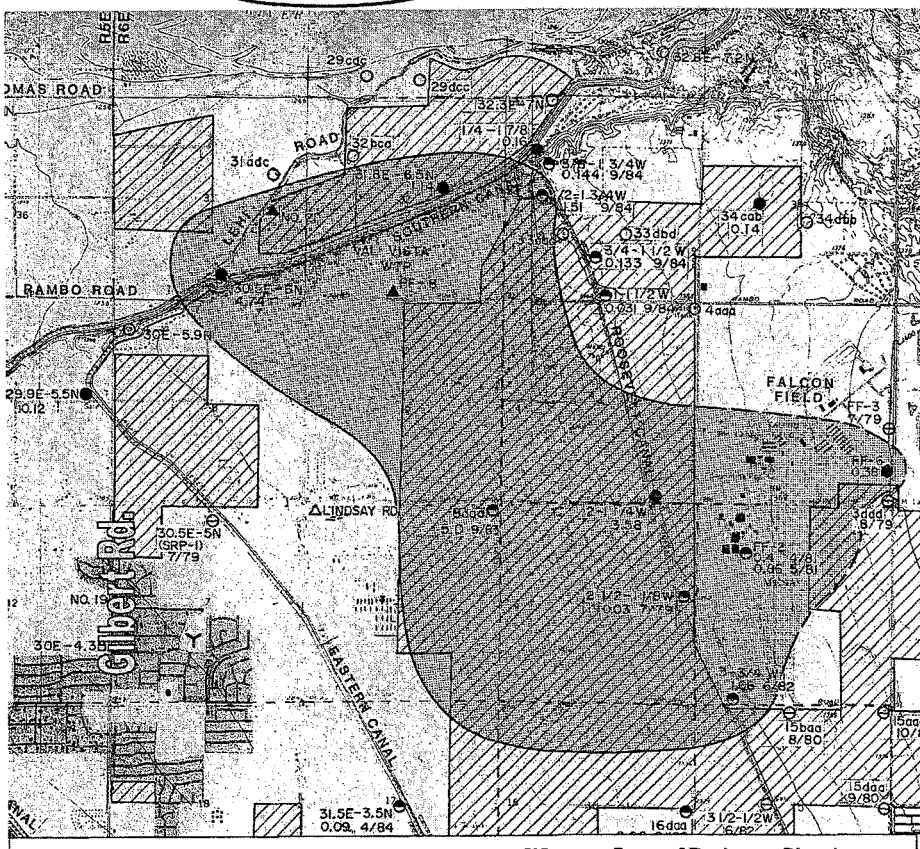

Fig. 20.—Map showing the DBCP plume (dark gray), from US Army Corps of Engineers, Planning Section C file data. This work has been attributed to a 1986 report by K.D. Schmidt & Associates. The hachured areas are early 1950's citrus orchard locations, perhaps the source of the DBCP releases. For scale, note that the squares are 1 mile across. Darkened circles, half circles, and triangles indicate wells and test pits where DBCP was detected; the white circles, triangles, half circles are test locations free of DBCP. Note Gilbert Rd., and the red oval (GRUSP location) for orientation. North at top of map page.

regulatory database summary in the Phase I EA, eight of these eleven LUSTs have been remediated to the point they are "case closed" and no longer under regulatory oversight as an environmental concern for ADEQ; only one involved any groundwater contamination (site 33 on fig. A-1). There is no suggestion that any sites currently are under remediation.

The unresolved LUSTs (i.e., those not yet documented beyond data presented in the Phase I EA, and with no proof of a "case-closed" status) include:

- Site 2, Salt River Sand and Rock, Metro (or Dobson) Operations, which is inside the study area; status is unclear from reading the Phase I EA;
- Site 14, United Metro, inside the study area; status is unclear from reading the Phase I EA;
- Site 48 (fig. A-1), classed as "undefined" in the regulatory database reported in the Phase I EA; it is near, but outside the study area.

Geology & Investigations has recommended further research into regulatory oversight files on these sites, such as those of the ADEQ in Phoenix, to be done in conjunction with the existing in-kind services arrangement for HTRW work for this study. This avenue of research likely would obtain more current data than would normally be available through the generalized, electronic database search that characterizes a Phase I EA, and it is thought by Geology & Investigations that the most current data on those sites may show they are indeed "case closed" or otherwise be informative as to risk assessment. SRPMIC staff reported in May 2003 that other regulatory file data exist showing that all three of these sites have been resolved; documentation has not been provided as of publication time. Also recommended is additional research into the details surrounding the other two known LUSTs in or adjacent the Salt River (3 (Vulcan), and site 28 (Chandler Ready Mix), both of which are "case closed". Regardless of the fact that they are "case closed", when planning groundwater manipulation, irrigation, and infiltrating water manipulation, as do the Alternatives of this study, it is wise to learn the details on former LUSTs that are within the study confines. SRPMIC staff have been tasked with this research on all the aforementioned LUST properties as part of the in-kind services agreement for geotechnical issues; data will be included in this report when provided.

8.1.7 *Minor TSD[18] issues*. There are several, minor, TSD issues reported in the Phase I EA, all associated with sand and gravel, cement, asphalt quarry operations and/or their plant operations (sites 2, 3, 14, 16, 22, 23, and 51 on fig. A-1). All are in the Salt River or adjacent to it. All or most owned by SRPMIC, but there are some three or four operating lessees involved. Boundaries of the operations (presumably the quarry perimeters) are shown on fig. A-1, all apparently recently mapped (Jones and Stokes, 2002). Most of the sites were defined by Liesch (2002) to have minor TSD issues related to washing and maintaining vehicles and chemical storage, but not all were visited by Liesch and one (site 16) was not listed in Liesch (2002), so there are unknowns to be addressed. It is the Geology & Investigations opinion that the sites possibly could release chemicals into the environment if there were to be flooding or high flows in the Salt River, but that the impact likely would be small. Whether or not that risk is acceptable to study goals needs to be determined by other disciplines on the team. As before, Geology & Investigations recommends additional research into the details of the operations and TSD issues, and documentation of the findings, all as a part of the existing HTRW in-kind services arrangement with SRPMIC.

[18] "TSD" is "treatment, storage, and disposal".

The same Geology & Investigations recommendation (additional documentation under the existing HTRW in-kind services arrangement) holds for the SPILLS database listing for the SRPMIC Cypress golf course (site 9, fig. A-1), where some unspecified 60-gal. release occurred. It likely is just a matter of documenting the substance released and the clean-up that was enacted. At a separate location, there is an issue with the surface debris scraped off the Arizona Propane site (no. 6 on fig. A-1); more information should be obtained to assure it is not a RCRA site.

8.1.8 *Regulated materials use*. Numerous sites among those listed in table A-1 use some types of regulated materials, which could become hazardous waste if released into the environment. These sites are not listed as problem sites in any regulatory database, and most, if not all, have *no* environmental problems associated with them. For the purposes of US Army Corps of Engineers criteria, a complete listing of these sites and the materials they use/treat/store/dispose of should be compiled. If construction is to occur in or adjacent to such sites, the Construction Division needs to be made aware of them. Much, if not all of this information is in the Phase I EA. The data should be drawn onto one, concise list. The Geology & Investigations recommendation is that this task be done as a part of the existing HTRW in-kind services arrangement with SRPMIC.

9.0 Non-hazardous waste. Non-hazardous waste is **not** an HTRW issue, but it is an important issue with regard to estimating project costs, and could easily become a monetary issue with regard to construction schedule delays, if time has to be taken to classify unexpected wastes as encountered. Even if eventually shown to be not hazardous, stockpiling and removal of those wastes can become a noticeable and unexpected project cost increase. For this reason, Geology & Investigations has recommended that debris / illegal dumps scattered in the study area need to be accurately located, cataloged, and that their quantities need to be estimated. The Phase I EA made reference to "wildcat" or unregulated waste dumping, but was not specific as to location. In the first quarter of 2004, Environmental Services staff of the SRPMIC carried out a detailed field survey to meet these goals and supplied existing, additional documentation from their files from their earlier survey of waste concrete dumps in and along the Salt River. Their field notes and their pre-existing file data on this subject of non-hazardous waste, or debris, are the sole source of data used to compile the following summary.

While some debris discussed below, such as tires and some appliances[19] may not wholly fall into the category of *non-hazardous waste*, the view is that such items are readily identifiable, large objects that readily can be segregated when processing waste streams, and afford little risk of release into this environment. For example, tires can be expected to be removable intact and can then be handled appropriately. So can refrigerators, if there are any, and if they contain CFCs. If there were any CFCs in refrigerators that no longer are intact, those CFCs likely already have volatilized.

[19] Refrigerators, for example, if they contain and have not been drained of CFCs. While numerous household appliances were noted in the survey, the notes were not specific as to whether those observed included any refrigerators.

Table 4.—Non-hazardous waste and debris catalog, Va Shly'ay Akimel study area.

See figs. 21, 22, 23 for numbered site locations. This debris, etc., were mapped and quantities estimated by Environmental Services staff, SRPMIC, in Jan.-Mar. 2004, and earlier. The drum dump on top of Cypress landfill is addressed under a separate section in this report (as a RCRA site), but other, non-hazardous surface dumping that occurred on top of the closed Cypress landfill is addressed in this table.

#	Type	Map	Contents
1	Possibly an illegal dump	See fig. 21	Estimated 750 cu yds of metal, concrete, and tires; scattered; boundary as shown in red on inset map of fig. 21. According to the Phase I EA and SRPMIC staff, landfilled waste washed out from unspecified upstream landfill(s) as they breached in past floods, collecting at the Dobson operations and that debris has not been removed since; this polygon likely is that area. USACE (2002, p. III-4) notes two landfills breached in 1992-93 (location not specified).
2	Northern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	See fig. 21	Estimated 43,000 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21. Covers approximately 5.2 acres.
2	Southern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	See fig. 21	Estimated 6,700 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21.
3	Illegal dump	See fig. 21	Outside of the study area; boundary as shown in red on inset map of fig. 21; extensive area with scattered, usually small loads of wide variety of illegally dumped materials, including bricks, wood, other refuse. Estimated total of 50 cu yds. Likely of little relevance to the study area as it is north of McKellips Rd.
4	Concrete debris	See figs. 23, 21	Estimated 370 cu yds of concrete debris.
5	Illegal dump	See figs. 23, 21	Small area with construction debris. Quantity not estimated.
6	Illegal dump	See figs. 23, 21	Small areas with dumped trash bags of household refuse. Quantity not estimated.
7	Concrete debris	See figs. 23, 21	Estimated 250 cu yds of scattered concrete debris, possibly washed out from the adjoining Cypress landfill.
8	Illegal dumping on top of Cypress landfill	See figs. 23, 21	Scattered refuse, household appliances, tires, estimated total of 3,000+ cu yds.
9	Illegal dump	See figs. 23, 21	Furniture and household appliances, 64 pieces, total, estimated to total 1 ½ tons in mass.
10	Concrete/cement waste, two, non-contiguous areas	See figs. 23, 21	On south bank of Salt River and in the river bottom. Total for both areas numbered "10" on fig. 23 is estimated to he 11,400 cu yds. The material is dried in eight different "fans" or separate deposits, varying from 1.5 ft to 6 ft in thickness, and typically about 3 ft thick. Most is down the south Salt River bank, but one area, a slab of about 550 cu yds, is within the Salt River bottom and the study area near the Mesa city property line.
11	Illegal dump	See figs. 23, 21	Furniture and household appliances, 9 pieces, total, estimated to total ¼ ton in mass.
12	Debris from Cypress landfill washout	See figs. 23, 21	Miscellaneous debris washed out from landfill; estimated 800 cu yds, total.

Table 4.—Non-hazardous waste and debris catalog, Va Shly'ay Akimel study area.

See figs. 21, 22, 23 for numbered site locations. This debris, etc., were mapped and quantities estimated by Environmental Services staff, SRPMIC, in Jan.-Mar. 2004, and earlier. The drum dump on top of Cypress landfill is addressed under a separate section in this report (as a RCRA site), but other, non-hazardous surface dumping that occurred on top of the closed Cypress landfill is addressed in this table.

#	Type	Map	Contents
13	Concrete debris	See figs. 23, 21	Estimated 80 cu yds of scattered concrete debris, within the blue oval area shown on fig. 23.
14	Metal debris	See figs. 23, 21	Metal grizzlies used for screening large rock at portable sand and gravel operations; uncertain if this is dumped or stored material. No quantity estimated.
15	Concrete/cement waste at "Rinker" operations	See fig. 21	Estimated 48,400 cu yds of hardened concrete and cement wastes, within the white area encircled on fig. 21. Extends into the river bottom. Covers and estimated 3.8 acres. May date from the time this was a United Metro operation.
15	Asphalt waste at "Rinker" operations	See fig. 21	Estimated 3,500 cu yds of asphalt wastes, within the white area encircled on fig. 21. Does not extend into the river bottom. Has been dumped on top of concrete/cement wastes. May date from the time this was a United Metro operation.
16	Tire dump, 300 tires, uncertain if this is an illegal dump	See fig. 21	Two, non-contiguous areas within the blue circle shown on fig. 21; one area has 100 tires, and the other area, farther to the north has an estimated total of 200 tires in three different non-contiguous places.
17	Calcium soil additive, uncertain if this is an illegal dump	See figs. 21, 22	Crushed sea shells, a calcium soil additive, within the white area encircled in blue on fig. 21. Unclear if this is a stockpile for future agriculture operations, or a dump of unwanted material. Estimated 1,800 cu yds of material, total. Red, elongate polygon shown on fig. 22.
18	Metal tower	See figs. 21, 22	Electric transmission tower, downed, dismembered into two pieces, approximately 100 ft long, estimated 2 tons of metal in total.
19	Illegal dump	See fig. 22	On the south river bank near Thomas Rd. Comprised of PVC pipe, cement bags, furniture. Estimated total mass is 5 tons. Red, roundish polygon shown on fig. 22.
20	Illegal dump	See fig. 22	On the west side of Gilbert Rd. Un-cataloged refuse and debris. Estimated total 50 cu yds. Yellow polygon shown on fig. 22.
21	Concrete debris	See fig. 22	On the east side of Gilbert Rd. Estimated total 375 cu yds. Very small, red polygon shown on fig. 22, also with a white "6" nearby.
22	Illegal dump	See fig. 22	East of Gilbert Rd. Refuse and debris, including tires. Estimated total 200 cu yds. In the areas shown by two red polygons, each with a separate number "22", shown on fig. 22.
23	Illegal dump	See fig. 22	Refuse and debris, scattered along Gilbert Rd., both sides, as per the two long red lines shown on fig. 22. Estimated total 80+ cu yds. The material is scattered by the winds and likely will blow into the restoration area unless cleaned up, according to SRPMIC Environmental Services staff.
24	Illegal dump	See fig. 22	Debris scattered along the Salt River bottom, as far as 2,000 ft downstream of Granite Reef Dam, in area shown as large red polygon, fig. 22. Estimated total quantities: galvanized metal pipe, 3 tons; concrete rubble, 12 tons; 2 empty drums.

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Fig. 11.—Non-hazardous waste in the Va Shly'ay Akimel study area, including debris, illegal dumping, and construction/demolition/asphalt wastes. All locations from SRPMIC Environmental Services staff, including Jan.–Mar. 2004 field survey. See also the inset maps and figs. 12–23 for more detail. The numbered sites are cataloged in table 4. Note Mesa, Horne, Country Club, Dobson, Alma School, and Lavender Rds. for orientation. North is to the top of the page. Base image adapted from aerial from SRPMIC Environmental Services.

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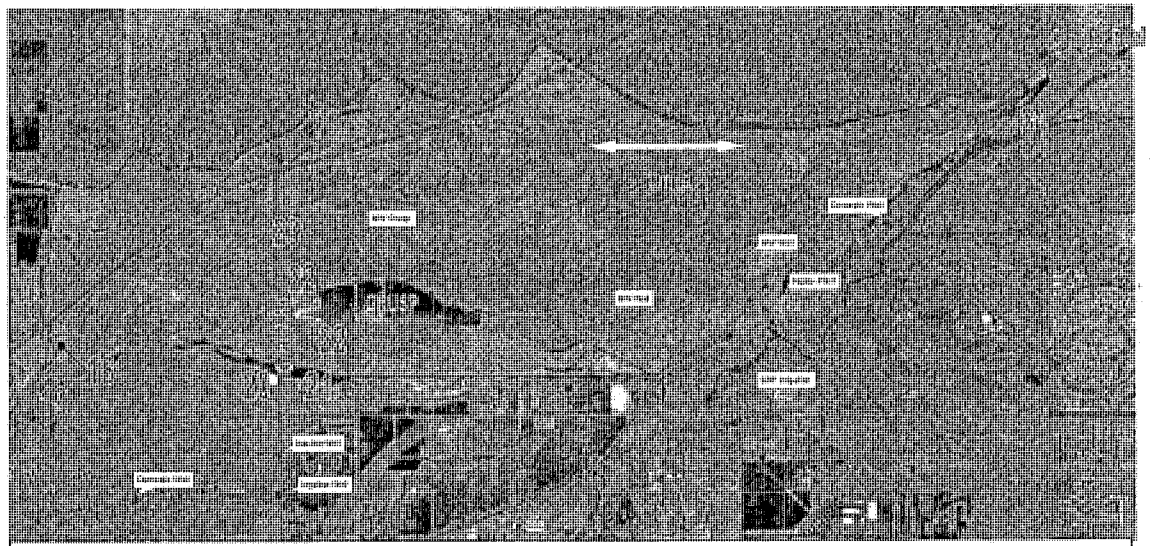

Fig. 13.—Additional non-hazardous waste sites in the Va Shly'ay Akimel study area, upstream of the Rinker sand and gravel facility and downstream of Granite Reef dam. Base, data from SRPMIC Environmental Services. Note CRUSP, the dam, Gilbert Rd. for orientation. North is to the top of page.

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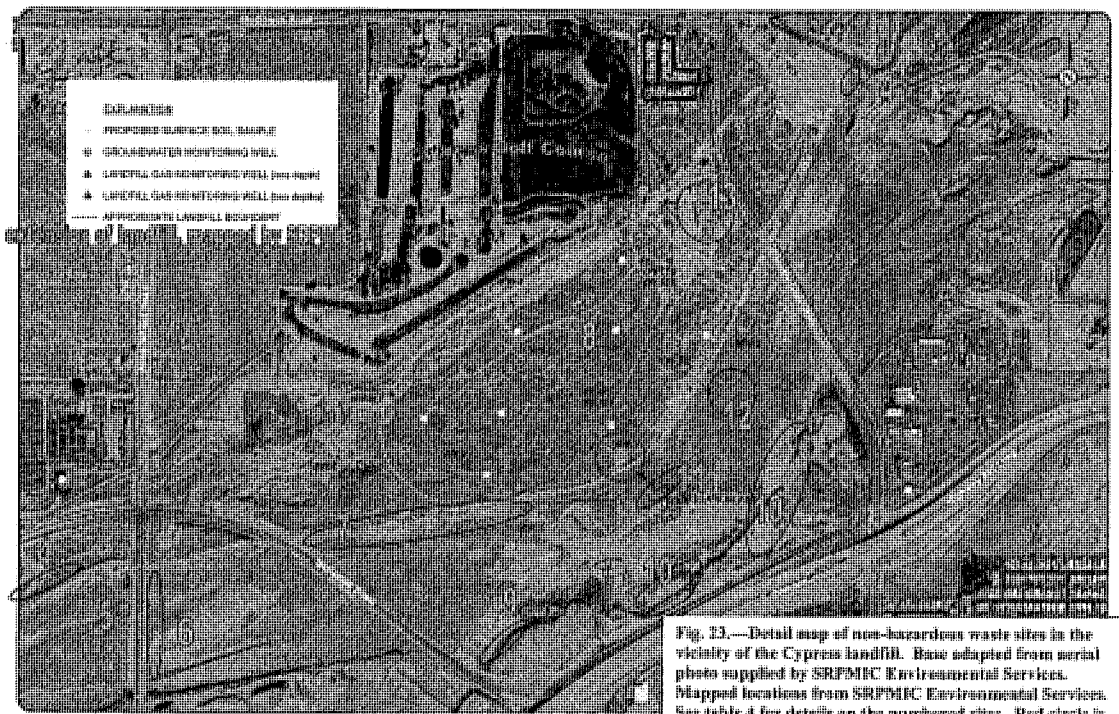

Fig. 23.—Detail map of non-hazardous waste sites in the vicinity of the Cypress landfill. Base adapted from aerial photo supplied by SRPMIC Environmental Services. Mapped locations from SRPMIC Environmental Services. See table 4 for details on the numbered sites. Red circle is probable underground fire in the landfill.

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9.1 ***Concrete, cement, and asphalt dumps.*** There are several cement batching plants and one asphalt plant in the study area, and, as is typical of that type of industry, there is the continual need to wash concrete from cement trucks as they return from deliveries, and, sometimes, there is the need to dispose of unused concrete, cement, or asphalt. There are several debris areas populated by concrete and cement, and one area of asphalt. Some of the cement/concrete waste areas cover multiple *acres*, both on the banks of the Salt River and, in places, the river bottom (see figs. 21, 22).

9.2 ***Illegal dumping.*** Materials including household debris, construction materials, green waste, appliances, furniture, and tires are found in the study area. Known sites are shown on figs. 21-23, and detailed in table 4.

9.3 ***Analysis of the non-hazardous waste situation.*** **There is significant overlap/impact between waste areas and the footprint of Alternative O** (late Mar. '04 version); details in Attachment A-1, pg. 92. The primary concern to the study, regarding non-hazardous waste, should be the thick concrete and cement layers of sites 2, 10, and 15 (figs. 21-23). Shaping banks, placing irrigation water supply wells, locating pumps, or laying irrigation water supply lines in those areas could be substantially more costly than similar work in natural bank materials. Plantings may be impossible in these areas. Design team members were notified by Geology & Investigations as to the locations of these concrete/cement dump areas as soon as the information became available (January 2004). This report is a situation update. The sites should be kept in the forefront of planning as conceptual designs are modified in the future.

Of a secondary level of importance are the non-hazardous materials that readily could be mobilized into a completed restoration area, should river flow take place, or that could be mobilized by other means. From the list in table 4, those that appear to represent the highest risk of mobilization are the Cypress landfill (loc. 8, fig. 23, and fig. 15); materials already released from the Cypress landfill into the wash (loc. 12, and possibly loc. 7, fig. 23); materials released from an unspecified landfill washout that collected near the Dobson plant (loc. 1, fig. 21); the 300 tires (loc. 16, fig. 22); and blowing materials from trash thrown along Gilbert Rd. (loc. 23, fig. 22). Consideration should be given to cleaning up these specific sites (and perhaps others), regardless of whether or not they fall within the confines of the environmental restoration areas.

10.0 Geologic Hazards. Geologic hazards considered in this report include faulting and seismicity, as well as subsidence.

10.1 ***Faulting and Seismicity.*** Faults in central Arizona are generally short, discontinuous normal faults, some of which displace Quaternary formations. Most of these faults are within the Jerome-Wasatch Structural Zone, a 50-mile-wide band that extends from Utah to Mexico. In Arizona, the zone includes the Main Street Fault in the northwest corner of the state and the Verde Fault about 50 miles north of Tempe. Both of these faults are considered to be potentially active.

A zone (approximately ¼ mile wide) of exposed, Tertiary age inactive normal faults, exists immediately north of Tempe Butte gap, approximately 2.5 miles west of the western boundary of the Va Shly'ay Akimel study area. The zone trends northwest to southeast, and extends northwestward for a distance of 2.7 miles. Additionally, an east- to west-trending (1.1 miles

long) Tertiary age fault lies concealed below the alluvium, in the middle of the Salt River, at Tempe Butte Gap (USACE, 1998).
The Va Shly'ay Akimel study area is located in an area of low seismicity as referenced in Zone 1 of the Seismic Zone Map of the Contiguous States (U.S. Army Corps of Engineers, 1983). DuBois, et al. (1982) list 29 earthquakes with maximum epicentral intensities between II and VI on the Modified Mercalli Intensity Scale (MM) which have occurred within a 100 mile radius of the study area from 1870 through 1980 (I-III represent slight shaking, IV-VI represent non-damaging, widely perceptible shaking). The largest of these known earthquakes occurred southeast of Ajo in 1961, northeast of Globe in 1969, and northwest of Prescott in 1976. The 1961 event, 95 miles from the study area, had a Richter magnitude of 4.7 (No known reports from the Phoenix area). The 1969 event, 72 miles from the study area, had a Richter magnitude between 4.4 and 5.1 (assigned an MM intensity of II at Phoenix). The 1976 event, 81 miles from the site, had a Richter magnitude of 5.1 (assigned an MM intensity of IV at Phoenix).

From 1980 through 1998, additional earthquake information can be found on the Arizona Earthquake Information Center (Northern Arizona University) website ww4.nau.edu/geology/aeic. Numerous small earthquakes are listed within a 100 mile radius of the project. All of these are at the extreme limits of the search area, including the Jerome-Prescott area to the north, and the Mogollon Rim area to the northeast. The highest Richter magnitude quake occurred along the Mogollon Rim in 1989, registering a 3.4 value.

The largest known earthquake to occur in Arizona was of Richter magnitude 5.7 recorded in 1959 near Fredonia, 240 miles from the study area. The seismic historical record for the last 125 years indicates that only one major damaging earthquake (1887 Sonora, Mexico) has occurred and was located outside the 100 mile radius. This earthquake measured a Richter magnitude of 7.2, and was located more than 255 miles from Tempe, AZ, causing rockfalls (MM VI) near the study area. The most recent (1974) nearby events, the "New River earthquakes", located 15 miles north of the study area, had recorded Richter magnitudes of only 2.5 and 3.0 (DuBois, et el., 1982).

In conclusion, the study area is located within a region of low seismicity, and ground rupture and shaking are not expected to significantly impact the design at Va Shly'ay Akimel.

10.2 ***Subsidence.*** Earth fissures and subsidence are both produced by groundwater (pumping) withdrawal, whereby ground (soil) compresses (subsides) because it has lost the support of water within its pores. In Arizona, earth fissures have developed in unconsolidated sediments, typically near the margins of basins where groundwater levels have declined from 180 feet to more than 500 feet (Péwé, et al., 1987). Differential surface subsidence and horizontal extension occurs over buried bedrock hills, ridges and fault scarps, as well as where there are lateral variations in type and thickness of alluvium, or caliche.

Ground failure in the form of (pumping) subsidence and earth-fissures has occurred in nearby areas of the Phoenix Basin. Near Luke Air Force Base, 28 miles west-northwest from the project area, extensive removal of groundwater for irrigation purposes lowered the groundwater level 340 feet from 1923-1976 (Laney, 1976). The resultant 1 to 3 feet of subsidence has been measured and exhibits the shape of a 2-mile diameter bowl-shaped depression. In the Queen Creek area, 20 miles southeast of the project area, the water table has declined up to 420 feet during the same period (the greatest decline in the Phoenix region). The land surface in the

Queen Creek area subsided 3-5 feet from 1948 to 1967 (Raymond, et al., 1978). A compaction recorder installed by the U.S.G.S. in the area has measured compaction of about 0.2 feet per year, with water levels falling about 5 feet per year from 1976 to 1986 (Péwé, et al., 1987).

Groundwater levels were lowered 330 feet from 1923-1976 just north of Scottsdale, 7 miles northwest of the study area, with up to 1 foot of subsidence recorded along the trace of the Arizona Canal to the east (Laney, 1976).

Numerous earth fissures have been mapped in the Queen Creek area, and a less extensive area east of Buckhorn, 12 miles east-southeast of the study area. Péwé, et al. (1987) state that the deepest and widest earth fissure observed in Arizona (up to 1980) was located at Chandler Heights in the Queen Creek area, and was 15 feet wide at the surface, and up to 50 feet deep. Péwé, et al. (1987) state that the maximum measured subsidence between 1948 and 1981 of a benchmark about 1 mile west of Buckhorn is 5.1 feet. Fissuring in the area in the 1970's and 1980's damaged U.S. Highway 60 and threatened the Central Arizona Project Aqueduct.

In the last four decades, an increasing portion of groundwater withdrawal from Scottsdale, SRP, Tempe, Arcadia Water Co., and Arizona American Water Co. and the NIBW area has raised concerns about land subsidence (primarily west of SRPMIC). Land subsidence is not an immanent threat to NIBW Area, but rather a condition from historical groundwater pumping. The ADWR initiated a regional subsidence program in 1999. ADWR will develop the necessary baseline data to verify and quantify any future subsidence (SRPMIC, 2002).

Available information suggests that subsidence within the study area has not occurred in the past and there is not expected to occur in the future. Therefore, subsidence is not expected to significantly influence design at Va Shly'ay Akimel.

10.3 ***Slope stability***. Slope stability may be an issue with regard to conceptual wetlands construction that would adjoin existing incised river banks or that would adjoin existing sand and gravel pits. Local increases in the water table, sufficient to support these conceptual wetlands, may result in some slope instability in places. The topic needs to be addressed. Such an assessment cannot be made with available data concerning the conceptual construction because existing design-type information and influence-type information simply are too sparse. For example, for each wetland this type of information would be needed for the assessment, "feature x will raise the local groundwater to y elevation over an influence area of z". Locations of existing hardened structures in the riverbed and nearby areas have not been compiled. They may mitigate slope stability problems. These data gaps should be closed so that an assessment can be made.

10.4 ***Foundation conditions***. The latest Alternatives to be added to the list of 30 Alternatives under consideration (Alternatives O_1 and O_2) include a 2,000-ft-long grade control structure. At the time of this writing, design and location information for this structure is not available to the US Army Corps of Engineers Geotechnical Branch. At some future date, an assessment of the foundation conditions under this structure will have to be made. Several smaller dikes also are features of the newest Alternatives. Similarly, their locations are not known at this time and an assessment of foundation conditions will have to be made later.

11.0 Sources of Construction Materials. Two stone borrow sites have been identified as sources of construction material and are available for use, in the event an engineering design is proposed for Va Shly'ay Akimel. The two quarries have produced stone for previous Corps flood control projects at the Arizona Diversion Canal and Indian Bend Wash areas. Stone from both quarries exhibit a good service record and passed all rock quality compliance tests. The quarries are listed as:

Sun State Rock and Materials	and	Salt River Sand & Rock (Mesa or Dobson Oprns.)
-located 20th St. and E. Beardsley Rd, Phx, AZ.		-located at Dobson & McKellips Rds, Phx, AZ.
-passed 1990 rock quality tests		-passed 1994 rock quality tests
-passed 1994 visual inspection		-passed 1994 visual inspection
-produces granite.		-produces green schist (cobbles and boulders).

The Salt River Sand and Rock operation is owned by the SRPMIC, and is the largest stone borrow site in the study area. The Corps of Engineers utilized SRSR materials for flood control projects at the Arizona Diversion Canal and Indian Bend Wash areas. Stone from the quarry exhibit a good service record and passed all rock quality compliance tests.

Two quarries operated by the Granite Express Company were visited by a USACE LAD Geotechnical Branch geologist in 2003. Granite Express Pit #1, approximately 35 miles southeast of the study area between Florence and Gold Canyon, produces a hard rhyolite, predominately for landscaping purposes. Abrasion test results are available, but no specific gravity or absorption testing was submitted. A Granite Express gravel pit, located near the intersection of Highway 87 and Gilbert Road (approximately 1 mile north of the study area), was also visited. The operation produces gravel and cobbles up to a 24 inch limit. Granite Express operates another quarry, Saddle Crown, which produces a more expensive white granite, used predominately for landscaping. This quarry was not visited, and no test results were submitted.

11.1 ***Concrete Materials.*** Concrete aggregate sources investigated in previous studies are described below (SRPMIC, 2002). Each source is identified by the stream from which materials are taken. Future studies would require reevaluation of these sources in accordance with SPD policy. On-site sources will be investigated and evaluated for production of aggregates for use in construction.

- Salt River. Sands and gravels from the Salt River are historically the oldest producing sources of aggregates for the Phoenix area. Coarse aggregates and cobbles are generally present in sizes to 12 inches. In some cases material as large as 24 inches is available. Some deposits have run out of sizes larger than gravel. The percentage of sand in these sources is adequate for economical concrete construction.

- Cave Creek. The Cave Creek sources have cobbles to 24 inches. A sufficient quantity of coarse aggregates is available. Some of the plants are importing sand from the Agua Fria River.

- Agua Fria River. The Agua Fria sources are the youngest sources being mined in the Phoenix area at this time. The maximum size of material generally varies between 12 to 18 inches, with a larger proportion of sand than other sources.

11.2 ***Cement.*** There are two major producers of cement in the state of Arizona who are presently producing cements which are pre-qualified by the Waterways Experiment Station for use in Corps of Engineers projects. These plants are the Phoenix Portland Cement Corporation at Clarkdale, approximately 130 miles north of the study area; and the Arizona Portland Cement Company at Rillito, approximately 130 miles southeast of the study area. Additional cements would be available from the California Portland Cement Company at Colton, California, approximately 360 miles west of the study area. Recently, cements produced in Mexico have been imported to the United States and have been used in the Tucson area. The Clarkdale site likely would be used for any project needs, as it is owned by the SRPMIC.

There are two cement plants producing Type III cement which conforms to ASTM Specification C 150. These are the Genstar Cement Company plant at Stockton, California, approximately 540 miles northwest of the study area, and the Calaveras Cement Company at San Andreas, California, approximately 775 miles northwest of the study area.

11.3 ***Pozzolan.*** In accordance with current Federal regulations, the option to use fly ash, a pozzolanic admixture, as a substitute for Portland cement will be allowed in the production of concrete for the study. Concrete generally produced in the area at the present time uses pozzolan to offset reactivity between the cement and silicates in the aggregate and to reduce the heat of hydration. Fly ash, proven to be suitable in the past, would be available from a plant near Page, Arizona, approximately 400 miles north of the study area, and from a plant at Cochise, Arizona, approximately 185 miles southeast of the study area.

11.4 ***Admixtures.*** Two types of admixtures are used extensively by concrete producers in the Phoenix area. These are air-entraining admixtures and water reducing admixtures, Some high range water reducing admixtures have been used. It is anticipated that all classes of admixtures will be used in construction of the project.

11.5 ***Water.*** Sufficient water suitable for concrete construction would be available at existing concrete plants. Concrete is produced at the SRSR facilities (which is on-site) by numerous local concrete companies and suitable water is available.

11.6 ***Soil Cement.*** Soil cement has been used extensively in the Southwest, particularly in Arizona, as stream bank protection (USACE, 2000). There are several examples of this type of construction along the Salt River in the nearby area which have exploited the use of soil cement. Some of these projects were protection of the 19th Ave. landfill, protection for ADOT structures through the Tempe area, and a soil cement levee at Sky Harbor International Airport.

Additionally, the Corps of Engineers constructed soil cement lined levees along the Agua Fria River in the middle 1980's. The Salt River has historically been the source of the majority of aggregates used in concrete construction in the Phoenix area. No detailed surveys of potential borrow sources for soil cement aggregates have been completed. Based on previously available information and the performance of the above-cited projects, it is likely that suitable materials would be available from excavation in the stream bed. One of the possibilities which could increase the cost of the soil cement is the lack of sufficient fine grained materials. Excavated materials from some of the sources being exploited, in the Salt River, are primarily gravels and cobbles.

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Attachment A.

Assessment of sites of potential HTRW and non-hazardous waste concerns, with regard to each of the 30 study area Alternatives under consideration as of March 2004. Note that the assessment regarding HTRW was updated from the Oct. 2003 edition for this March 2004 edition only for Alternative O, which was the only Alternative modified after Oct. 2003. But the lack of update was necessitated primarily by another factor: insufficient time was allotted to allow this detailed analysis to be made for the 28 other Alternatives. The assessment with regard to non-hazardous waste was made **only** with regard to Alternative O, a decision again dictated by the calendar: with crucial data delivered to Geology & Investigations less than 24 hours before "publication time" for the final feasibility documents, this was all the analysis that could be done with the time available. Should any Alternatives besides Alternative O move forward in the planning process, they can be addressed as needed and this section can be updated. Geology & Investigations should be informed directly (see phone numbers and e-mail on the cover of this report), should such a need arise.

A-1.1 **Background.** The US Army Corps of Engineers, Geotechnical Branch, Los Angeles District (*hereafter* "USACE-Geotech") was tasked by the USACE Planning Division[20] with evaluating the to-date findings on potential HTRW[21] in the Va Shly'ay Akimel study area. The data source on the to-date findings on HTRW used by USACE-Geotech to make this evaluation was almost exclusively the June 2002 Phase I Environmental Site Assessment (*hereafter* "Phase I EA") by Liesch Southwest, Inc. The Phase I EA was supplied for this study as an in-kind service by the Salt River Pima-Maricopa Indian Community (SRPMIC), the Local Sponsor teamed with USACE for this study. SRPMIC contracted out this in-kind service work to Liesch Southwest, Inc.

Considered in this HTRW assessment was the possible impact by current[22] study alternatives designated A through O on existing or potential HTRW sites and *vise versa*, based on what information is found in the Phase I EA, plus much smaller amounts of data input from the USACE's Planning Div., and Hydrology and Hydraulics Branch. A color map of the 15 basic[23] Alternatives is available as a .jpg file, but these files are so large (between 10 and 18+ MB *each*) that implanting them as figures into this report would be technically impossible. The reader's computer likely would never be able to open the resulting massive digital document. To solve this problem, USACE-Geotech posted a separate .jpg file for each of the Alternatives which should be in the same subdirectory where the reader found this report, be it on a CD, hard-drive, ftp site, etc. The chart below lists each Alternative; posted .jpg files use the acronym designations (for example, "LOAD", or "MAX"). Alternatives N and O are new as of Oct. 2003 and have no acronym designations.

[20] The Planning Division, Section C, Phoenix AZ, which is providing the oversight and direction for this study.

[21] "HTRW" = "potentially *h*azardous, *t*oxic, or *r*adioactive *w*aste". There are no known or suspected radioactive sites in this study area.

[22] The Feb.-Mar. 2003 time frame.

[23] By October 2003, the basic Alternatives ("A", "B", "C", etc., through "O") each had been subdivided into two sub-alternatives, giving 30 Alternatives in all. "A_1" now represents the features shown on the "LOAD" illustration, with drip irrigation; "A_2" represents those same features, supported by "braided" irrigation. The same pattern follows with all the other letter designations: each has B_1, B_2, C_2, C_3, etc., irrigation options.

Chart listing the 30[15] Alternatives being given consideration by study stakeholders as of October 2003 (see separate .jpg files for color map of each alternative)				
New Alt desig.[15]	Old Alt. #	former acronym	Name	Level of vegetative restoration
A	1	LOAD	Xero-riparian dominate; low water requirements	Minimal
B	2	MEAD	Xero-riparian dominate; medium water requirements	Moderate
C	3	HIAD	Xero-riparian dominate; high water requirements	Extensive
D	4	MINE	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with channelized stream to avoid mining area	Moderate
E	5	VHAD	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian)	Extensive
F	6	MAX	Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with reshaped and channelized stream	Maximum
G	7	CWAD	Cottonwood dominate with braided channel network	Extensive
H	8	MSAD	Mesquite dominate with braided channel network	Extensive
I	9	CHNL	Cottonwood dominate with channelized stream	Moderate
J	10	BRAD	Cottonwood dominate with reshaping of sand and gravel pits	Extensive
K	11	NODL	Cottonwood dominate without reshaping of sand and gravel pits	Extensive
L	12	POCK	Cottonwood and mesquite dominate with high visibility from roads	Moderate
M	13	WET	Hydro-riparian dominate	Extensive
None	14	(none)	No action	None
N	no #	n/a	not under consideration in Feb.-Mar. 2003 time frame	--
O	no #	n/a	not under consideration in Feb.-Mar. 2003 time frame	--
Note that Alternative "14" from the Feb.-Mar. 2003 time frame has been discarded from the alternatives list of Oct. 2003.				

In the Jan.-March 2004 time frame, data were sent to Geology & Investigations by SRPMIC Environmental Services staff, regarding a SRPMIC field survey of non-hazardous wastes in the study area. This included older data from Environmental Services files on the extensive concrete and cement dumps that cover multiple acres of the Salt River banks and some of the invert, and a new, more extensive field survey of all types non-hazardous wastes in the study area. Many of these survey results were made available to Geology & Investigations at "publication time" for this document, and so their assessment is limited to Alternative O. No time was available for such detailed analysis for all 28 other alternatives. But the reader is referred to the text sections under section "9" (non-hazardous wastes") and figs. 21-23, which, collectively are an assessment of the non-hazardous waste situation, looking at the study area as a whole.

A-1.2 ***Overall study concepts and objectives.*** To understand the relative importance of the potential HTRW sites, they must be considered in context with conceptual plans for the study area. The current study does not involve any flood-control work. The objectives of the Study Alternatives include raising the groundwater level to varying degrees in varying parts of the study area for the purpose of supporting new, emplaced, plant communities. Consideration must be given to the impacts of that raising of the groundwater level. Specifically, the question to be considered for each alternative is, "with the projected increase in the level of groundwater, would or could contaminants at any of the potential sites of environmental concern be mobilized?" If the answer is, "yes", consideration has to be made regarding the impact of that study feature. As one example, there are several landfills in and near the river. The objective should be to prevent wetting and possible migration of contaminants in the landfills by added water. Other conceptual study area actions, beyond planting and irrigating of target plant communities, include channelizing flow to varying degrees (that is, small channels *within* the existing and much larger, incised Salt River bottom). Any channel that would be constructed, according the USACE H&H, would be no more than 6 ft deep and would contain flows no greater than the 5- to 10-year flood event. Any additional water would overflow these constructed channel banks. In some alternatives, there would be channel re-directing to avoid the existing recharge ponds of the GRUSP, and bank hardening to prevent channel migration into one of the existing in-river sand and gravel operations (Chandler Ready Mix, site 28 on fig. A-1)

Most of the sites of potential environmental concern fall within the 10-year-level flood floodplain boundary, and even more are within the 100-year-level flood floodplain boundary. Should flooding of those levels occur, surface soil contaminants could be mobilized and would travel downstream, possibly impacting some part of the study area. Mitigating this is the fact that the study's basic concept is development of plant communities, including wetlands. Wetlands naturally remove some water-borne contaminants. Thus, the study's basic concept serves to mitigate contamination mobilized from flooding, that is, provided the plant community survives the flood. It is possible that capacity for infiltration at flood stages may be reduced by the elevated groundwater level. This needs to be determined. It potentially is an issue because the overall amount or frequency of overbank flooding could be increased by completing this study's conceptual plan elements. Possibly, erosional impacts on riverbanks could increase. There could be increased risk of breakthrough into the banks that protect the several landfills on the banks in the study area. Some breached previously. Cypress landfill contents comprise the north bank of the Salt, in the study area. A large pile of debris reported at the Salt River Sand and Rock Mesa Operations is from another breach, according to data in the Phase I EA.

A-1.3 ***Summary of environmental concerns.*** Fifty-six different sites of existing activities, many with some relation to environmental concerns, were identified. Nearly all were reported in the Phase I EA, or in supplementary data attached to the Phase I EA. These sites and their significance have been summarized by USACE-Geotech and are listed in table A-1, below; a map showing the locations of each site is fig. A-1. **Updates from Jan.-Mar.'04 additional research and data collection included now in this table.**

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	ACTIVITY AND DEVELOPED SITES, INCLUDING SOME SITES OF ENVIRONMENTAL CONCERN ON THE NORTH SIDE OF THE SALT RIVER OR IN THE SALT RIVER AND GENERALLY TOWARD THE NORTH SIDE						
1	**North Indian Bend Wash and South Indian Bend Wash**	Low to none	yes	yes	Two Superfund sites with various VOCs in groundwater and soil; under EPA-directed remediation. **Will not** impact Alternative O (Ramirez, 2004).	There is a need to monitor contaminant plumes in future with regard to groundwater elevation level increases caused by conceptual study actions, and interactions with existing groundwater recharge (locations 4, 53, this table).	E, F, G, H, I, J, K, L, M, N, O should be aware of this site
2	**Salt River Sand & Rock, MESA OPERATIONS**. A.k.a "Dobson" operations. 160ac quarry site with SRPMIC opms. since 1985 and subleases to Vulcan, Hansen, United Metro (all with cement batch plants), and JD Excavating (dynamite storage). Vulcan has asphalt batch plant too, which apparently is same site as entry #3, below	Low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems mostly related to practices at vehicle maintenance and washing sites, and chemical storage practices at all 4 quarry/batch plant operations; problems extend to sand blasting practices and cement dumping at SRSR opm., which has a LUST (repaired?, closed?[25]). Debris piles are from u/s landfill washouts (Liesch (2002)	Numerous ASTs on site with fuel, automotive chemicals. If potential flood-release risk of them is deemed unacceptable to study goals, team should check regulatory databases to assure all are meeting inspection requirements; and get written documentation that SRSR LUST case has been closed; and get details on United Metro cesspool. SRPMIC reportedly can document this LUST site as "case closed" via EPA data.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
3	**Vulcan asphalt batch plant** and maintenance yard	Low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems related to practices at equipment washing sites, and chemical storage practices, debris. LUST, associated with former operator CalMat, was remediated by 1993	ASTs on site with burner fuel, 20,000 gal. of asphalt; USTs present and formerly present. If potential flood-release risk of them is deemed unacceptable to study goals, team should check regulatory databases to assure all are meeting / have met inspection requirements / closure requirements; an get details on 1999	B, C, D, E, F, G, H, I, J, K, L, M, N, O

[24] A preliminary ranking regarding potential to impact some element within the 30 study Alternatives under consideration, or some potential to be impacted by those study elements. Ranking based on the Phase I information and other limited data sources available to USACE-Geotech as of March 2003.

[25] SRPMIC environmental team members quoted as saying ALL LUST cases on the SRPMIC land have been remediated to completion.

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					(Liesch, 2002, p. 23) (i.e., "case closed").	site explosion, which resulted in rebuilding a new asphalt batch plant here.	
4	SRPMIC's 5 groundwater recharge ponds (see detail on location, fig. 18)	None but combined effects with conceptual study water addition should be modeled	No (apparently protected by dikes)	No (apparently protected by dikes)	No environmental problems. Receives wastewater from City of Mesa (Liesch, 2002). A foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biological issue, not a geotechnical issue. SRPMIC reports the ponds total 75 acres.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	E, F, G, H, I, J, K, L, M, N, O
5	Six or seven irrigation runoff detention ponds; only one pond is in the study area, or close enough to potentially impact it; that location is shown on fig. 19 only.	None but combined effects with conceptual study water addition should be modeled (for one pond only)	No (apparently protected by dikes)	No (apparently protected by dikes)	No environmental problems specified (Liesch, 2002). Site is outside of Alternative O, but there is a cumulative effect on local groundwater, along with that from SRPMIC wastewater retention ponds (site 4, this table). That impact likely should be modeled. Runoff likely nutrient-rich but no data. Nutrient absorbing capacity of study elements is a biological issue, not a geotechnical issue.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
6	Arizona Propane (former Forest Homes site)	Low	no	no	Liesch (2002) implies that the disposition has not been documented for Forest Homes waste abandonment problems (drums of chemicals). Abandonment documented in pre-1995 EAs, not addressed in 1995 EA. Some scrap-off of surface waste exists in stockpile(s). Issues probably could be addressed by more interviews with Arizona Propane reps. (likely the ones who cleaned up the abandoned waste), some soil samples, and examination of the scrap-off stockpile(s).	Should check regulatory databases to assure 6,000 and 10,000-gal. diesel ASTs and maintenance sump all are meeting inspection requirements.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
7	Saddleback Communications (the SRPMIC telecom oprn.)	None	no	no	Liesch (2002) reports no potential environmental concerns	--	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
8	**Cyprus landfill** (a.k.a. "old" Tri-Cities landfill, a.k.a Country Club landfill)	High, **exposed landfill contents comprise north river bank in study area**	yes	yes	SRPMIC reports this site will receive Brownfields funding for remediation of "known contamination" (contamination unspecified in Liesch (2002)). Operated from early 1960's to about 1980; no closure procedures undertaken; never permitted.	Precise boundaries / depth of the landfill, contents, not specified and likely unknown. Modeling of study features (irrigation immediately upstream and wetlands adjoining and nearby downstream) should be done to determine potential inundation/mobilizing of contaminants (see this text, section 8.1.2.1.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
9	**Cypress golf course**	Minor to none	no	no	A facility of the SRPMIC (Benson, 1990(?), p. 2). FirstSearch lists 10 April 2001 60-gal. release of unknown substance	Check the SPILLS database for more information.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
10	**RV storage facility**	None	no	no	Liesch (2002) reports no potential environmental concerns	--	none
11	**Dumped drum site (this is on top of site #8 Cypress landfill)** also a former gravel pit	High, surface-exposed contents could leach into adjoining study wetlands, be mobilized by adjacent study irrigation	no	yes	According to Benson (1990(?)): Illegally dumped group of 60-65 drums in the "bank flood plain" of the Salt River on SRPMIC land was discovered, along with stained areas of completely disintegrated drums. On- site tests determined organic vapors around 14 of the drums, all immediately removed (May 1990) under WQARF, and speculated to be recently dumped waste solvents. Remaining drums were corroded or badly decayed and held solids (paint wastes, resins, smelter slag(?) observed in breached drums. All in NE part of apparent historic landfill, exhibiting "uneven topography and occasional "breakthrough" of municipal waste". Interviewee quoted as saying this site was the "Tri-City landfill", and operated from late 1960's until 1972, taking household waste from Tempe and Mesa; also the drums post-date the landfill. SRPMIC was planning to expand the golf course (site 9, above, and cover this area with 5 ft of soil)—this was not done according to SRPMIC staff, 2004. Tests on the non-VOC drums showed no pesticides or PCBs but did show percent levels of Cr, Pb, Zn, suggestive of old paint residues. It was	SRPMIC Environmental Services staff (2004) reports the liquid-waste drums were removed by ADEQ in the early 1990s and that the solid waste drums remain as they were, exposed on the surface and deteriorating. SRPMIC Environmental Services is counting on cleanup of this waste to be done in conjunction with brownfields work on the Cypress landfill.	B, C, D, E, F, G, H, I, J, K, L, M, N, O

787

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					concluded that site would be classed as a RCRA hazardous materials site. Notes in Benson (1990(?), attachment C, which has 1993 data in it) appear to be made from a combination of aerial photo review notes and interview notes, though interviewee is not identified: 1962 undeveloped; 1963 gravel operations (inundated in 1996); 1969 gravel operations to adjoining land on the west side; 1970 gravel exhausted; 1972 landfilling in progress; 1973 drums appear (but apparently not the drums removed in 1990); 1979 landfilling ends. And these notes: landfill unlined and may have impacted groundwater; some areas never covered; some cover eroded, some drums where they were placed as per air photos; some landfilling started as early as 1966. Best estimate boundary shown on air photo.		
12	JRs Convenience Store	None	no	no	Liesch (2002) reports no potential environmental concerns	A check regulatory databases could be made to assure the three 10,000-gal. fuel USTs are meeting inspection requirements. No releases reported as of 2002 databases (Liesch, 2002, p. 23)	none
13	Enviro-Systems (former Defiance of Arizona site)	None	no	no	Enviro-Systems, former land user, produced pre-cast concrete, operating from 1978-2001, approximately. Form used form oil. SRPMIC identified stains, had soil removal done; successful results documented (Liesch, 2002, p. 13)	No apparent further needs.	none

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(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
14	**United Metro** (170 ac. leased for quarry and cement batch plant; asphalt batch plant; in operation since 1954; United Metro since 1995) Apparently the current name of this facility is "Rinker"	Medium	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems mostly related to practices at vehicle washing sites and chemical storage practices. There is overbank dumping of asphalt and cement, former USTs (Liesch (2002). LUST[26] on site, associated with Union Rock and Materials has been cleaned up, according to SRPMIC rep. (Liesch, 2002, p. 23).	Obtain written documentation that LUST closure requirements met and add to study files. SRPMIC reportedly can document this LUST site as "case closed" via EPA data. Verify that the washdown area / asphalt release agent use is not impacting the study area. Consider the viability of continued overbank dumping of asphalt and cement, with regard to study goals.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
15	**Tri-Cities landfill** and SRP methane gas power plant	Moderate to high, depending on the Alternative; **concern is with conceptual irrigation interaction**	no	no	Received 40-million cu yds of waste from 1972-1993, including demolition debris and residential waste (Liesch 2002). VOCs in groundwater were a problem until methane collection system installed; then VOCs dropped and no longer exceed MCLs. UST has been removed without incident. Power plant, new in 2002 has ASTs in secondary containment (Liesch 2002). UST had no record of releases (Liesch, 2002, p. 23). Bank hardened to prevent washout. Conceptual study plantings and irrigation for some Alternatives would involve the entire site, but not Alternative O.	Boundaries reported in local-sponsor-supplied data (Liesch 2002). "Final closure report", 1994, states no cap has been built. Documentation could not be obtained that the cap has been completed. Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	All
16	**Salt River Sand and Rock Beeline One Plant, a.k.a. "Gilbert quarry"**	uncertain	yes	yes	Location from Jones and Stokes (2002); names from USACE-ED-HH contacts and PD Alternatives map. Not mentioned in Liesch (2002). No information with which to assess this site.	Need to determine if site has any of the potential environmental concerns as do the other quarry and cement / asphalt plant sites.	unknown, possibly all
17	**GRUSP** (Granite Reef Underground Storage Project) groundwater recharge ponds	None **but combined effects with conceptual study**	yes	yes	No HTRW environmental concerns. Banks CAP water in seven recharge ponds. Many study concepts include wetlands around this site, so the resulting amount of groundwater increase must be calculated.	Monitored by SRPMIC and GRUSP to assure minimum distance between top of groundwater and bottom of active Salt River landfill is maintained (Liesch, 2002). What is that elevation?	All

[26] "LUST" is "leaking underground storage tank".

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
		water addition should be modeled				Modeling should be done of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	
18	**Salt River landfill**	High	no	no	An active landfill (Liesch, 2002, p. 14); location shown on fig. 17.	Modeling should be done of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	All
19	**Arizona Canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses (Liesch, 2002)	None	None
20	**Granite Reef dam**	None	yes	yes	No HTRW environmental concerns. Stores water for municipal and agricultural use (Liesch, 2002)	None	None
	ACTIVITY AND DEVELOPED SITES, INCLUDING SOME SITES OF ENVIRONMENTAL CONCERN ON THE SOUTH SIDE OF THE SALT RIVER OR IN THE SALT RIVER, GENERALLY TOWARD THE SOUTH SIDE						
21	**Primate Research Center**	None to minor	ad-joins	proba-bly	On site of early 1900's hydro-generating station. Bio-waste from primates is reportedly removed daily from the site; taken to landfill. The only foreseeable issue might be bacteria and nitrate levels induced by bio-waste that might escape clean-up, but this is a biological issue, not a geotechnical issue.	The location in Liesch (2002, fig. 1) is imprecise but text reports it is on the river bank; USACE-PD alt map suggests such a location due to visible land alteration.	None with regard to HTRW
22	**Salt River Sand & Rock, HIGLEY OPERATIONS**. with leases to Vulcan, Hansen, United Metro (all with cement batch plants), and JD Excavating (dynamite storage).	Minor to low	no	no	Data suggest the contamination, *if any*, could be cleaned readily, mostly by pick up and removal and/or install secondary containment, perhaps with some surface soil removal. Potential problems related to practices at vehicle maintenance and washing sites, and chemical storage practices at all 4 quarry/batch plant operations; reported data unclear if SRSR has its own oprn. here, as it does at Beeline One plant and Mesa oprns. / (Liesch (2002)	Three ASTs on site with fuel. Should check regulatory databases to assure all are meeting inspection requirements. Liesch (2002) reports oil and lubricant containers are in secondary containment already.	All
23	**Salt River Sand and Rock offices** (for Higley oprns.)	None	uncer-tain	uncer-tain	It is not clear why Liesch (2002, p. i) discusses these offices separately from the Higley operations quarry in the Phase I EA exec. summary; it may or may not	None	probably none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					be a separate site, but logic would suggest it is the same site as site #22, above. Liesch reports no problems and may be mentioning the site solely to complete the list of land use practices. In that regard the precise location is not critical information		
24	**South Canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses (Liesch, 2002)	None	None
25	**Southern canal**	None	no	no	No HTRW environmental concerns. Conveys water stored by Granite Reef dam for municipal and agricultural uses; is the same as the South canal and is an outmoded name for the South canal (Liesch, 2002, p. 16) (site #24 listed above), so assessment is the same. Unclear why this gets a separate listing in the Phase I EA	None	None
26	**Talley Defense Systems** Several locations south of the South Canal	Low to high, depending on the Alternative	no	no	Risk of perchlorate release into the Salt River considered very likely (see text documentation, sec. 8.1.1.2.2) and perchlorate is highly mobile in groundwater; could impact overall river ecology. Metals releases possible, not proven to have reached the study area.	Refer to the analysis in text sec. 8.1.1.4 as the planning iteration process proceeds. This will not impact Alternative O (as modified, late March 2004, and shown on last page of this document), but if Alternative footprint expands, it may be necessary to test soil and groundwater during construction for perchlorate, primarily, and for several metals (on a less prioritized need).	All
27	**horse farm**	None to minor	uncer-tain	uncer-tain	The only foreseeable issue might be bacteria and nitrate levels induced by bio-waste, enhanced since this site is apparently adjacent to a alt. #13 proposed wetland, but this is a biological issue, not a geotechnical issue.	The location in Liesch (2002, fig. 1) is imprecise but is suggestive that the farm is on the riverbank; USACE-PD alt map photo base reaffirms this as the likely location due to visible land alteration.	None with regard to HTRW
28	**Chandler Ready Mix quarry**	Low	ad-joins	yes	Boundaries are not supplied in the EA but USACE-PD alts. map base suggests a large area in and adjacent to the river channel. Potential problems observed at sites 2, 3, 14, 22, were presumed to occur here also by Liesch (2002, p. 14), but more importantly, summary of Environmental FirstSearch results (Liesch, 2002, p. 22) lists 6 LUST incidents,	LUSTs are all "case closed", and so are not an issue, but no data have yet been collected on the day-to-day operations, as they were for sites 2, 3, 14, and 22. Such data should be obtained.	All

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Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					all closed due to soil levels meeting RBCA Tier I.		
29	**Lehi Cemetery**	None	no	no	Liesch (2002, p. 13) reports no problems or suspected problems.	None	none
30	**North Center St. landfill (a.k.a. "Tri-Cities landfill (south side) and the "Salt River landfill")**	High **and the effect of conceptual study water addition should be modeled**	ad-joins	ad-joins	The SRPMIC-operated or administered site contains 3 million cu yds of waste deposited in 1979-1980, incl. asphalt, demolition materials and residential waste. Groundwater contamination and methane migration are two risks suggested (Liesch, 2002, p. iii, 10,) A memo from an unlisted agency (written by Bill Johnson on 20 Aug. 1991) reveals this same site also was named the "Salt River landfill". The 1994 closure report gives no evidence any work has been done on this landfill, only on the one on the opposite side of the river. This landfill did NOT wash out (i.e., no bank breach), and also was used in 1981, reports Johnson. It is obvious from Johnson's writing that there is much more data beyond this memo, but none is within the EA by Liesch, (2002). Adjoins large proposed study wetland alt 13. Regulatory category: CERCLIS NFRAP (Liesch, 2002, p. 21).	Boundaries reported in local-sponsor-supplied data (Liesch 2002, appendix B, "client-supplied information"; map and some data pages bound out of place in the report). Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
31	**Vulcan demolition debris landfill**	Unknown but prelim-inarily Medium to High	no	partial -ly	Liesch (2002, p. 11, iii) lists no details and suggests no data are available	The size and contents are unknown. It is close enough to conceptual study area irrigation and wetland that some details of size, depth, and contents are needed.	B, C, D, E, F, G, H, I, J, K, L, M, N, O
32 A	**Mesa Police dept. firing range**	None to low	ad-joins	yes	City of Mesa will be installing lead recovery system in the near future to take existing lead from the embankments. Asphalt covering of the range surface has been installed to prevent lead dust dispersal. Has a septic system. Berms are of various soil, including much landfill waste (site was a landfill prior to becoming the firing range (Liesch, 2002, p. 9). Existence of plans to clean up the lead contamination and (apparently) control it in the future leads USAE-Geotech to conclude this site will not be an environmental concern for any study alternatives.	Monitor progress to ensure the future clean-up discussed in the EA actually happens	B, C, D, E, F, G, H, I, J, K, L, M, N, O (if not cleaned up)

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
32 B	**Mesa (City) storage yard**	None to low	ad-joins	yes	Same location as site 32A, above, the firing range. Just a separated zone of land usage. Has vehicles, including impounds, and empty trash dumpsters, also a large supply of ground asphalt.	None	none
32 C	**"Old Mesa" North Center St. landfill** (under Mesa Police firing range)	**High and the effect of conceptual study water addition should be modeled**	ad-joins	yes	Landfill name according to Mesa is North Center St. landfill but it is NOT the same as the North Center St. landfill shown on the EA map, which was operated by SPRMIC. There are maps with the City of Mesa showing approximate boundaries but these were not put into the EA. It has not been investigated, dates back to at least the 1960's (Liesch, 2002, pp. 9) and so may be one of the older landfills around. No knowledge of contents is suggested.	Get the data on the landfill from City of Mesa. Modeling should be done of infiltrating water / zone of influence from conceptual study features (see text, section 8.1.2.1).	B, C, D, E, F, G, H, I, J, K, L, M, N, O
33	**ADOT storage yard** (a.k.a. ADOT Mesa Maintenance and Ariz. Dept. of Public Safety in databases, all at 2409 N Country Club Dr Mesa, AZ	Low to none	no	yes	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 2 in place USTs, 4 removed USTs, 2 LUSTs: one "unknown or soil contamination", and one 1993 "free product on groundwater and/or surface water", CLOSED OUT on 5-10-95; also 1997 LUST incident closed on 3-16-98 due to soil levels meeting RBCA Tier I. Apparently all LUST cases combined and closed.	None. LUST cases closed out	none
34	**Bingo Hall / Ray station** 2435 N Country Club Dr Mesa, AZ	None	no	yes	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I, and lists 3 removed USTs.	None. LUST case closed out	none
35	**Cashway Concrete and Materials** 650 W. McKellips Rd. Mesa, AZ (probably south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 22) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
36	**Valley Wide Contracting** 620 W. McKellips Rd. Mesa, AZ	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	(probably south of Hwy. 202)						
37	**Alumi-Cover Awning Company, Inc.** 604 W. McKellips Rd. #A Mesa, AZ 85201 ph. (480) 969-2286 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
38	**Allpride Marble and Granite** 556 W McKellips Rd Mesa, AZ 85201 ph. (480) 962-7743 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
39	**Carports, Etc.** 550 W McKellips Rd Mesa, AZ 85201 ph. (480) 649-0982 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
40	**Superstition Springs Crushing** (a.k.a. Sun Valley Crushing Co.) 2343 N. Country Club Mesa, AZ (north of Hwy. 202)	None	no	yes	Environmental FirstSearch summary in Liesch (2002, p. 22) lists one removed UST and one inactive UST at this address; no LUSTs listed.	--	none
41	**Redburn Tire Company** 2339 N Country Club Dr Mesa, AZ 85201 ph. (602) 272-7601 (north of Hwy. 202)	None	no	yes	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21-22 summary).	--	none
42	**Pete's Diesel Repair** 2333 N. Country Club Dr Mesa, AZ 85201 ph. (480) 964-2001 apparently shared property with	Low to none	no	yes	Environmental FirstSearch summary in Liesch (2002, p. 22) lists one removed UST at this address under the operator name of "W R Skousen Contractor, Inc."; no remaining USTs or LUSTs listed.	Due to nature of the businesses on site, proximity of the property to the river, likely should check to see if any automotive chemicals are stored and assure they are stored properly.	E, F, G, H, I, J, K, L, M

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	another business of same current address: **Heritage Trucking** ph. (480) 964-7577 property also formerly was WR Skousen Contractor (north of Hwy. 202)						
43	**Little Dealer-Little Prices** 2038 N. Country Club Dr. Mesa, AZ 85201 ph. (480) 834-9581 (south of Hwy. 202)	None	no	no	No listings of USTs or LUSTs in Environmental FirstSearch results at this address Liesch, 2002, p. 21 summary). Type of business not specified in Liesch.	--	none
44	**Karl Watkins** 2116 N. Country Club Mesa, AZ (south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 1 LUST incident, closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
45	**Contreras Contractors** 2110 N. Country Club Mesa, AZ (south of Hwy. 202)	None	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists 7 LUST incidents, all closed due to soil levels meeting RBCA Tier I.	None. LUST cases closed out	none
46	**Car Smart** (business of unspecified nature) no listing can be found in Mesa on or near Country Club Dr.; no address can be determined and none provided by Liesch (2002) (south of Hwy. 202)	Unknown, probably low to none	no	yes	Liesch (2002) is imprecise but suggests *possibly* a former UST or LUST at this site; Environmental FirstSearch summary does not list any property for UST or LUST as under the name "Car Smart". Only chance to compare the database is through the street address, which is not provided in Liesch (2002).	No way to compare with existing data until the address of the business is determined. No listing can be found after exhaustive search through Internet business listings by Geology & Investigations.	possibly E, F, G, H, I, J, K, L, M
47	**Artistic Ice Creations** (business of unspecified nature) no listing can be found in Mesa on or near Country Club Dr.; no address can be determined and none provided by Liesch (2002) (south of Hwy. 202)	Unknown, probably low to none	no	yes	Liesch (2002) is imprecise but suggests *possibly* a former UST or LUST at this site; Environmental FirstSearch summary does not list any property for UST or LUST as under the name "Artistic Ice Creations". Only chance to compare the database is through the street address, which is not provided in Liesch (2002).	No way to compare with existing data until the address of the business is determined. No listing can be found after exhaustive search through Internet business listings by Geology & Investigations.	possibly E, F, G, H, I, J, K, L, M
48	**Tevizo Hay Company**	Medium	no	no	Summary of Environmental FirstSearch results	Check regulatory files (ADEQ UST	none

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
	1747 N. Alma School Rd. Mesa, AZ				(Liesch, 2002, p. 21) lists 3 USTs, all removed, and one LUST incident with undefined soil contamination. SRPMIC reportedly can document this site as "case closed" via EPA data.	SECTION?) to see if LUST exists, or case closed, etc. SRPMIC Environmental Services staff has the assignment to complete this research as part of in-kind services on HTRW.	
49	**Sunward Materials / BCW** 1564 N. Alma School Rd. Mesa, AZ	Low	no	no	Summary of Environmental FirstSearch results (Liesch, 2002, p. 21) lists one LUST incident closed due to soil levels meeting RBCA Tier I.	None. LUST case closed out	none
50	Unspecified **other businesses at unspecified addresses (see note 1)**	Likely low to none	no data	no data	Liesch (2002) mentions this more in a comprehensive land-use manner than in an environmental concern manner.	No apparent needs.	none
51	**Cemex quarry operations**	Medium to high	no	yes	Liesch (2002) admits having no data and assuming that the washwater, maintenance, and perhaps chemical storage and UST/AST situations that characterize sites 2, 3, 14, and 22, above, probably exist here too.	No data. Visit the site. Perhaps can be documented as a non-issue	B, C, D, E, F, G, H, I, J, K, L, M
52	**Mesa Northwest Wastewater Treatment Plant**	Minor to none	no	no	No environmental problems cited (Liesch, 2002). The only foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biology issue, not a geotechnical issue.	No apparent need for data regarding the plant; the recharge ponds (see # 53, below) are of interest.	None
53	City of Mesa's 2 **groundwater recharge ponds**	**None, but combined effects with conceptual study water addition should be deter-mined**	No (appar ently protect ed by dikes)	No (appar ently protect ed by dikes)	No environmental problems cited. Receives wastewater from City of Mesa (Liesch, 2002). The only foreseeable issue might be bacteria and nitrate levels induced by effluent, but this is a biological issue, not a geotechnical issue. SRPMIC reports the ponds total 27 acres.	Modeling of cumulative infiltrating water / zone of influence with conceptual study features (see text, section 8.1.2.1).	E, F, G, H, I, J, K, L, M, N, O
54	Non-specific **residential property** locations **(see note 1)**	Likely low to none	no data	no data	Liesch (2002) mentions this more in a comprehensive land-use manner than in an environmental concern manner.	No apparent needs.	None
55	Non-specific **agricultural land** locations **(see note 1)**	None with regard to HTRW	no data	no data	Liesch (2002) reports no problems, details, or specific locations. The only foreseeable issue might be enhanced nutrient levels in surface runoff water an	None apparent	None with regard to HTRW

Table A-1.--Activities in and near the Va Shly'ay Akimel study area that have some relation to environmental concerns, or that are noted land uses.

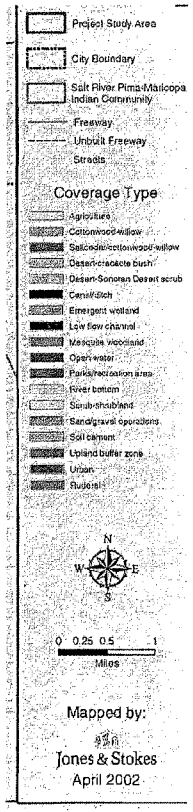
(See fig. A-1 for locations. Nearly all these sites are listed in the Phase I EA, or in supplementary data found within that EA.)

Site no.	Site name	Environ-mental concern ranking[24]	In 10-yr flood-plain?	In 100-yr flood-plain?	Potential interactions, risks, contaminants	Data voids / actions needed	Affects or is impact-ed by alt(s) #?
					perched groundwater (if any), but this is a biology issue, not a geotechnical issue.		
56	**Hwy 202 constr. & storage area (see note 1)**	None to unknown	uncer-tain	uncer-tain	Liesch (2002) reports no problems or details (or specific location) and may be mentioning the site solely to complete the list of land use practices. In that regard the precise location is not critical information	No location provided in Liesch (2002)	probably none

Note 1: Site not shown o fig. A-1. No location provided in the data source.

797

Legend and scale for fig. 1, which follows on the next page. To see this legend or the map in greater detail, use the "zoom" feature in Microsoft's WORD word-processing program. If your zoom feature is not activated, go to the standard tool bar in WORD, click the down arrow at the far right side of the toolbar, click "add or remove buttons", and then click "zoom". The source for fig.1 is the Jones and Stokes (2002) EIS for this study. The map is used here as a base because it is the only known viable map base that shows the boundaries of the existing seven sand and gravel operations in the study area. Note the magenta-colored polygons, which are the sand and gravel operations.



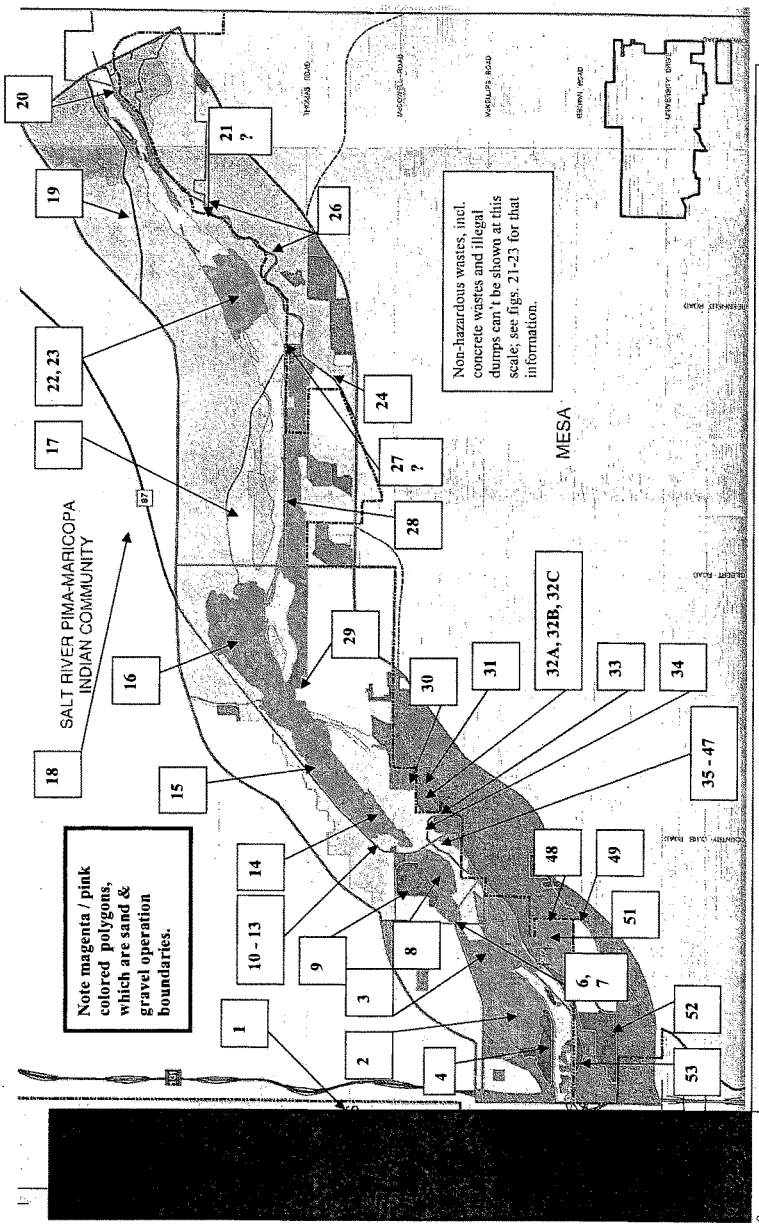


Fig. A-1.—Land use activities in and near the Va Shly'ay Akimel study area, reported in the Phase I EA (Leisch, 2002). These include e some that are or at one time had potential to be HTRW sites, some that are non-hazardous waste sites, and some that are unrelated to environmental concerns. See table A-1 for details on the numbered sites. See text, sections 8, 9 for assessment of potential problems.

A-1.4 ***Assessment of each study Alternative, in relation to environmental concerns.*** These are the USACE-Geotech assessments of Alternatives A through O.

A-1.4.1 *Alternative A* (acronym designation "*LOAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Sonoran desert dominate, minimal vegetation". Other PD data descriptions include, "Xero-riparian dominate; low water requirements", and "Minimal level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallLOAD.jpg*". For this Alternative, as with all the Alternatives, no separate assessment is made of the A_1 (drip irrigation) and A_2 (braided irrigation) options because: a) the issue is the amount that the local zone of influence of infiltrating waster that would be created by irrigation or other addition (not quantified in the conceptual plans to date); and b) no quantified difference in the volume of water to be added has been specified for the $_1$ and $_2$ options.

Summary of conceptual study actions, Alternative A: "Soronan desert" vegetation surrounding the GRUSP (site 17) and overtop at least half of the Tri-Cities landfill (site 15). "River bottom" vegetation to be added to about a quarter of a square mile immediately river-side and upstream of the Tri-Cities landfill. This is the alternative with the least vegetation, the least conceptual actions, and the least water added to the ecosystem. Irrigation will have to continue for the first three to four years to establish the vegetation according to USACE-ED-HH team members.

USACE-Geotech's list of environmental concerns, Alternative A.

1. Interaction between study-induced irrigation and the local GRUSP-supported water table must be determined and coordination must be done. The GRUSP-supported local water must remain at least 25 ft below the bottom of the Tri-Cities landfill, to avoid any leaching of landfill contents. The cumulative effects of this study action will have to be considered and documented as it would certainly be under the same regulatory restrictions as those controlling the GRUSP (site 17).

- 3. Plantings overtop the Tri-Cities landfill (site 15) also will be a concern due to irrigation. Both leaching through the landfill and impacts of rising groundwater elevation from below in response to the irrigation need to be considered and documented.3. The surface runoff from irrigation may impact the study-adjoining Chandler Ready Mix site (site no. 28). A detailed site map with the relative elevations of the river bottom and the Chandler operations needs to be obtained. That surface pollutants and potential surface pollutants from vehicle maintenance and wash-rack practices, and chemical storage practices *may* exist at the site was suggested in the Phase I EA, but this was not ascertained as the site was not visited inside property boundaries. These data should be collected and assessed. If there are potential surface pollutants that could be mobilized *by* this study's elements, or that could be mobilized *into* the study elements in flood events, this should be assessed. Will the results be acceptable for the functioning of the study elements or not?
- 4. The same issues and questions in item no. 3, above, also may apply to the Salt River Sand and Rock Beeline One operations (site 16), which were not included in the Phase I EA (a.k.a. the Gilbert quarry). Details of the operation need to be determined and documented.

- 5. The downstream extent of the expected groundwater elevation change, if any, should be determined, so as to make sure potential impacts such as nos. 3 and 4, above, will not occur farther downstream at other sites.
- 6. While more distant from the planned study actions than the sites discussed above, Talley Defense Systems (site 26) is suspected, by previous investigators, of releasing perchlorate into groundwater in the Salt River (which would be inside the study area if it has occurred), and possibly releasing heavy metals into soil, all resulting from TSD practices, such as burning and exploding waste rocket propellants at the boundary of SRPMIC lands. Specific testing would have to occur at the future construction excavation or dewatering zones in the study area in order to ascertain if contaminants would impact any given feature. Pasty testing by others was not designed to answer such a study-area-specific question and has not answered the question.

USACE-Geotech's recommended follow-on work, Alternative A.

- 1. More data exist concerning the Tri-Cities landfill than what has been collected by the study team to date would be useful; documentation that construction of its barrier cap has been completed has been particularly elusive, as has all documentation of the cap construction methods. If potential hydrocarbon-containing surface runoff is an issue with the study elements, get the information on the Beeline and Chandler sand and gravel operations. Some of this could be done by research of regulatory agency files, other information could be gathered by sites visits.
- 2. Modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills.

A-1.4.2 *Alternative B* (acronym designation "*MEAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Mesquite and Sonoran desert dominate, moderate vegetation". Other PD descriptions include, " Xero-riparian dominate; medium water requirements", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMEAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative B: Similar to but substantially more extensive than those for Alternative A. More "Soronan desert" vegetation, plus "mesquite" vegetation surrounding the GRUSP (site 17). Those two types of vegetation are planned to cover the entire Tri-Cities landfill and more, extending downstream to about the upstream end of the United Metro sand, gravel, cement, and asphalt operations (site 14). "River bottom" vegetation immediately river-side and upstream of the Tri-Cities landfill is slightly reduce in size relative to Alternative A, with its place taken by Sonoran desert vegetation. A small area of Sonoran desert vegetation is to be added to the south bank of the river, adjoining the Lehi Cemetery. Irrigation will have to continue for the first three to four years to establish the vegetation according to USACE-ED-HH team members.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative B. All of USACE-Geotech's listed environmental concerns and recommended

follow-on work for Alternative A also apply to Alternative B. Since the area to be planted under Alternative B is more extensive, the amount of irrigation, if any, will be more and the potential impact from infiltrating water and its zone of influence will be more. In addition, due to the increased area of irrigation, there is potential to impact an additional six sites by irrigating and possibly raising the local groundwater elevation. Those sites include the United Metro sand, gravel, cement, and asphalt operations (site 14), which has overbank dumping of unwanted asphalt and cement, and formerly had a LUST[27] classification. Also potentially impacted are several landfills, including the landfill under the drum site (site 11), the Cypress, North Center St. ("Tri-Cities south"), "Old Mesa", and Vulcan demolition debris landfills (sites 8, 30, 32C, and 31, respectively). Additional research and evaluation would be needed with regard to the following.

- 1. Barrier cap and other constructed closure documentation for the Tri-Cities landfill (site 15); existing closure report of 1994 does not answer these questions. Modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills.
- 2. The same information needs and considerations listed in issue no. 1, above, also apply to The Cypress landfill (site 8).
- 3. As above, for sites 11 and 32C.
- 4. A decision will have to be made regarding whether or not potentially mobilized hydrocarbons and other chemicals from runoff, if any, at the United Metro site are acceptable to the study elements, and whether overbank dumping of cement and asphalt at United Metro is an issue or not.

A-1.4.3 *Alternative C* (acronym designation "*HIAD*"). Descriptive title on the PD graphic of early Feb. 2003, " Sonoran desert dominate, extensive vegetation". Other PD descriptions include, "Xero-riparian dominate; high water requirements ", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallHIAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative C: More extensive study area alteration than Alternative B. In comparison to Alternative B, Alternative C eliminates much of the mesquite and some of the Sonoran desert plantings, in favor of cottonwood-willow plantings; increases the amount of river bottom plantings by a factor of more than two, including such that is immediately adjacent to the Tri-Cities landfill (site 15); adds two wetlands, including one nearly adjacent to the Tri-Cities landfill (site 15) on the upstream side, and another adjacent to the horse farm (site 27) (as implied in the Phase I EA) and Talley Defense Systems site. The amount of plantings within the main channel increases sharply from the plan of Alternative B, as does the amount of plantings on the south bank, extending upstream from near Lehi Cemetery. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative C. All of USACE-Geotech's concerns and recommendations listed under Alternatives A and B, above, also apply to Alternative C. Since more water would be added to

[27] "LUST" is the acronym for "leaking underground storage tank".

the system to achieve the goals of alternative C and the area of surface impact also is greater, the potential to impact or be impacted by the landfills, the GRUSP and Tri-cities landfill groundwater elevation limits, and quarry operations runoff, all are enhanced relative to Alternative B. Similarly, the potential to mobilize any Talley Defense Systems pollutants in groundwater or soil, if any, is enhanced.

A-1.4.4. *Alternative D* (acronym designation "*MINE*"). Descriptive title on the PD graphic of early Feb. 2003, "Channelized stream, avoiding mining". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with channelized stream to avoid mining area", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMINE.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative D: A substantially more geographically compact study area alteration than Alternative C, eliminating entirely the Gilbert Rd. to 40th zone of south-bank plantings as well as the study elements north, south, and east of the GRUSP. Alternative C includes wetlands and south bank alterations between Center St. and Horne Rd., and includes more wetlands adjacent or near the Tri-Cities landfill (site 15). Includes channelization within the river between Gilbert and Horne Rds. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative D. All of USACE-Geotech's concerns and recommendations listed under Alternatives A and B, above, also apply to Alternative D. For Alternative D, the potential for impacting or being impacted by the Chandler quarry drops out and the potential impact of the Talley Defense Systems site diminished sharply, both due to increased distance. Conversely, the potential to impact the Tri-Cities landfill (site 15) and the other landfills farther downstream, is enhanced, due to adding much more water. This is particularly so for the North Center St. landfill (site 30), and the Old Mesa and Vulcan Demolition Debris landfills due to enhanced plans for altering the south bank. The potential for impact with the "drum site" (site 11) and the Cypress landfill (site 8) also are enhanced, relative to Alternative C.

A-1.4.5 *Alternative E* (acronym designation "*VHAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Sonoran desert dominate, moderate vegetation". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian)", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallVHAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative E: Alternative E is very similar to Alternative C, in geographic area altered and somewhat similar in the types / degrees of alteration. Alternative E, though, uses less water and has more Sonoran-desert-type vegetation. The only two wetlands in Alternative E are the same as those for Alternative C (one by the horse farm (site 27) and one near the upstream end of the Tri-Cities landfill (site 15)). Alternative E includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river. While the re-planting zone at the downstream end of the study area does adjoin the official outer perimeter of the Indian Bend Wash Superfund sites, SRPMIC Environmental

Services has reported that the pollutants have not and likely will not impact the study area due to downgradient locations and distance. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative E. Identical to those mentioned above for Alternative C, plus the following.

- 1. Additional modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the potential impact on Indian Bend Wash groundwater contaminant plumes should be assessed. The most recently encountered data in research suggest that the plumes are far distant and that impact likely will be nil. It is considered wise to do the modeling and document that there will be no conflict.

A-1.4.6 *Alternative F* (acronym designation "*MAX*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate with reshaping and channelized stream". Other PD descriptions include, "Meso-riparian dominate (cottonwood, mesquite, and xero-riparian) with reshaped and channelized stream", and "Maximum level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMAX.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative F: Alternative F is a combination of essentially all the elements of Alternatives C and D plus more. The additions beyond Alternatives C and D include more than doubling the length of the channelized stream, extending it upstream from Gilbert Rd. to Val Vista Dr. Wetlands are larger and more numerous in those areas. Alternative F extends substantially farther downstream than any of Alternatives A through E, extending about one-quarter mile downstream of Alma School Rd., and this Alternative includes a third segment of channelized stream, from Center St. downstream to Alma School Rd. The most extensive wetlands of any in the first five alternatives are planned in Alternative F, immediately downstream of Alma School Rd. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative F. Identical to those mentioned above for Alternatives C and D, plus the following.

- 1. While the channelization downstream from Center St. to Alma School Rd. *may* reduce the chances for washout of the banks at the various landfills downstream of Center St. (proposed depth of channelization is not known to USACE-Geotech), the enhanced wetlands area increases the potential for interaction between study- elevated groundwater and the landfills beyond that of any of Alternatives A through E. Therefore, modeling should be done regarding the infiltrating water conditions/equilibrium/and zone of influence that would/could result from constructing study area features, and the results assessed for potential impacts on landfills potentially impacted specifically by these additional Alternative F features.
- 2. An additional data need arises with Alternative F, that of potential groundwater interaction with the existing Mesa Wastewater Treatment recharge ponds (site53) and existing SRPMIC recharge ponds (site 4). Groundwater already is being elevated in the vicinity of those ponds. Modeling should be done to determine the cumulative effects with infiltrating water conditions/equilibrium/and zone of influence that would/could

result from constructing study area features; the same holds for modeling with regard to impacting Indian Bend Wash groundwater contaminant plumes.

A-1.4.7 *Alternative G* (acronym designation "*CWAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, braided channel network". Other PD descriptions include, "Cottonwood dominate with braided channel network", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallCWAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative G: Alternative G is similar to Alternative F in areal extent, but has substantially less wetlands, in both number and in size. The zones where Alternative G differs the most from Alternative F are three in number. One concerns channelization. There is none in Alternative G. The other main difference is between Center St. and Alma School Rd., where Alternative G has much less planting on the south-side river bank area. A third area of difference between Alternatives F and G is at the downstreammost end of the study area, where Alternative G includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river. This re-planting zone is immediately adjacent the Indian Bend Wash NPL site, so research and potential problems regarding Indian Bend Wash that are detailed under Alternative F, above, are even more urgently in need of resolution for Alternative G. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative G. Identical to those mentioned above for Alternatives F, with enhanced need to model infiltrating water equilibrium conditions related to cumulative effects with Mesa Wastewater Treatment recharge.

A-1.4.8 *Alternative H* (acronym designation "*MSAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Mesquite dominate, braided channel network". Other PD descriptions include, "Mesquite dominate with braided channel network", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallMSAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative H: Alternative H covers essentially the same geographic area as Alternative G, with one major exception: there is no planned activity at the downstreammost end of the study area, where Alternative G includes a large cottonwood-willow planting area outside of the SRPMIC boundary and on the south bank of the river (and adjacent the Indian Bend Wash NPL site). Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative H. Identical to those mentioned above for Alternatives G, but with a reduced need to model the impacts on Indian Bend Wash NPL site. Indian Bend Wash data needs here are identical to those expressed for Alternative F.

A-1.4.9 *Alternative I* (acronym designation "*CHNL*"). Descriptive title on the PD graphic of early Feb. 2003, "Channelized stream". Other PD descriptions include, "Cottonwood dominate with channelized stream", and "Moderate level of vegetative restoration". For a map of this

Alternative, see the separate electronic .jpg file named "*SmallCHNL.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative I: Alternative I covers much of the same geographic area as Alternative F, with reduced areas of plantings and reduced sizes of some of the wetlands between Center St. and Alma School Rd. A major difference between Alternatives I and F is at the Tri-Cities landfill area (site 15). Alternative I does *not* plan any plantings over *top* of the Tri-Cities landfill. This planting overtop of the Tri-Cities landfill, in full or in part, is a study element for all the other Alternatives designated A through H, making Alternative I nearly unique in that regard (Alternative L also has this feature, see below). Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative I. Identical to those mentioned above for Alternatives F.

A-1.4.10 *Alternative J* (acronym designation "*BRAD*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, extensive vegetation with reshaping". Other PD descriptions include, "Cottonwood dominate, with reshaping of sand and gravel pits", and "Extensive level of vegetative restoration". Irrigation will have to continue through the project life. For a map of this Alternative, see the separate electronic .jpg file named "*SmallBRAD.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative J: Alternative J is essentially Alternative F *less* all the channel work and in-channel wetlands from Alma School Rd. upstream to Center St., and from Horne St. upstream to Val Vista Dr., covers much of the same geographic area as Alternative F, with reduced areas of plantings and reduced sizes of some of the wetlands between Center St. and Alma School Rd.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative J. Identical to those mentioned above for Alternative F, but with less impact with the GRUSP (site 17), from the Tri-Cities landfill (site 15), and from the group of landfills on both banks of the river between Country Club Dr. and the alignment of Extension Rd. (sites 8, 11, 30, 31, and 32C).

A-1.4.11 *Alternative K* (acronym designation "*NODL*"). Descriptive title on the PD graphic of early Feb. 2003, "Cottonwood dominate, extensive vegetation NO reshaping". Other PD descriptions include, " Cottonwood dominate without reshaping of sand and gravel pits", and "Extensive level of vegetative restoration". Irrigation will have to continue through the project life. For a map of this Alternative, see the separate electronic .jpg file named "*SmallNODL.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative K: Alternative K is essentially the same as Alternative J and, *additionally*, planting work around the United Metro quarry operations (site 14).

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative K. Identical to those mentioned above for Alternative J.

A-1.4.12 *Alternative L* (acronym designation "*POCK*"). Descriptive title on the PD graphic of early Feb. 2003, "High visibility from road, cottonwood and mesquite dominate". Other PD descriptions include, "Cottonwood and mesquite dominate with high visibility from roads", and "Moderate level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallPOCK.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative L: Alternative L is very similar to Alternative M (see below), *less* all work on the south bank of the river upstream from Gilbert Rd., and less all planting overtop the Tri-Cities landfill (site 15). Plans and vegetation types to be used in and around the GRUSP (site 17) also vary. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative L. Identical to those mentioned above for Alternative F, with reduced emphasis on the Talley Defense Systems location (site 26) and less chance to impact the Tri-Cities landfill (site 15).

A-1.4.13 *Alternative M* (acronym designation "*WET*"). Descriptive title on the PD graphic of early Feb. 2003, "Wetland dominate". Other PD descriptions include, "Hydro-riparian dominate", and "Extensive level of vegetative restoration". For a map of this Alternative, see the separate electronic .jpg file named "*SmallWET.jpg*". See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

Summary of conceptual study actions, Alternative M: Alternative M is essentially the same as Alternative F, *less*, all the channel work. Irrigation will have to continue through the project life.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative M. Identical to those mentioned above for Alternative F.

A-1.4.14 *Alternative 14* (no acronym designation). Description: None. **This alternative was not included in the alternatives list of Oct. 2003 and therefore is given no further consideration here.**

Summary of conceptual study actions, Alternative 14: No action

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative 14. None.

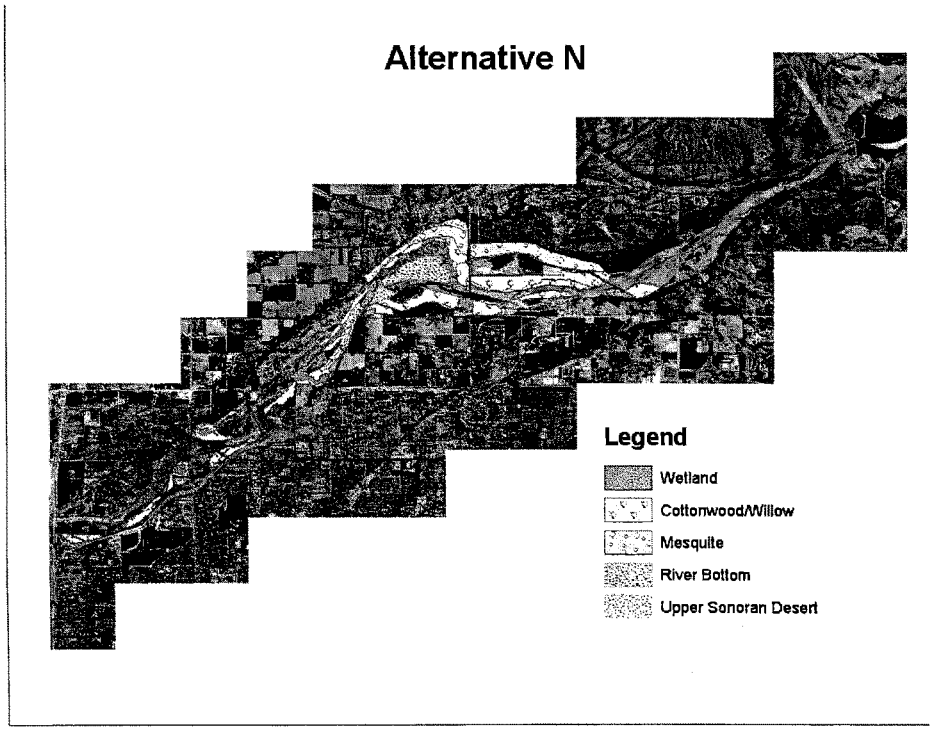
A-1.4.15 *Alternative N* (no acronym designation). Description: see figure, following page. See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative N. Issues relate to potential conflicts with potential increases in groundwater elevation caused by the planned irrigation:

- Model cumulative influences of infiltrating water and zone of influence with the impacts from existing GRUSP (site 17) groundwater recharge. The GRUSP recharge is limited such that the top of the water table is always at least 25 ft below the bottom of the active Salt River landfill.
- The largest of all the planned wetlands construction adjoins the north side of the North Center St. landfill (site 30) raises potential conflicts with inundating the landfill contents with the groundwater. Modeling should be done to develop the infiltrating water equilibrium conditions and zone of influence resulting from conceptual features and to determine whether this will impact the landfill contents; the same holds true for the TriCities landfill (site 15), where the second largest of all the planned wetlands construction is nearly adjoining.

In addition to the above HTRW considerations, there are geotechnical issues with regard to slope stability questions that eventually will have to be addressed (refer to text, paragraphs 9.3 and 9.4).

- Planned wetlands construction both upstream and downstream of adjoining sand and gravel operations (sites 2, 3) raises potential slope stability questions. Assess the potential impacts.
- Planned wetlands construction adjoins sand and gravel operations at site 28 (Chandler Ready Mix) raising potential slope stability questions. Assess the potential impacts.


Alternative N
Legend
Wetland
Cottonwood/Willow
Mesquite
River Bottom
Upper Sonoran Desert

A-1.4.16 *Alternative O* (no acronym designation). Description: see figure, following page. **It is clear that US Army Corps of Engineers, Geotechnical Branch does not have access to the full conceptual design. It has been stated by study management that there are to be in the river channel several constructed features, including a 2,000-ft long, approximately 20-ft-deep grade control structure, and several small berms** Alternative O is very much like Alternative N, but has, additionally, more and larger planned wetlands adjoining existing sand and gravel operations (sites 2, 3), which makes slope stability issues of even greater importance than they are for Alternative N. See note under section A-1.4.1 regarding the reasoning behind having *no* separate assessments here for the $_1$ (drip irrigation) and $_2$ (braided irrigation) options.

USACE-Geotech's list of environmental concerns, and recommended follow-on work, Alternative O. Issues relate to potential conflicts with potential increases in groundwater elevation caused by the planned irrigation:

- Modeling should be done to develop the infiltrating water equilibrium conditions and zone of influence resulting from conceptual features and to determine whether this will impact the GRUSP (site 17), North Center St. landfill (site 30) or TriCities landfill (site 15).

In addition to the above HTRW considerations, there are geotechnical issues with regard to slope stability questions that eventually will have to be addressed (refer to text, paragraphs 9.3 and 9.4).

- Planned wetlands construction both upstream and downstream of adjoining sand and gravel operations (sites 2, 3) raises potential slope stability questions. Assess the potential impacts.
- Planned wetlands construction adjoins sand and gravel operations at site 28 (Chandler Ready Mix) raising potential slope stability questions. Assess the potential impacts.

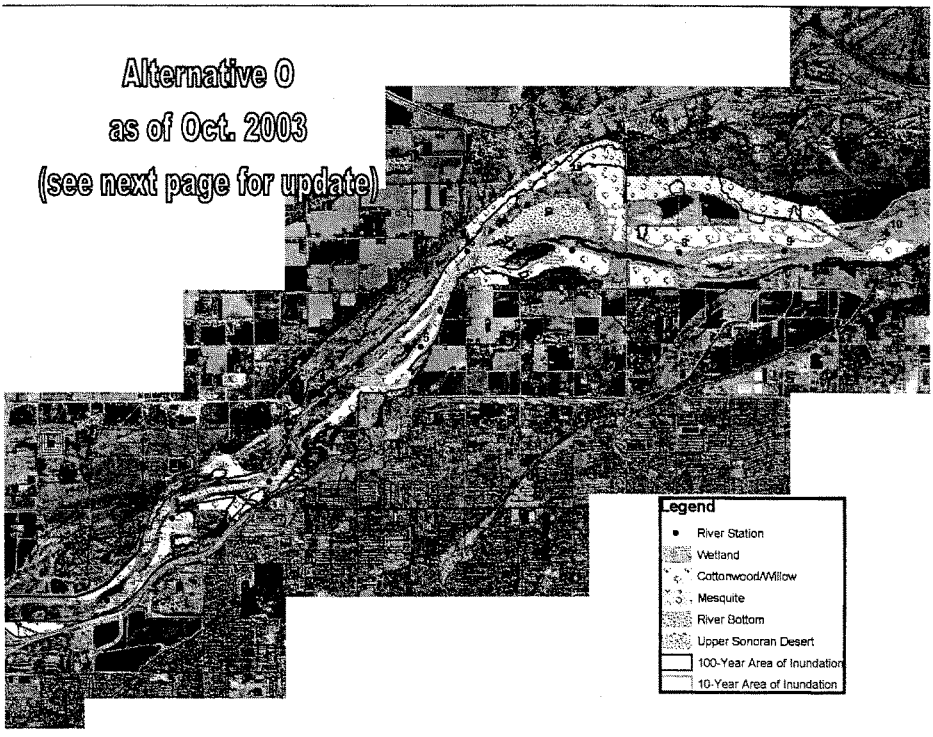
The main change from the Oct. 2003 version of Alternative O, assessed above, and the late March 2004 version is that the upstreammost wetland and willow bog have been eliminated. This is favorable with regard avoiding any potential Talley Defense Systems conflict, if any, and eliminates the need to do testing for potential Talley Defense Systems releases at construction sites for "new" Alternative O, because the next closest downstream to-be-constructed wetland is very far away.

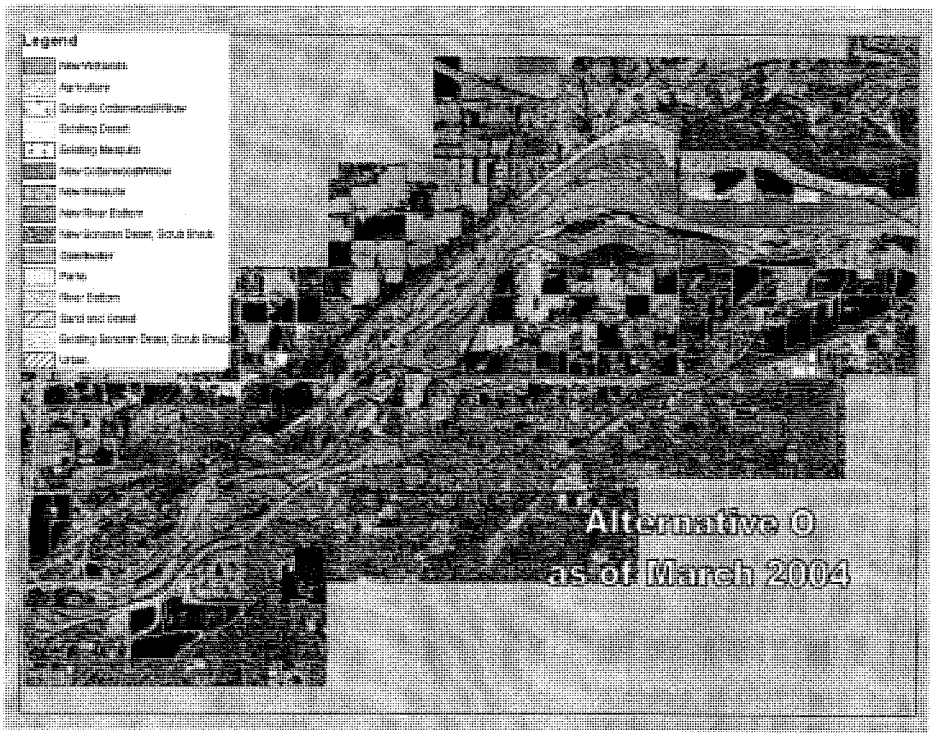
A-1.5. ***Non-hazardous wastes impacts with the footprint of Alternative O (version of late March 2004)*** (see features map, below). Refer to table 4 and figs. 21-23 in the above text for more details on the numbered sites of wastes.

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
1	Possibly an illegal dump	Half covered by a conceptual wetland
2	Northern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	Mostly covered by a conceptual wetland

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
2	Southern part: concrete/cement waste at Salt River Sand & Rock, Dobson operations	Completely covered by a conceptual wetland and a cottonwood/willow planting area
3	Illegal dump	No conflict, no impact
4	Concrete debris	Completely covered by a conceptual wetland and a cottonwood/willow planting area
5	Illegal dump	Completely excavated by conceptual new channel bottom
6	Illegal dump	About one-third excavated by conceptual new channel bottom
7	Concrete debris	About one-half would be covered by a conceptual cottonwood/willow planting area
8	Illegal dumping on top of Cypress landfill	Upgradient of and close to a large, conceptual wetland
9	Illegal dump	Nearly all covered by new, conceptual plantings, including willow, and a new, large, conceptual wetland
10 !	Concrete/cement waste, two, non-contiguous areas	(Downstream part): Nearly all covered by new, conceptual plantings, including willow, and a new, large, conceptual wetland; (Upstream part): All except the bank slope will be covered by a large, conceptual wetland (including all the material on the toe of the bank and the invert), and all material on top of the bank will be covered by a conceptual willow planting; it is unclear whether bank shaping will be necessary; if so, the entire mass of this concrete waste pile likely will have to be moved to carry out Alternative O.
11	Illegal dump	About half covered by a new, large, conceptual wetland
12	Debris from Cypress landfill washout	About half covered by a new, large, conceptual wetland; the remainder is immediately upgradient of this wetland, approximately in line with the center of channel flow
13	Concrete debris	Will be immediately downstream of conceptual willow bog (presumably irrigated); probably no significant impact
14	Metal debris	Under the footprint of a new, conceptual mesquite bosque
15	Concrete/cement waste at "Rinker" operations	Probably no impact; nearly adjoins the largest conceptual wetland of this study
15	Asphalt waste at "Rinker" operations	Possibly a water-quality/runoff issue, as it nearly adjoins the largest conceptual wetland of this study; perhaps the asphalt could be removed for water quality concerns and the underlying concrete left in place?
16	Tire dump, 300 tires, uncertain if this is an illegal dump	Over half inside the footprint of a new, conceptual wetland, the largest of the entire study; the remainder would be on the downstream edge of this wetland.
17	Calcium soil additive, uncertain if this is an illegal dump	Completely under the footprint of a new, conceptual willow bog
18	Metal tower	Within a new, conceptual wetland footprint
19	Illegal dump	Completely under the footprint of a new, conceptual willow bog
20	Illegal dump	Totally beneath the footprint of a new, conceptual willow bog and wetland.
21	Concrete debris	Immediately adjoining and downgradient of a new, conceptual willow bog; if any bank shaping is planned, this site almost certainly will be totally under the footprint of the reshaping
22	Illegal dump	Totally beneath the footprint of new, conceptual plantings, including

Conflicts are extensive between the Alternative O footprint (ver. Of late March 2004) and the non-hazardous wastes in the study area (refer to numbered sites on table 1 and on figs. 21-23 for details and locations):		
# (on table 4)	Waste	Conflict
		mesquite (all the northern area of dump #22), and willow (all the southern area of dump #22)
23	Illegal dump	About three-quarters is under the footprint of new, conceptual plantings, including willow, and (mostly) under mesquite
24	Illegal dump	No conflict, no impact


Alternative 0
as of Oct. 2003
(see next page for update)
Legend
River Station
Wetland
Cottonwood/Willow
Mesquite
River Bottom
Upper Sonoran Desert
100-Year Area of Inundation
10-Year Area of Inundation


Legend
Alternative 0
as of March 2004

DESIGN

APPENDIX D - ENGINEERING DESIGN
FOR
VA SHLY'AY AKIMEL SALT RIVER RESTORATION PROJECT
FEASIBILITY STUDY
MARICOPA COUNTY, ARIZONA

CONTENTS

1.0	OBJECTIVE		3
2.0	STUDY AREA		3
3.0	DESIGN CRITERIA		3
	3.1	Structural Requirements	3
	3.2	Hydrology and Hydraulic Requirements	3
	3.3	Geotechnical Requirements	3
	3.4	Environmental Considerations	4
	3.5	Dumped Materials	4
4.0	DESIGN FEATURES		4
	4.1	Low Flow Channel	4
	4.2	Reshaping the Salt River Riverbed	4
	4.3	Bank Stabilization	5
	4.4	Wetland	5
	4.5	Control Invasive Vegetation	5
	4.6	Planting	5
	4.7	Water Well	5
	4.8	Grade Control Structure	5
	4.9	Water Distribution System	6
	4.10	Planting Irrigation System	6
	4.11	Diversion Structures	6
5.0	CONSTRUCTABILITY		6
	5.1	Construction Materials	6
	5.2	Access Roads	7
	5.3	Borrow Sites	7

6.0	UTILITY RELOCATION		7
7.0	CONSTRUCTION TIME		7
8.0	OPERATION AND MAINTENANCE		7
	8.1	Structures	7
	8.2	Plants	7

1.0 OBJECTIVE

The objective of the Va Shly'ay Akimel Salt River Ecosystem Restoration project is to implement environmental restoration by restoring riparian habitat within the Salt River from Granite Reef Dam downstream to the Pima Freeway (US 101). The purpose of this appendix is to present feasibility study results of the civil design effort. Design data and calculations were developed sufficient to determine the technical and economic feasibility of each alternative and in the event the project is authorized, to provide a base design leading to the development of the construction plans and specifications.

2.0 STUDY AREA

The Va Shly'ay Akimel Salt River Restoration project is located in the Salt River Pima-Maricopa Indian Community adjacent to the City of Mesa in Maricopa County, Arizona, 18 miles east of the City of Phoenix. The study area is approximately 14miles long extending from immediately downstream of the Granite Reef Dam to the Pima Freeway (US101). The study area averages 1,500 feet wide, and encompasses approximately 5,633 acres.

3.0 DESIGN CRITERIA

3.1 Structural Requirements

The structural materials required for grade control structural and wetland features involve concrete, back fill gravel, riprap, wetland clay material, and coarser gravel.

The structural requirements for the bank stabilization and concrete spillway include static and dynamic stability, refer to Geotechnical Appendix for details.

3.2 Hydrology and Hydraulic Requirements

Hydrology and hydraulic design criteria are discussed in their respective appendices. The Hydrology Appendix provides the design discharges for the existing drainage structures that discharge into the study reaches. Evaluations of the hydraulic conditions of the low flow channel and drainage areas are discussed in the Hydraulic Appendix.

3.3 Geotechnical Requirements

Geotechnical analysis examined low flow channel stability based on both side slopes of 1V:3H and 5 feet channel depth. Borrow material from the

streambed may or may not be used for the fill. Refer to Geotechnical Appendix for commercial source of borrow material.

3.4 Environmental Considerations

The project area includes approximately 14 miles of river channel and encompasses approximately 5,633 acres of over bank areas. Existing vegetation includes Cottonwood/Willow, Mesquite and Sonoran Desert Scrub Shrub. Refer to Environmental Appendix for with project environmental considerations.

3.5 Dumped Materials

There are several possible opportunity uses for the excavated material from construction of the low flow channel and reshaping the Salt River riverbed. The excavated material is considered to be valuable as a mineral resource for sand, gravel and aggregate materials. The possible uses include backfilling of existing gravel pits adjacent to the river, and reshaping the riverbed.

4.0 DESIGN FEATURES

Table D-1 shows the design features vs. Alternatives.

4.1 Low Flow Channel

The low flow channel located in the middle of Reach 2 has a length of approximately 4000 feet with bottom width of 300 feet, side slopes of 1V to 3H, and a depth of 5 feet. A typical cross section of the low flow channel is shown in Plate D-1. The location of the low flow channel is shown in Plate D-7.

4.2 Reshaping the Salt River riverbed

Reshaping the Salt River riverbed is required in Reaches 1,2, 4, 5 and 6 with a total cutting volume of approximately 1,320,500 cubic yards, and filling volume of approximately 751,800 cubic yards. The locations of the riverbed required reshaping are shown in Plates D-8 and D-9. To minimize the cost of reshaping the quarry sites, the recommended configuration of the "left shaped" existing quarry sites should have a minimum side slopes of 3H: 1V with a more preferable side slopes of 5H: 1V. A terracing effect is recommended for the quarry site where the slope has a vertical drop of approximately 15–20 feet then terrace for a minimum horizontal distance of approximately 30-40 feet. This pattern should then continue toward the riverbed.

4.3 Bank Stabilization

Soil cement bank stabilization is needed on the south bank in reach 6 of the Salt River. Cross section of eight feet wide and approximately 20 feet deep of soil cement is shown in Plate D-3. The location of the bank stabilization is shown in Plate D-10.

4.4 Wetland

New Wetlands are restored in the reaches of 1, 2, 4, 5 and 6 with a total area of approximately 200 acres. The locations of new wetlands are shown in Plates D-6, D-7, D-8, and D-9. Typical cross section of restored new wetland is shown in plate D-5.

4.5 Control Invasive Vegetation

Control invasive vegetation is required in the reaches of 1, 8 and 9 with a total area of approximately 150 acres. The locations will be defined in the next phase study.

4.6 Planting

Planting includes approximately 883 acres of Cottonwood/Willow, 380 acres of Mesquite, and 24 acres of Sonoran Desert Scrub Shrub. The locations of plantings are shown in Plates D-6, D-7, D-8, D-9, D-10, and D-11.

4.7 Water Well

To support the planting areas of 5.1, 5.2 and 6.1, a water well with annual capacity of 1,800 ac-ft is added in reach 6 with a design depth of approximately 150 feet deep. The yield of the well has an average flow rate of 5,000 gallons per minute. The location of the water well is shown in Plate D-9.

4.8 Grade Control Structure

A grade control structure is needed to protect the project features. It provides incidental benefit to the Gilbert Road Bridge. The concrete grade control structure has a dimension of 30' in depth, 8' in width, and 3,500' in length. On the upstream face of the structure, the invert is aligned with the top of the grade control structure. On the downstream side of the

structure, the grade control structure has a toe down of 15' and a grouted riprap toe protection of 20' in width, 6' in thickness, and 3,500' in length. A typical cross section is shown in plate D-4. The location of the grade control structure is shown in plate D-9.

4.9 Water Distribution System

The water distribution system consists of 1) approximately 40,600 feet of 12" diameter buried up to 3 feet deep PVC pipeline, 2) a 1,500 gallons per minute pump station at Alma School road and another 1,500 gallons per minute pump station at Country Club road, and 3) a 1,700 feet long bridge crossing at Country Club road and another 1,700 feet long bridge crossing at Gilbert road. The locations of pump stations are shown in plate D-7. Backup pump will be provided at both pump stations. The locations of the distribution pipeline are shown in plates D-7, D-8, D-9, and D-10.

4.10 Planting Irrigation System

Drip irrigation system is used for planting areas in reaches 1, 2, 3, 4, 5, and 6 during the first three years of the project life. From the fourth year on, surface braided irrigation system will be used to sustain the vegetated areas. Same pipeline arrangements are used for both the drip irrigation system and the surface braided irrigation system. Refer to the surface braided irrigation network diagram in the main report for the pipeline arrangement. Water will be distributed to the vegetated areas through the distribution channel network.

4.11 Diversion Structures

To divert surface water from the Salt River Pima Maricopa Indian Community (SRPMIC) to the project areas, T-junction diversion structures are required at nine locations to divert from the triangular irrigation channel with 4' top width and 2' deep to 12" diameter buried PVC pipeline. The diversion structures are shown in Plates D-7, D-8, D-9, and D-10.

5.0 Constructability

5.1 Construction Materials

The construction materials required for the design features described above include soil and gravel for structural fill, soil for soil cement, cement, water, concrete, clay, PVC pipe, pumps and specified plants. All of these materials are available locally. Plants can be purchased locally or

can be grown locally from native seed sources in advance of up to 2 years to develop healthy rootstock.

5.2 Access Roads

Environmental corridors or recreational trails will be used as access roads for operation and maintenance purposes. Horse ramps will be used to connect from the access road to the low flow channel and river bottom for operation and maintenance purposes.

5.2 Borrow Sites

Construction materials are most cost effectively available from two local borrow sites. Refer to section 10 of Geotechnical Appendix for borrow sites locations and details.

6.0 Utility Relocation

No utility relocation has been identified in this study. Any possible utility relocation will be defined in the PED phase. Local sponsor will be responsible for constructing the utility relocation.

7.0 Construction Time of the Recommended Plan

Construction time of the recommended plan is being estimated to be approximately three years.

8.0 Operation and Maintenance Requirements

8.1 Structures

Operational inspections for structural cracking and functional capability are made periodically, with at least one official annual inspection, and as needed during flood season. Inspections should include unwanted wild plants that if allowed to grow may exacerbate a structural crack. These plants are controlled by cutting or spray.

8.2 Plants

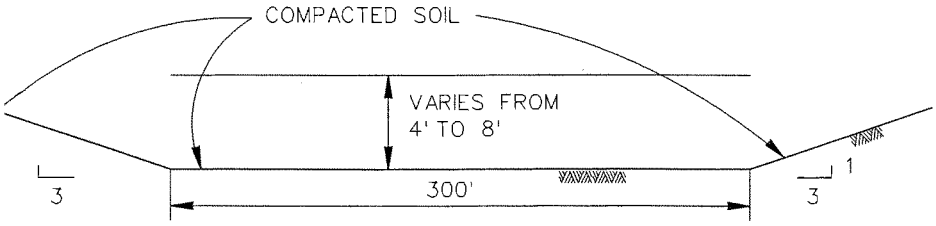
Replacement for plants will be required due to occasional flooding events and other natural causes. To support the plantings over the life of the project, the water budget and estimated annual costs for the selected plan are included in the Cost Engineering Appendix.

Vs Only, Maricopa County, Arizona
Environmental Restoration Study
Phase - ES
Design Features vs. Alternatives

Design Features	Alternatives														
	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1	L1	M1	N1	O1
1. Low Flow Channel Excavation						X			X						X
2. Reshaping the Salt River Riverbed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Bank Stablization		X	X	X	X	X	X	X	X	X		X	X		
4. Wetland Features			X	X	X	X	X	X	X	X	X	X	X	X	X
5. Control Invasive Vegetation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Planting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Concrete Spillways		X	X	X		X	X	X		X		X	X		
8. New Water Well		X		X	X	X	X	X		X	X	X	X	X	X
9. Grade Control Structure				X		X			X			X	X	X	X
10. Water Distribution System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Road Crossings for the Pipeline System		X	X		X	X	X	X	X	X	X	X	X	X	X
12. Drip Irrigation System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. Braided Irrigation System															
14. SRPMIC T-Junction to Pipe Diversion Structures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15. Remediation to Vegetate 4.1 Landfill Areas		X	X	X	X	X	X	X	X	X	X		X		
16. Distribution Channel Network Excavation		X	X		X		X	X	X				X		
17. Debris Removal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Design Features	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2	L2	M2	N2	O2
1. Low Flow Channel Excavation						X			X						X
2. Reshaping the Salt River Riverbed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Bank Stablization		X	X	X	X	X	X	X	X	X		X	X		
4. Wetland Features			X	X	X	X	X	X	X	X	X	X	X	X	X
5. Control Invasive Vegetation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Planting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Concrete Spillways		X	X	X		X	X	X		X		X	X		
8. New Water Well		X		X	X	X	X	X		X	X	X	X	X	X
9. Grade Control Structure				X		X			X			X	X	X	X
10. Water Distribution System		X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Road Crossings for the Pipeline System		X	X		X	X	X	X	X	X	X	X	X	X	X
12. Drip Irrigation System															
13. Braided Irrigation System	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. SRPMIC T-Junction to Pipe Diversion Structures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15. Remediation to Vegetate 4.1 Landfill Areas		X	X	X	X	X	X	X	X	X	X		X		
16. Distribution Channel Network Excavation		X	X		X		X	X	X				X		
17. Debris Removal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table D-1 Design Features vs. Alternatives

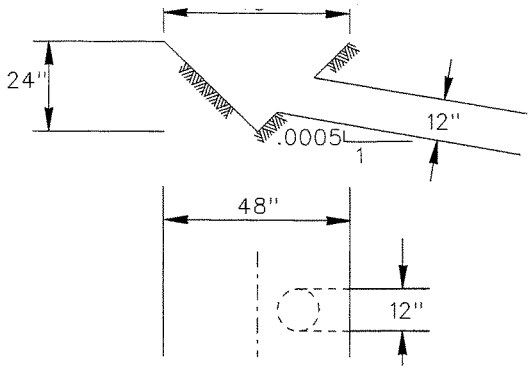


TYPICAL SALT RIVER LOW FLOW
CHANNEL CROSS SECTION

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-1

PLATE D-2



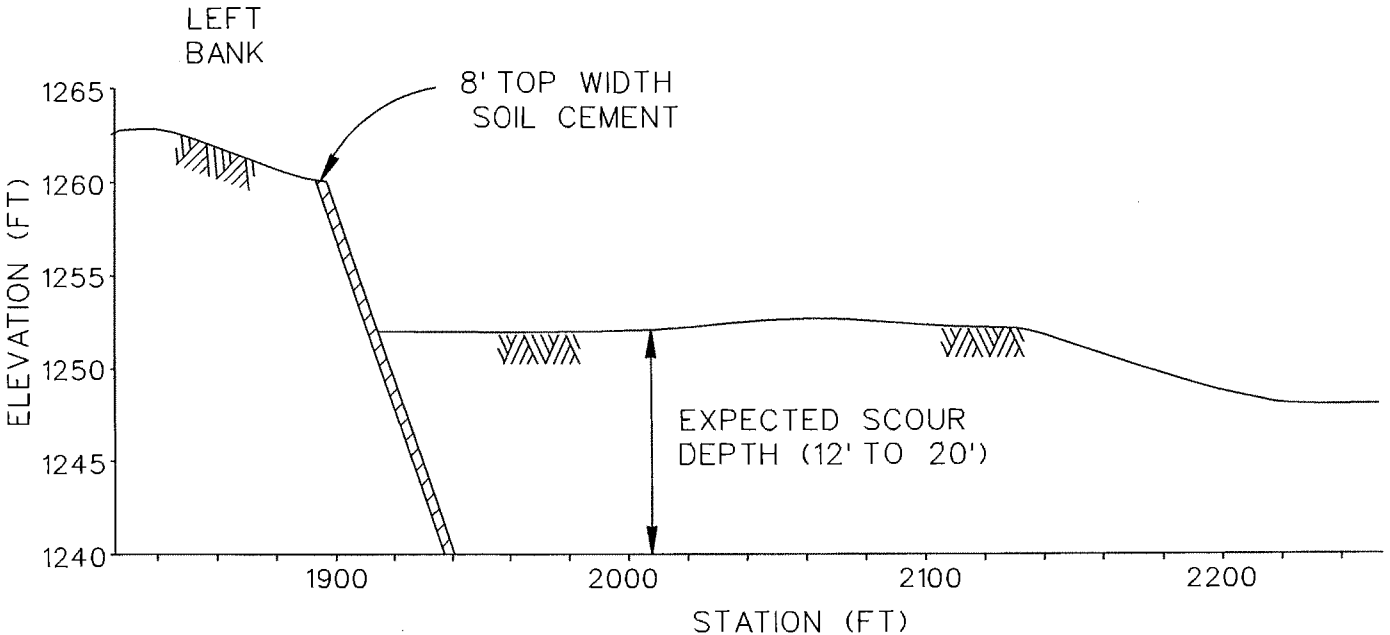
CROSS SECTION

TOP VIEW

T-JUNCTION DIVERSION STRUCTURE FROM THE TRIANGULAR IRRIGATION CHANNEL, 48" TOP WIDTH AND 24" DEEP TO 12" DIAMETER PVC DISTRIBUTION PIPE

LTERNATIVES	WATER DISTRIBUTION SYSTEM PIPE LINE LENGTH - 12" PVC
A	8,965
B	23,526
C	31,865
D	33,378
E	38,491
F	55,176
G	52,568
H	52,568
I	52,568
J	49,976
K	49,976
L	29,846
M	49,976
N	40,617
O	40,617

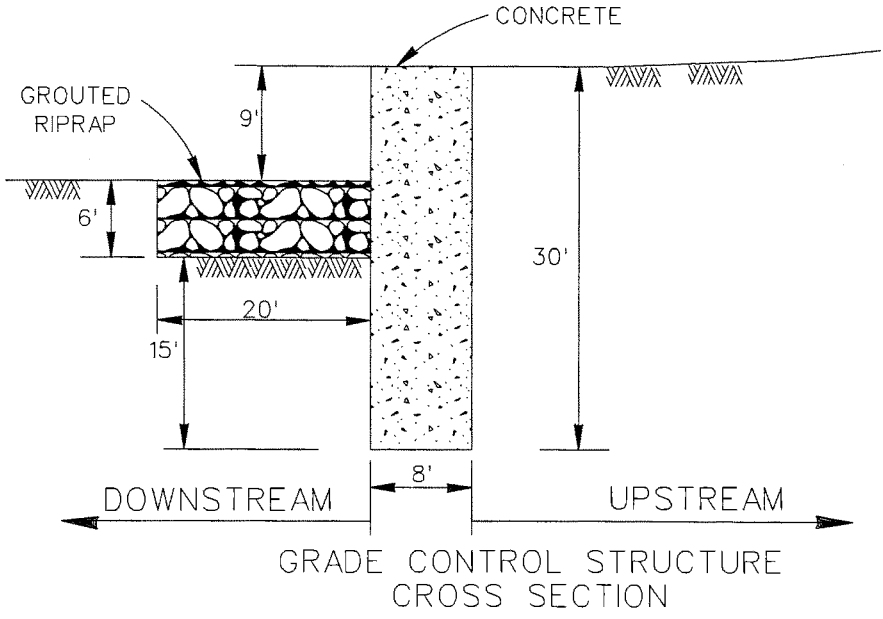
Va Shly 'Ay
SALT RIVER RESTORATION PROJECT



TYPICAL CROSS SECTION OF
SOIL CEMENT BANK STABILIZATION AT REACH 62

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-3

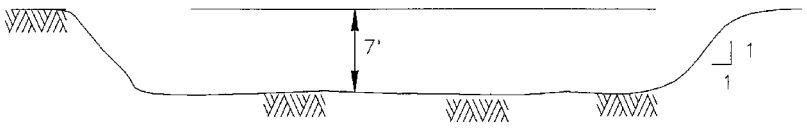


GRADE CONTROL STRUCTURE
CROSS SECTION

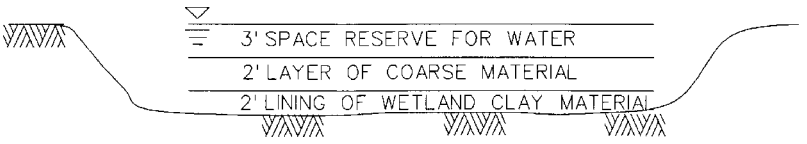
Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-4

a. EXISTING GROUND PROFILE



b.REMOVE 7' TOP LAYER



c.RESTORE WETLAND CROSS SECTION

WETLAND FEATURES

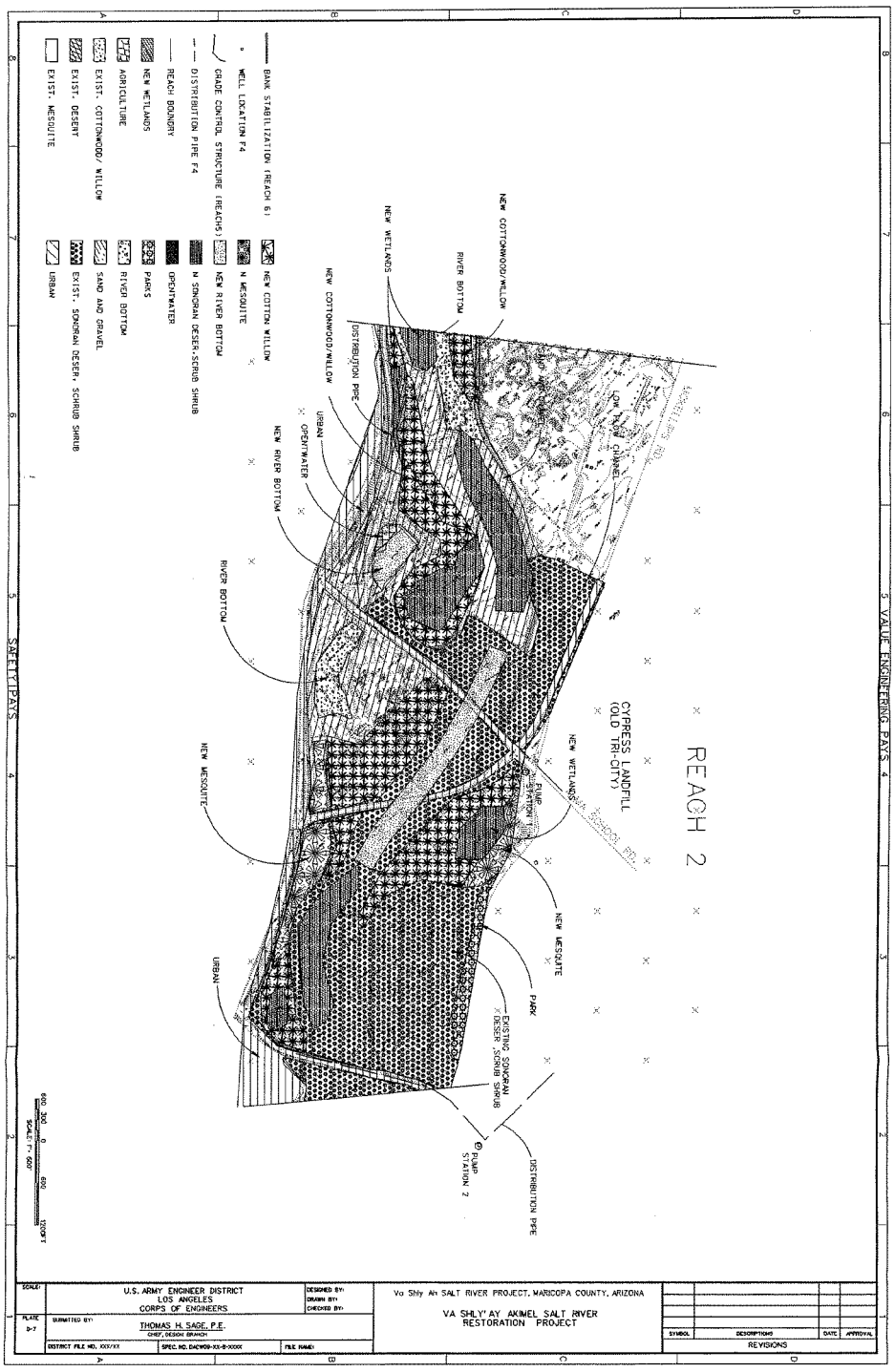
NOTES:

1. Side drains are part of irrigation system.
2. Location and design of side drains will be completed in PED Phase.

Va Shly 'Ay
SALT RIVER RESTORATION PROJECT

PLATE D-5

BANK STABILIZATION (REACH 6)
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACH5)
DISTRIBUTION PIPE F4
REACH BOUNDARY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N SONORAN DESER. SCRUB SHRUB
OPEN WATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESERT SCRUB SHRUB
URBAN
NORTHWEST WATER RECLAMATION PLANT
REACH 1
URBAN
NEW COTTONWOOD / WILLOW
EXISTING COTTONWOOD
RIVER BOTTOM
NEW COTTONWOOD / WILLOW
EXISTING COTTONWOOD
URBAN
NEW WETLANDS
OPEN WATER
SCALE 1" = 600'
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
DESIGNED BY
DRAWN BY
CHECKED BY
SUBMITTED BY
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH
DISTRICT FILE NO. XXX/XX
SPEC. NO. DACW09-XX-R-XXXX
FILE NAME
Va Shly Ah SALT RIVER PROJECT, MARICOPA COUNTY, ARIZONA
VA SHLY'AY AKIMEL SALT RIVER
RESTORATION PROJECT
SYMBOL
DESCRIPTIONS
DATE
APPROVAL
REVISIONS
SAFETY PAYS
VALUE ENGINEERING PAYS


REACH 2
BANK STABILIZATION (REACH 6)
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACH5)
DISTRIBUTION PIPE F4
REACH BOUNDRY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N SONORAN DESER. SCRUB SHRUB
OPENTWATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESER. SCHRUB SHRUB
URBAN
NEW COTTONWOOD/WILLOW
NEW WETLANDS
RIVER BOTTOM
DISTRIBUTION PIPE
URBAN
OPENTWATER
NEW RIVER BOTTOM
RIVER BOTTOM
NEW MESQUITE
URBAN
CYPRESS LANDFILL (OLD TRI-CITY)
NEW WETLANDS
PUMP STATION 7
NEW MESQUITE
PARK
EXISTING SONORAN DESER. SCRUB SHRUB
PUMP STATION 7
DISTRIBUTION PIPE
SAFETY PAYS
VALUE ENGINEERING PAYS
SCALE: 1" = 600'
U.S. ARMY ENGINEER DISTRICT
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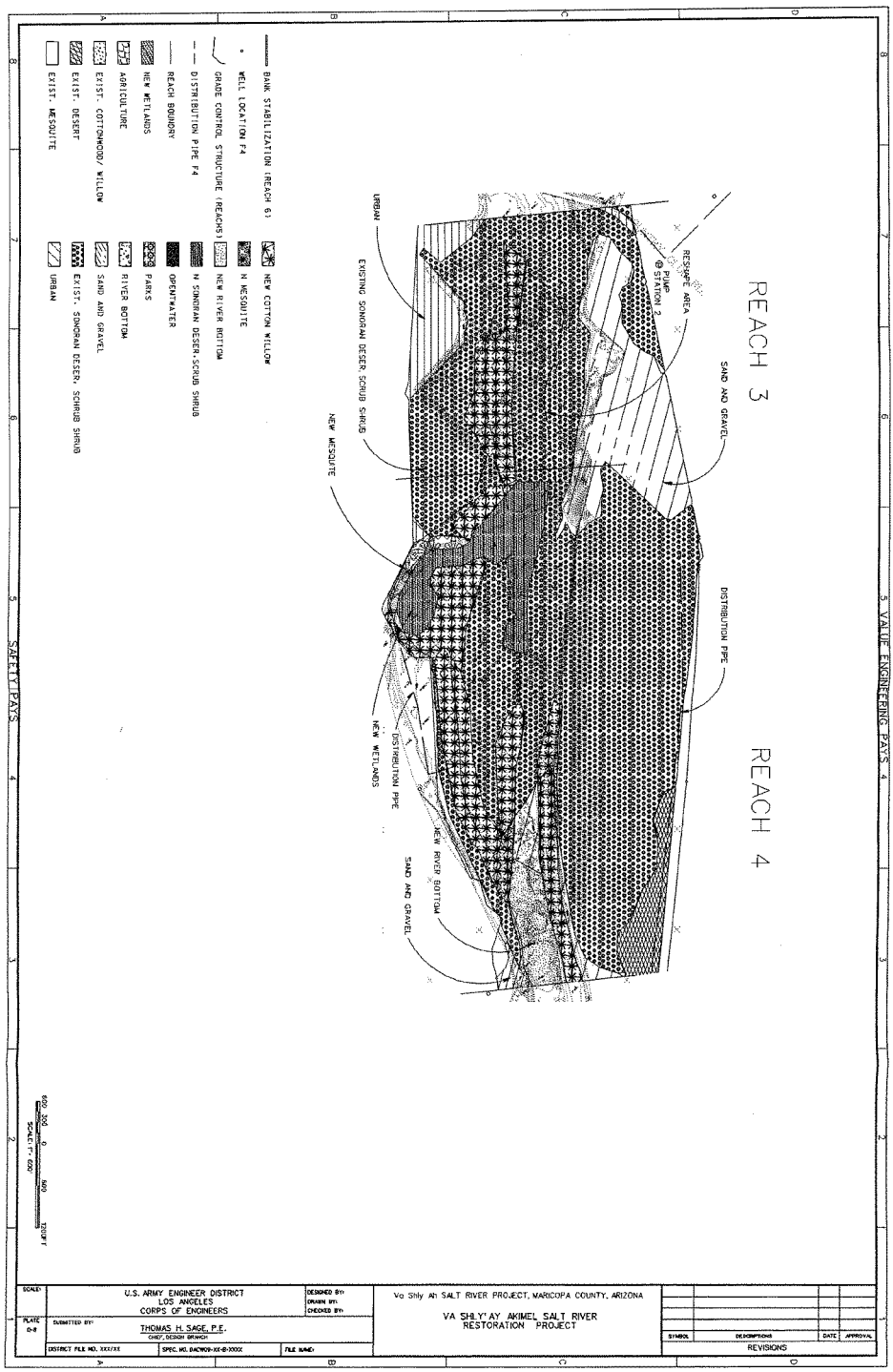
REACH 3
REACH 4
RESHAPE AREA
PUMP STATION 2
SAND AND GRAVEL
DISTRIBUTION PIPE
URBAN
EXISTING SONORAN DESERT SCRUB SHRUB
NEW MESQUITE
NEW WETLANDS
DISTRIBUTION PIPE
NEW RIVER BOTTOM
SAND AND GRAVEL
BANK STABILIZATION (REACH 6)
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACHES)
DISTRIBUTION PIPE F4
REACH BOUNDRY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N SONORAN DESERT SCRUB SHRUB
OPEN WATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESERT SCRUB SHRUB
URBAN
VALUE ENGINEERING PAYS
SAFETY PAYS
SCALE: 1" = 600'
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
DESIGNED BY
DRAWN BY:
CHECKED BY
SUBMITTED BY:
THOMAS H. SAGE, P.E.
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DISTRICT FILE NO. XXXXX
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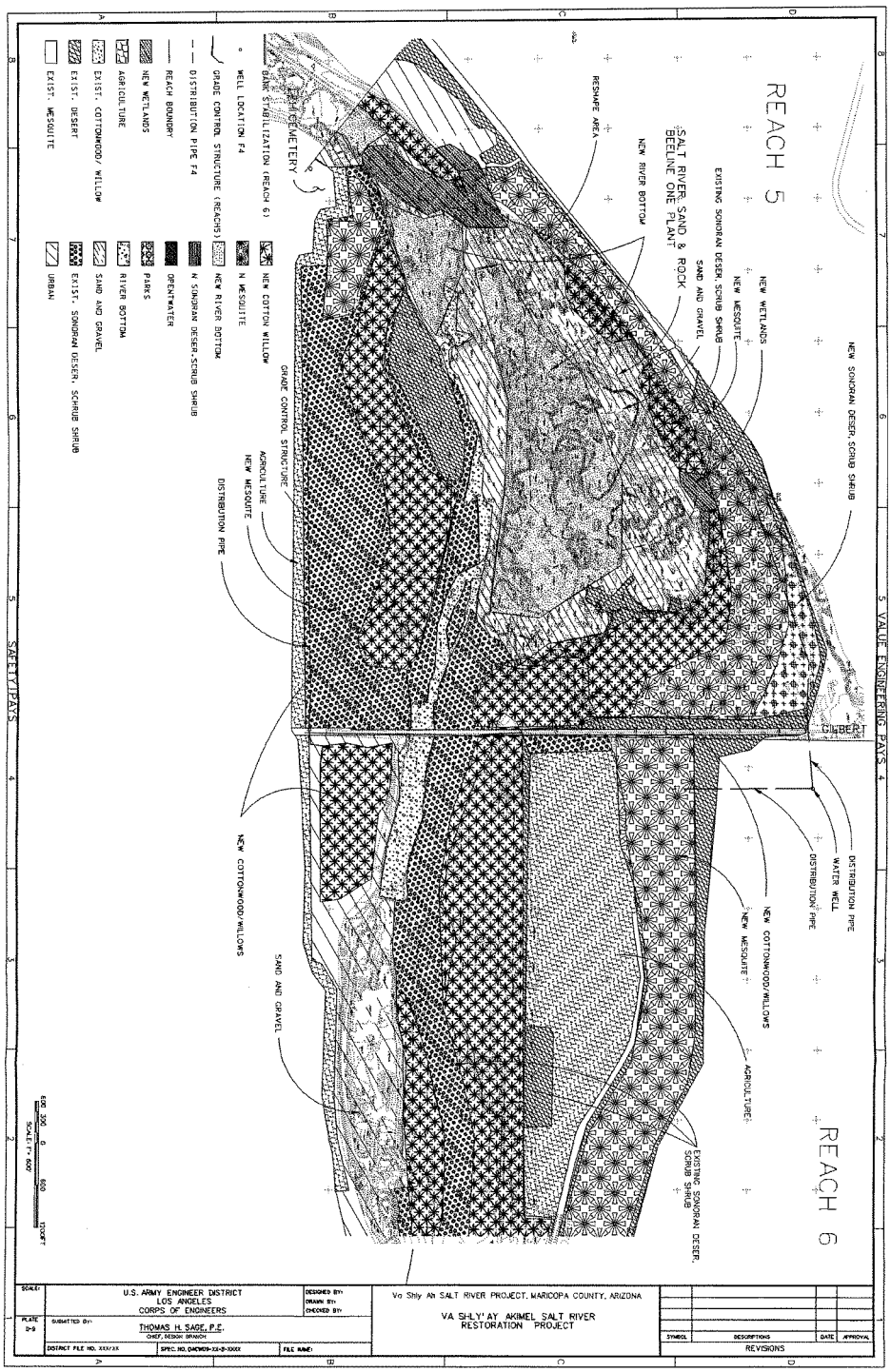
REACH 5
REACH 6
SALT RIVER SAND & ROCK BEELINE ONE PLANT
EXISTING SONORAN DESERT SCRUB SHRUB
NEW WETLANDS
NEW MESQUITE
SAND AND GRAVEL
NEW RIVER BOTTOM
RESHAPE AREA
BANK STABILIZATION (REACH 6)
GRADE CONTROL STRUCTURE
AGRICULTURE
NEW MESQUITE
DISTRIBUTION PIPE
NEW COTTONWOOD/WILLOWS
SAND AND GRAVEL
DISTRIBUTION PIPE
WATER WELL
DISTRIBUTION PIPE
NEW COTTONWOOD/WILLOWS
NEW MESQUITE
AGRICULTURE
EXISTING SONORAN DESERT SCRUB SHRUB
NEW SONORAN DESERT SCRUB SHRUB
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N SONORAN DESERT SCRUB SHRUB
DISTRIBUTION PIPE F4
REACH BOUNDRY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACH5)
OPENWATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESERT SCRUB SHRUB
URBAN
VALUE ENGINEERING PAYS
SAFETY PAYS
GILBERT
SCALE: 1" = 600'
U.S. ARMY ENGINEER DISTRICT
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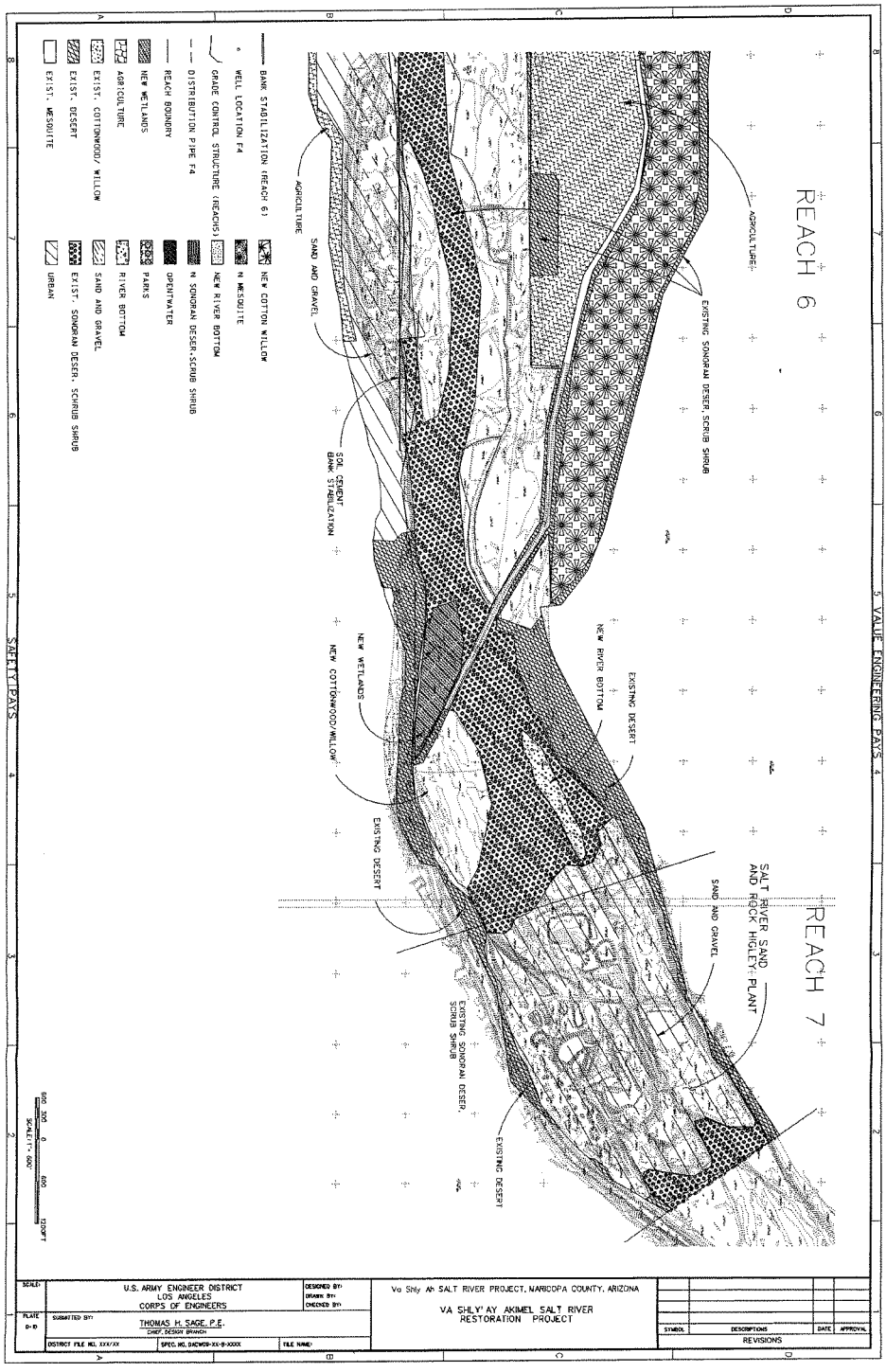
REACH 6
REACH 7
AGRICULTURE
SAND AND GRAVEL
SOIL CEMENT BANK STABILIZATION
EXISTING SONORAN DESERT SCRUB SHRUB
NEW WETLANDS
NEW COTTONWOOD/WILLOW
NEW RIVER BOTTOM
EXISTING DESERT
SALT RIVER SAND AND ROCK HIGLEY PLANT
SAND AND GRAVEL
EXISTING SONORAN DESERT SCRUB SHRUB
EXISTING DESERT
BANK STABILIZATION (REACH 6)
NEW COTTON WILLOW
WELL LOCATION F4
N MESQUITE
GRADE CONTROL STRUCTURE (REACH 6)
NEW RIVER BOTTOM
DISTRIBUTION PIPE F4
N SONORAN DESERT-SCRUB SHRUB
REACH BOUNDRY
OPEN WATER
NEW WETLANDS
PARKS
AGRICULTURE
RIVER BOTTOM
EXIST. COTTONWOOD/ WILLOW
SAND AND GRAVEL
EXIST. DESERT
EXIST. SONORAN DESERT SCRUB SHRUB
EXIST. MESQUITE
URBAN
SCALE: 1"=600'
SAFETY PAYS
VALUE ENGINEERING PAYS
U.S. ARMY ENGINEER DISTRICT
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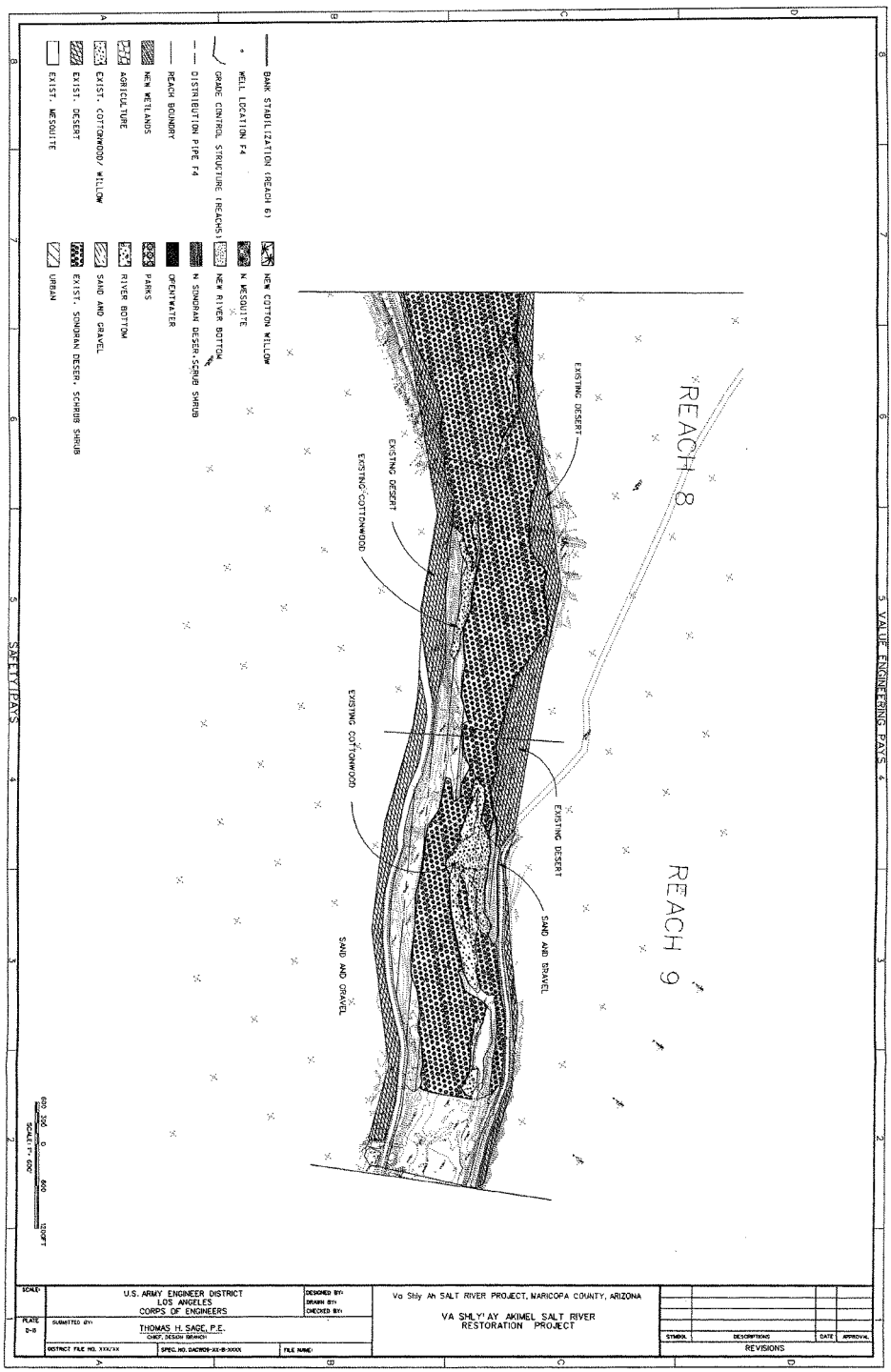
PLATE
D-13


REACH 8
REACH 9
EXISTING DESERT
EXISTING COTTONWOOD
EXISTING DESERT
EXISTING COTTONWOOD
EXISTING DESERT
SAND AND GRAVEL
SAND AND GRAVEL
BANK STABILIZATION (REACH 6)
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACH 5)
DISTRIBUTION PIPE F4
REACH BOUNDRY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N. SONORAN DESER-SCRUB SHRUB
OPEN/WATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESER. SCRUB SHRUB
URBAN
SCALE: 1"= 600'
SAFETY PAYS
VALUE ENGINEERING PAYS
U.S. ARMY ENGINEER DISTRICT
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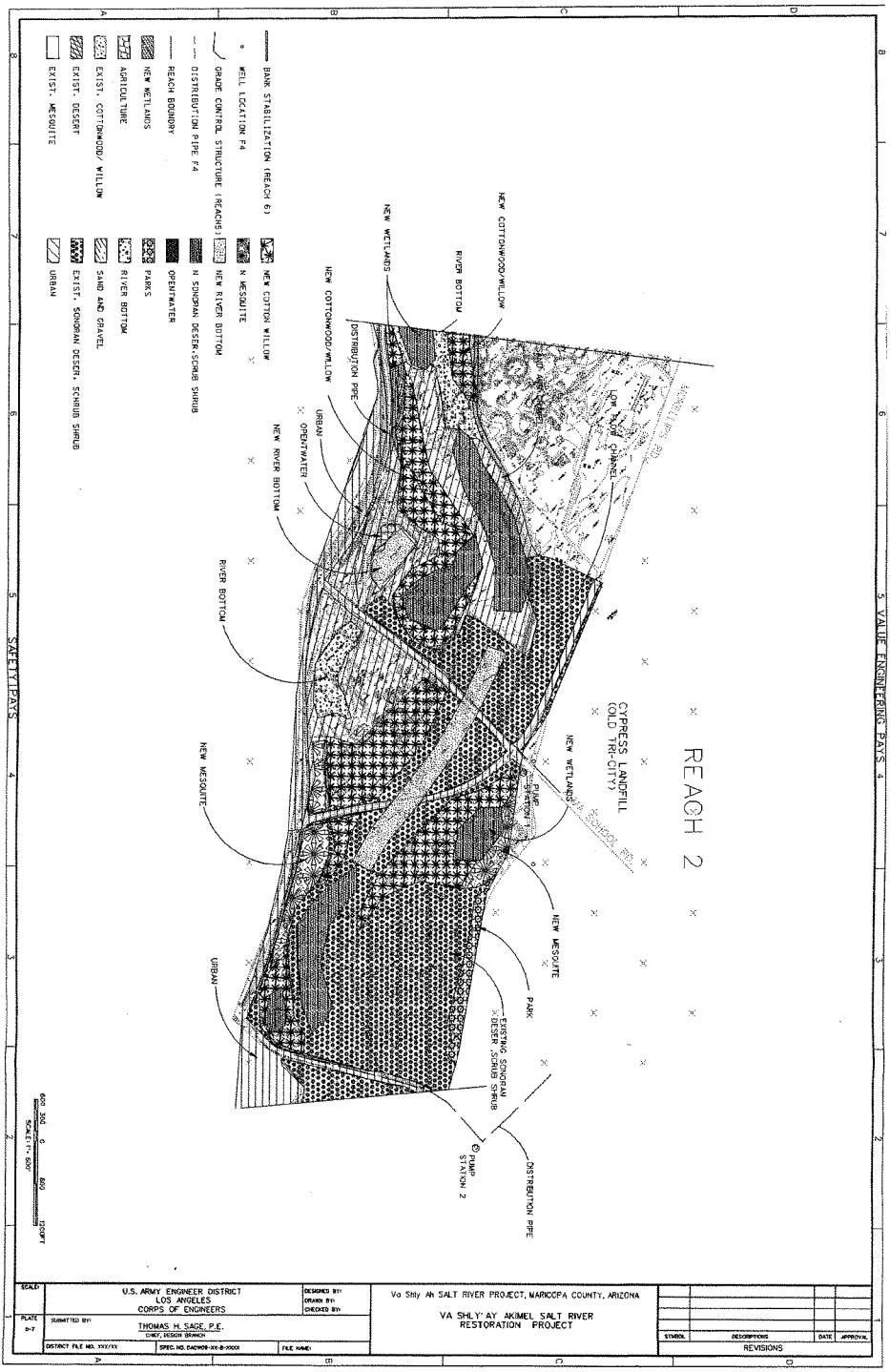
BANK STABILIZATION (REACH 6)
WELL LOCATION F4
GRADE CONTROL STRUCTURE (REACH 5)
DISTRIBUTION PIPE F4
REACH BOUNDARY
NEW WETLANDS
AGRICULTURE
EXIST. COTTONWOOD/ WILLOW
EXIST. DESERT
EXIST. MESQUITE
NEW COTTON WILLOW
N MESQUITE
NEW RIVER BOTTOM
N SONORAN DESER-SCRUB SHRUB
OPENWATER
PARKS
RIVER BOTTOM
SAND AND GRAVEL
EXIST. SONORAN DESER. SCRUB SHRUB
URBAN
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NEW COTTONWOOD/WILLOW
RIVER BOTTOM
DISTRIBUTION PIPE
URBAN
OPENWATER
NEW RIVER BOTTOM
RIVER BOTTOM
NEW MESQUITE
URBAN
NEW COTTONWOOD/WILLOW
LOW FLOW CHANNEL
CYPRESS LANDFILL (OLD TRI-CITY)
NEW WETLANDS
PUMP STATION
NEW MESQUITE
PARK
EXISTING SONORAN DESER. SCRUB SHRUB
PUMP STATION 2
DISTRIBUTION PIPE
REACH 2
SAFETY PAYS
VALUE ENGINEERING PAYS
SCALE
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COST

The purpose of this Basis of Cost Estimate is to document the sources of data and assumptions used in developing the study cost estimates for the alternatives formulated in the Va Shly'ay Akimel Feasibility Study.

Where possible, unit cost information was established from actual cost data provided by manufacturers. Additional historical data were derived from similar projects. The cost estimate quantity items were developed for each Alternative for the 50-year design discharge.

A. CONSTRUCTION COSTS

1. Excess Excavated Material: It is assumed that all excess material will be spread on site.

2. Backfill Material: In order to assure the suitability of backfill material, a processing fee will be applied.

3. Landfill Cap: Cost was obtained from historical data provided by Omaha District.

4. Contingency: A 25% contingency was included, in accordance with Corps of Engineers regulations for feasibility study construction cost estimates.

5. Planning, Engineering & Design (PED) and Engineering During Construction (EDC): The PED and EDC were 10% and 1%, respectively.

6. Supervision & Administration (S&A): A 6.5% S&A cost was taken on the construction cost. This percentage is required by the Corps of Engineers regulations.

B. OPERATION AND MAINTENANCE COSTS

The wetland areas are designed as close as possible to a natural riparian ecosystem and should be self-sustaining as long as sufficient amounts of water are provided. However, as in any manmade, controlled system, maintenance will be required.

1. Invasive Control: $59/acre as recommended by Parks & Recreation, Pima County.

2. Low Flow Channel:
   a. For 16,500-ft long channel
      i. Clear & Grub – Every 10 years.
         Total area = 125 acres
         Cost = $2,400 * 125 = $300,000 or $30,000/yr

      ii. Grading – Once during project life

Assume 1-ft layer
Total volume = 200,000 CY
Cost = $5 * 200,000 = $1,000,000 or $20,000/yr

iii. Total cost = $50,000/yr

b. For 4,000-ft long channel
   i. Clear & Grub – Every 10 years.
      Total area = 30 acres
      Cost = $2,400 * 30 = $72,000 or $7,200/yr

   ii. Grading – Once during project life
      Assume 1-ft layer
      Total volume = 49,000 CY
      Cost = $5 * 49,000 = $245,000 or $4,900/yr

   iii. Total cost = $12,100/yr

3. Wetland: Assume sediment will be removed every 10 years. Crew consists of 3 laborers ($160/day/ea) plus 3 equipment operators ($256/day/ea) plus 3 backhoe loaders ($160/day/ea). Total crew cost is $1,728/day. Allow 10 days or total cost is $17,280. Also, assuming $100,000 for hauling.

Total cost = $117,280/10 yr or $11,728/yr

4. New Water Well:
   a. Pump Operation – Assume $1,000/pump/month or $2,000/month.

   b. Pump Replacement – Assume lifespan is 25 yrs. Replacement cost is $80,000/ea or $160,000 for 2 pumps. Cost = $160,000/25 = $6,400/yr

   c. Total cost = $24,000 + $6,400 = $30,400/yr

5. Irrigation System Maintenance: Assuming crew needs to clean site once every 2 months. Use 2 laborers @ $160/day/ea plus $200/day for equipment and allow 3 days.
   Cost = $1,560/2 months * 12 months or $9,360/yr

6. Water: $75/acre-ft as recommended by SRPMIC.

7. Patrol/Biological Survey/Replanting:

   Patrol: Assume one day/week or 416hr/year @15/hr or $6,240/year

   Biological Survey:

- Qualitative Survey - Assume one biologist reviews site one day per month and writes brief report. Total cost = 16hr/month or 192hr/year at $30/hr or $5,760/year

- Quantitative Survey – Assume 2 biologists sample for 2 weeks, twice a year and write brief report. Total cost = 320hr/year at $30/hr or $9,600/year

Total cost = $6,240 + $5,760 + $9,600 = $21,600/yr

8. Landfill Area:
   a. Hydroseed – $4,356/acre.
      i. For 120-acre site, the total cost is $522,720 or $10,454/yr
      ii. For 130-acre site, the total cost is $566,280 or $11,326/yr
      iii. For 170-acre site, the total cost is $740,520 or $14,810/yr
      iv. For 180-acre site, the total cost is approx. $784,000 or $16,000/yr
      v. For 250-acre site, the total cost is approx. $1.1M or $22,000/yr
   b. Permanent Irrigation System – Assume drip irrigation system @ $16,700/acre.
      i. For 120-acre site, the total cost is $2,004,000 or $40,080/yr
      ii. For 130-acre site, the total cost is $2,171,000 or $43,420/yr
      iii. For 170-acre site, the total cost is $2,839,000 or $56,780/yr
      iv. For 180-acre site, the total cost is $3,006,000 or $60,120/yr
      v. For 250-acre site, the total cost is $4,175,000 or $83,500/yr
   c. Monitoring Wells (4 total, 4-in dia by 100-ft deep ea)
      i. Drilling @ $30/lf or $12,000
      ii. Casing @ $15/lf or $6,000
      iii. Sand packed $1,000/ea or $4,000
      iv. Plugs @ $100/ea or $400
      v. Vented caps @ $50/ea or $200
      vi. Protective enclosure @ $2,500/ea or $10,000
      Cost = $32,600 or $652/yr
   d. Daily Monitor – Assume 2 hrs/day @ $40/hr for an industrial hygiene technician. Cost = $80/day or $400/wk or $20,800/yr
   e. Sample Collection – Assume to take place every 2 months, 3 samples @ $1,000/ea or $3,000/2 mo or $18,000/yr

Total cost = $89,986/yr or $90,000/yr for 120-acre site
= $94,198/yr or $94,000/yr for 130-acre site
= $111,042/yr or $111,000/yr for 170-acre site
= $115,572/yr or $116,000/yr for 180-acre site
= $144,952/yr or $145,000/yr for 250-acre site

C. RECREATION COSTS

Recreation consists of 5.13 miles of trail with concrete curb, signs, parking lots, concrete benches, rest stops, gates, guard posts and mileage markers. In addition, cost sharing elements (restroom, habitat interpretive center, shade structure, parking lot, etc.) are included.

Va Shly' Akimel
Maricopa County, Arizona

Designed By: Corps of Engineers
Estimated By: Don D. Nguyen

Prepared By: Los Angeles District

Preparation Date: 08/23/04
Effective Date of Pricing: 08/23/04
Est Construction Time: 365 Days

Sales Tax: 0.00%

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Release 1.2

09.01. Low Flow Channel	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09. Construction											
09.01. Low Flow Channel											
09.01.001. Excavation & Stockpile											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	233333	CY	CODTB15	150.00	5,437	144,830	251,650	0	0	396,479	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium mati	233333	CY	CODEB12B	90.00	0.02 5,180	0.66 154,490	0.65 152,226	0.00 0	0.00 0	1.31 306,716	1.31
TOTAL Excavation & Stockpile	233333	CY			10,617	299,320	403,876	0	0	703,196	3.01

09.01. Low Flow Channel	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.01.002. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton	233333	CY	COFCB10E	212.50	0.01 1,657	0.20 46,387	0.22 52,360	0.00 0	0.00 0	0.42 98,747	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material	233333	CY	CODTB10M	150.00	0.01 2,333	0.28 65,730	0.66 155,003	0.00 0	0.00 0	0.95 220,733	0.95
TOTAL Spread Excess Mat'l on Site	233333	CY			3,990	112,117	207,363	0	0	319,480	1.37
TOTAL Low Flow Channel					14,607	411,436	611,239	0	0	1,022,675	

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02. Reshaping Salt River Riverbed											
09.02.001. Cut & Stockpile											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	1320489	CY	CODTB15	150.00	30,767	819,628	1424147	0	0	2,243,775	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl	1320489	CY	CODEB12B	90.00	0.02 29,315	0.66 874,296	0.65 861,487	0.00 0	0.00 0	1.31 1,735,783	1.31
TOTAL Cut & Stockpile	1320489	CY			60,082	1693923	2285634	0	0	3,979,558	3.01

09.02. Reshaping Salt River Riverbed		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.002. Fill												
USR AA < >	Processing of excess excav. matl	751803	CY		0.00	0.00 0	0.00 0	0.00 0	1.25 939,754	1.25 939,754	1.25
(02214 0000 Excavation/Backfill/Compaction) (02215 0009 Backfill) (02215 1199 Dozer or front end loader)												
USR AA <02215 2500 >	Waste, backfill, excess excavated on-site material	751803	CY	CODTB10M	150.00	0.01 7,518	0.28 211,783	0.66 499,423	0.00 0	0.00 0	0.95 711,206	0.95
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 5899 Self propelled roller)												
MIL AA <02220 5900 >	Compaction of backfill, structural, SP roller, 6" lift	751803	CY	COFCB10F	117.50	0.01 9,623	0.36 270,348	0.40 297,714	0.00 0	0.00 0	0.76 568,062	0.76
(02220 0010 Compaction) (02220 8999 Water)												
M MIL AA <02220 9030 >	Compaction, water, wagon, 6000 gal, 3 mile haul	751803	CY	COFWB59	250.00	0.00 3,007	0.10 76,458	0.22 168,554	0.20 150,361	0.00 0	0.53 395,373	0.53
TOTAL Fill		751803	CY			20,148	558,590	965,691	150,361	939,754	2,614,395	3.48

09.02. Reshaping Salt River Riverbed	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.003. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton					0.01	0.20	0.22	0.00	0.00	0.42	
	568686	CY	COFCB10E	212.50	4,038	113,055	127,613	0	0	240,668	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material					0.01	0.28	0.66	0.00	0.00	0.95	
	568686	CY	CODTB10M	150.00	5,687	160,199	377,778	0	0	537,977	0.95
TOTAL Spread Excess Mat'l on Site	568686	CY			9,725	273,254	505,391	0	0	778,645	1.37

09.02. Reshaping Salt River Riverbed		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.02.004. Vegetation Grading												
(02214 0000 Excavation/Backfill/Compaction)												
(02215 0009 Backfill)												
(02215 1199 Dozer or front end loader)												
USR AA <02215 2500 >	Waste, backfill, excess excavated on-site material	2186969	CY	CODTB10M	150.00	0.01 21,870	0.28 616,069	0.66 1452804	0.00 0	0.00 0	0.95 2,068,873	0.95
(02214 0000 Excavation/Backfill/Compaction)												
(02220 0010 Compaction)												
(02220 5899 Self propelled roller)												
MIL AA <02220 5900 >	Compaction of backfill, structural, SP roller, 6" lift	2186969	CY	COFCB10F	117.50	0.01 27,993	0.36 786,434	0.40 866,040	0.00 0	0.00 0	0.76 1,652,474	0.76
(02220 0010 Compaction)												
(02220 8999 Water)												
M MIL AA <02220 9030 >	Compaction, water, wagon, 6000 gal, 3 mile haul	2186969	CY	COFWB59	250.00	0.00 8,748	0.10 222,415	0.22 490,318	0.20 437,394	0.00 0	0.53 1,150,127	0.53
(02232 0010 Excavate and load)												
(02232 0011 Hydraulic excavator)												
(02232 0114 1-1/2 CY)												
L MIL AA <02232 0120 >	Excavate & load, hydr excavator, 1.5 CY, medium matl	2186969	CY	CODEB12B	90.00	0.02 48,551	0.66 1447992	0.65 1426779	0.00 0	0.00 0	1.31 2,874,771	1.31
TOTAL	Vegetation Grading	2186969	CY			107,161	3072910	4235940	437,394	0	7,746,244	3.54
TOTAL	Reshaping Salt River Riverbed					197,117	5598677	7992657	587,754	939,754	15,118,842	

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04. Wetland Features											
09.04.001. Excavation & Stockpile, 7' Layer											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	1689960	CY	CODTB15	150.00	39,376	1048958	1822622	0	0	2,871,580	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl	1689960	CY	CODEB12B	90.00	0.02 37,517	0.66 1118923	0.65 1102530	0.00 0	0.00 0	1.31 2,221,452	1.31
TOTAL Excavation & Stockpile, 7' Layer	1689960	CY			76,893	2167881	2925152	0	0	5,093,032	3.01

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.002. 2' Lining of Wetland Clay Mat'l											
(02262 0000 Slope/Erosion Control)											
(02266 0009 Erosion control)											
(02266 1299 Soil cement)											
B MIL AA <02266 1300 > Clay Material					0.30	7.94	5.19	5.00	0.00	18.13	
	422490	CY	COFCB70A	20.00	126,747	3353641	2193399	2112450	0	7,659,490	18.13
TOTAL 2' Lining of Wetland Clay Mat'l	422490	CY			126,747	3353641	2193399	2112450	0	7,659,490	18.13

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.003. 2' Layer of Coarser Mat'l on Top											
(02262 0000 Slope/Erosion Control)											
(02266 0009 Erosion control)											
(02266 1299 Soil cement)											
B MIL AA <02266 1300 > Coarser Material					0.02	0.53	0.35	6.50	0.00	7.38	
	422490	CY	COFCB70A	300.00	8,450	223,582	146,224	2746185	0	3,115,990	7.38
TOTAL 2' Layer of Coarser Mat'l on Top	422490	CY			8,450	223,582	146,224	2746185	0	3,115,990	7.38

09.04. Wetland Features	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.04.004. Spread Excess Mat'l on Site											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton	1689960	CY	COFCB10E	212.50	0.01 11,999	0.20 335,964	0.22 379,227	0.00 0	0.00 0	0.42 715,191	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material	1689960	CY	CODTB10M	150.00	0.01 16,900	0.28 476,062	0.66 1122640	0.00 0	0.00 0	0.95 1,598,702	0.95
TOTAL Spread Excess Mat'l on Site	1689960	CY			28,898	812,026	1501867	0	0	2,313,893	1.37
TOTAL Wetland Features					240,988	6557129	6766642	4858635	0	18,182,406	

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05. Planting											
09.05.001. Cottonwood/Willow											
84 poles/acre											
(02946 0000 Trees/Plants/Ground Cover)											
(02950 0010 Ground cover and vines, planting only, no prep)											
(02950 0559 Liriope)											
M USR AA <02950 0560 > CW Poles					0.15	3.22	0.92	10.00	0.00	14.14	
	74172	EA	ULABA2	20.00	11,126	238,782	68,594	741,720	0	1,049,096	14.14
TOTAL Cottonwood/Willow	74172	EA			11,126	238,782	68,594	741,720	0	1,049,096	14.14

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.002. Mesquite 85 poles/acre											
(02946 0000 Trees/Plants/Ground Cover) (02950 0010 Ground cover and vines, planting only, no prep) (02950 0559 Liriope)											
M USR AA <02950 0560 > Mesquite Poles					0.15	3.22	0.92	10.00	0.00	14.14	
	24700	EA	ULABA2	20.00	3,705	79,517	22,843	247,000	0	349,359	14.14
TOTAL Mesquite	24700	EA			3,705	79,517	22,843	247,000	0	349,359	14.14

09.05. Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.003. Sonoran Desert 127 poles/acre											
(02946 0000 Trees/Plants/Ground Cover) (02950 0010 Ground cover and vines, planting only, no prep) (02950 0559 Liriope)											
M USR AA <02950 0560 > Sonoran Desert Poles					0.15	3.22	0.92	10.00	0.00	14.14	
	3048.00	EA	ULABA2	20.00	457	9,812	2,819	30,480	0	43,111	14.14
TOTAL Sonoran Desert	3048.00	EA			457	9,812	2,819	30,480	0	43,111	14.14

09.05 Planting	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.05.004. Wetland Vegetation											
(02946 0000 Trees/Plants/Ground Cover)											
(02951 0010 Mulch)											
(02951 0759 Pine straw)											
B USR AA <02951 0760 > 2" Pot at 2' OC					0.02	0.41	0.00	0.32	0.00	0.73	
	2178000	EA	ALABCLAB2	100.00	43,560	900,385	0	696,960	0	1,597,345	0.73
TOTAL Wetland Vegetation	200.00	ACR			43,560	900,385	0	696,960	0	1,597,345	7986.73
TOTAL Planting					58,848	1228496	94,256	1716160	0	3,038,912	

09.07. New Water Well	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.07. New Water Well											
(02670 0000 Water Wells)											
(02674 0010 Wells)											
(02674 0299 Drilled in rock)											
CIV AA <02674 0340 > Well, domestic water, drilled in rock, 24" dia	150.00	LF	ULABB23A	0.48	6.32 947	156.33 23,449	235.76 35,364	0.00 0	0.00 0	392.08 58,813	392.08
(02674 0010 Wells)											
(02674 8109 Well screen assembly)											
(02674 8109 Stainless steel)											
M CIV AA <02674 8230 > Well, domestic water, screen assembly, sst, 24" dia	150.00	LF	ULABB23A	2.98	1.01 151	24.96 3,744	37.64 5,646	338.87 50,831	0.00 0	401.47 60,221	401.47
(02674 0010 Wells)											
(02674 8399 Artificial gravel pack)											
M CIV AA <02674 8440 > Well, domestic water, 24" casing, 2" screen, artificial gravel pack	150.00	LF	ULABB23B	3.21	0.93 140	23.11 3,467	41.83 6,275	12.17 1,826	0.00 0	77.11 11,567	77.11
(02674 0010 Wells)											
(02674 8549 Pump test well)											
M CIV AA <02674 8550 > Well, domestic water, pump test well	20.00	HR	ULABB23B	1.00	3.00 60	74.25 1,485	134.40 2,688	46.62 932	0.00 0	255.28 5,106	255.28
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no coupling/hanger 12" dia	150.00	LF	MPLUPLUM2	11.00	0.18 27	7.84 1,176	0.00 0	13.00 1,950	0.00 0	20.84 3,126	20.84
(15200 0000 Plumbing Fixtures)											
(15284 0000 Pumps)											
(15298 0010 Pumps, well)											
B USR AA <15298 2060 > Submersible well pump, 240 HP	2.00	EA	MPLUQ	0.10	44.00 88	1568.70 3,137	191.60 383	18000.00 36,000	0.00 0	19760.30 39,521	19760.30
TOTAL New Water Well					1,414	36,457	50,356	91,538	0	178,352	

09.08. Grade Control Structure			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08. Grade Control Structure													
09.08.001. Concrete													
{02501 0000 Walks, Roads, Parking, Paving}													
{02512 0010 Fine grade}													
{02512 1099 For slab on grade}													
	MIL AA <02512 1100 >	Fine grade, for slab on grade, machine	4290.00	SY	COFGB11L	130.00	0.02 66	0.40 1,735	0.27 1,165	0.00 0	0.00 0	0.68 2,900	0.68
{03110 0000 Structural CIP Formwork, Accessories & Joints}													
{03170 0010 Forms in place, slab on grade}													
{03170 1169 Keyed joint form}													
M	MIL AA <03170 1170 >	Forms in place, SOG, 4 uses, wood, keyed joint form, 7" to 12" high	21000	LF	ACARC1	50.00	0.08 1,680	2.24 47,061	0.00 0	0.51 10,710	0.00 0	2.75 57,771	2.75
{03210 0000 Reinforcing Steel}													
{03217 0010 Reinforcing in place, A615 Gr 60}													
{03217 0599 Slab on grade}													
M	MIL AA <03217 0600 >	Reinforcing in place, slab on grade, #3 to #7	3111100	LB	SIWRRODM4	575.00	0.01 21,778	0.28 884,797	0.00 0	0.29 902,219	0.00 0	0.57 1,787,016	0.57
{03300 0000 Cast-In-Place Concrete}													
{03301 0000 Structural Concrete}													
{03326 0009 Concrete ready mix, matl only, placing see 03372}													
M	RSM AA <03326 0400 >	Concrete ready mix, regular weight, 5000 psi	31111	CY	N/A	0.00	0.00 0	0.00 0	0.00 0	67.65 2104659	0.00 0	67.65 2,104,659	67.65
{03301 0000 Structural Concrete}													
{03334 0009 Curing}													
M	MIL AA <03334 0300 >	Curing, sprayed membrane curing compound	385.00	CSF	ALABCLAB2	11.88	0.17 65	3.48 1,340	0.00 0	3.26 1,255	0.00 0	6.74 2,595	6.74
{03301 0000 Structural Concrete}													
{03372 0010 Placing concrete, see 03326 for material costs}													
{03372 4299 Slab on grade}													
	MIL AA <03372 4700 >	Placing conc, slab on grade, over 6" thick, w/crane & bucket	31111	CY	ULABC7	18.13	0.44 13,732	10.41 323,990	5.66 176,014	0.00 0	0.00 0	16.07 500,004	16.07
	TOTAL	Concrete	31111	CY			37,321	1258923	177,179	3018843	0	4,454,945	143.20

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.002. Excavation & Stockpile, U/S											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	58331	CY	CODTB15	150.00	1,359	36,206	62,910	0	0	99,116	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl	58331	CY	CODEB12B	90.00	0.02 1,295	0.66 38,621	0.65 38,055	0.00 0	0.00 0	1.31 76,676	1.31
TOTAL Excavation & Stockpile, U/S	58331	CY			2,654	74,827	100,965	0	0	175,792	3.01

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.003. Backfill & Compaction, U/S											
USR AA < > Processing of excess excav. matl					0.00	0.00	0.00	0.00	1.25	1.25	
	58331	CY		0.00	0	0	0	0	72,914	72,914	1.25
(02214 0000 Excavation/Backfill/Compaction)											
(02215 0009 Backfill)											
(02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess					0.01	0.28	0.66	0.00	0.00	0.95	
excavated on-site material	58331	CY	CODTB10M	150.00	583	16,432	38,749	0	0	55,181	0.95
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 8719 Air tamper)											
L MIL AA <02220 8900 > Compaction, structural/trench,					0.13	2.61	0.30	0.00	0.00	2.90	
by hand w/air tamp, 6" lift	58331	CY	ULABB9	40.00	7,291	152,168	17,254	0	0	169,422	2.90
(02220 0010 Compaction)											
(02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000					0.00	0.10	0.22	0.20	0.00	0.53	
gal, 3 mile haul	58331	CY	COFWB59	250.00	233	5,932	13,078	11,666	0	30,676	0.53
TOTAL Backfill & Compaction, U/S	58331	CY			8,108	174,532	69,081	11,666	72,914	328,194	5.63

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.005. Excavation & Stockpile, D/S											
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L USR AA <02224 5455 > Stockpile material					0.02	0.62	1.08	0.00	0.00	1.70	
	8332.00	CY	CODTB15	150.00	194	5,172	8,986	0	0	14,158	1.70
(02232 0010 Excavate and load)											
(02232 0011 Hydraulic excavator)											
(02232 0114 1-1/2 CY)											
L MIL AA <02232 0120 > Excavate & load, hydr excavator, 1.5 CY, medium matl					0.02	0.66	0.65	0.00	0.00	1.31	
	8332.00	CY	CODEB12B	90.00	185	5,517	5,436	0	0	10,952	1.31
TOTAL Excavation & Stockpile, D/S	8332.00	CY			379	10,688	14,422	0	0	25,110	3.01

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.006. Backfill & Compaction, D/S											
USR AA < > Processing of excess excav. matl	3000.00	CY		0.00	0.00 0	0.00 0	0.00 0	0.00 0	1.25 3,750	1.25 3,750	1.25
(02214 0000 Excavation/Backfill/Compaction) (02215 0009 Backfill) (02215 1199 Dozer or front end loader)											
USR AA <02215 2500 > Waste, backfill, excess excavated on-site material	3000.00	CY	CODTB10M	150.00	0.01 30	0.28 845	0.66 1,993	0.00 0	0.00 0	0.95 2,838	0.95
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 8719 Air tamper)											
L MIL AA <02220 8900 > Compaction, structural/trench, by hand w/air tamp, 6" lift	3000.00	CY	ULABB9	40.00	0.13 375	2.61 7,826	0.30 887	0.00 0	0.00 0	2.90 8,714	2.90
(02220 0010 Compaction) (02220 8999 Water)											
M MIL AA <02220 9030 > Compaction, water, wagon, 6000 gal, 3 mile haul	3000.00	CY	COFWB59	250.00	0.00 12	0.10 305	0.22 673	0.20 600	0.00 0	0.53 1,578	0.53
TOTAL Backfill & Compaction, D/S	3000.00	CY			417	8,976	3,553	600	3,750	16,879	5.63

09.08. Grade Control Structure	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.007. Spread Excess Mat'l on Site, D/S											
(02214 0000 Excavation/Backfill/Compaction)											
(02220 0010 Compaction)											
(02220 5799 Steel wheel tandem roller)											
AF AA <02220 5800 > Compaction, steel wheel tandem roller, 5 ton					0.01	0.20	0.22	0.00	0.00	0.42	
	5332.00	CY	COFCB10E	212.50	38	1,060	1,197	0	0	2,257	0.42
(02224 0010 Excavating, bulk, dozer)											
(02224 0999 Open site)											
(02224 5449 335 HP)											
L CIV AA <02224 5455 > Spread material					0.01	0.28	0.66	0.00	0.00	0.95	
	5332.00	CY	CODTB10M	150.00	53	1,502	3,542	0	0	5,044	0.95
TOTAL Spread Excess Mat'l on Site, D/S	5332.00	CY			91	2,562	4,739	0	0	7,301	1.37

09.08. Grade Control Structure		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.08.008. Riprap, 15' Drop												
{02262 0000 Slope/Erosion Control}												
{02270 0010 Rip-rap}												
{02270 0099 Machine placed for slope protection}												
M RSM AA <02270 0100 >	Rip-rap, random, machine placed for slope protection. Placed with clamshell.	8888.00	CY	UOEHB12G	7.75	0.26 2,294	7.69 68,336	5.26 46,717	24.97 221,933	0.00 0	37.91 336,987	37.91
TOTAL	Riprap, 15' Drop	8888.00	CY			2,294	68,336	46,717	221,933	0	336,987	37.91
TOTAL	Grade Control Structure					51,264	1598845	416,656	3253043	76,664	5,345,208	

09.09. Water Distribution System		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09. Water Distribution System												
09.09.001. 12" PVC Pipe												
(02214 0000 Excavation/Backfill/Compaction)												
(02215 0009 Backfill)												
(02215 1199 Dozer or front end loader)												
MIL AA <02215 1200 >	Backfill, trench, dozer, no compaction, 60 HP	3000.00	CY	CODTB10L	53.13	0.03 85	0.80 2,386	0.52 1,555	0.00 0	0.00 0	1.31 3,941	1.31
(02214 0000 Excavation/Backfill/Compaction)												
(02220 0010 Compaction)												
(02220 6999 Walk behind, vibrating plate)												
MIL AA <02220 7000 >	Compaction, struct/trench, 6" lifts, 2 passes18" wide, vib plate	3000.00	CY	ULABA1	25.00	0.04 120	0.83 2,480	0.12 365	0.00 0	0.00 0	0.95 2,846	0.95
(02220 0010 Compaction)												
(02220 8999 Water)												
M MIL AA <02220 9000 >	Compaction, water, truck, 3000 gal, 3 mile haul	3000.00	CY	COKBB45	236.00	0.01 26	0.24 729	0.24 735	0.20 600	0.00 0	0.69 2,064	0.69
(02228 0010 Excavating, trench or continuous footing (BCY))												
(02228 0300 Excavate with hydraulic excavator)												
(02228 0300 1/2 CY)												
MIL AA <02228 0302 >	Excavate trench, mdm soil, 4'-6' D, 1/2 CY excavator	3000.00	CY	CODEB12E	91.50	0.02 66	0.65 1,954	0.26 795	0.00 0	0.00 0	0.92 2,748	0.92
(15153 0000 Plastic Pipe)												
(15155 0010 Pipe plastic, no couplings and hangers)												
(15155 1839 PVC schedule 40)												
B USR AA <15155 1990 >	Pipe PVC sched 40 no coupling/hanger 12" dia	40617	LF	MPLUPLUM2	11.00	0.18 7,384	7.84 318,303	0.00 0	13.00 528,021	0.00 0	20.84 846,324	20.84
TOTAL 12" PVC Pipe		40617	LF			7,680	325,852	3,449	528,621	0	857,922	21.12

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.002. Pump Station at Alma School Rd											
USR AA < > Electrical work					0.00	0.00	0.00	0.00	500.00	500.00	
	1.00	LS		0.00	0	0	0	0	500	500	500.00
USR AA < > Housing					0.00	0.00	0.00	0.00	1000.00	1000.00	
	1.00	LS		0.00	0	0	0	0	1,000	1,000	1000.00
(15288 0010 Pumps, general utility)											
(15288 4000 Centrifugal, end suction, horizontal base mount,)											
(15288 4200 Horizontal split case, single stage)											
M MIL AA <15288 4210 > Pump, cntfgl,1.5"D, horiz mtd, horiz splt, sgl stg,2.5HP, 1500 GPM	1.00	EA	MPLUQ1	0.21	9.41	373.33	0.00	2192.39	0.00	2565.72	
					9	373	0	2,192	0	2,566	2565.72
TOTAL Pump Station at Alma School Rd	1.00	EA			9	373	0	2,192	1,500	4,066	4065.72

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.003. Bridge Crossing											
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no coupling/hanger 12" dia	1700.00	LF	MPLUPLUM2	11.00	0.18 309	7.84 13,322	0.00 0	13.00 22,100	0.00 0	20.84 35,422	20.84
TOTAL Bridge Crossing	1700.00	LF			309	13,322	0	22,100	0	35,422	20.84

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.004. Pump Station at Country Club Rd											
USR AA < > Electrical work					0.00	0.00	0.00	0.00	500.00	500.00	
	1.00	LS		0.00	0	0	0	0	500	500	500.00
USR AA < > Housing					0.00	0.00	0.00	0.00	700.00	700.00	
	1.00	LS		0.00	0	0	0	0	700	700	700.00
(15155 0010 Pipe plastic, no couplings and hangers) (15155 1839 PVC schedule 40) (15288 4200 Horizontal split case, single stage)											
B MIL AA <15288 4210 > Pump, cntfgl,1.5"D, horiz mtd, horiz splt, sgl stg,2HP, 700 GPM	1.00	EA	MPLUQ1	0.22	9.09	360.60	0.00	1005.00	0.00	1365.60	
					9	361	0	1,005	0	1,366	1365.60
TOTAL Pump Station at Country Club Rd	1.00	EA			9	361	0	1,005	1,200	2,566	2565.60

09.09. Water Distribution System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.09.005. Bridge Crossing											
(15153 0000 Plastic Pipe)											
(15155 0010 Pipe plastic, no couplings and hangers)											
(15155 1839 PVC schedule 40)											
B USR AA <15155 1990 > Pipe PVC sched 40 no coupling/hanger 12" dia	1700.00	LF	MPLUPLUM2	11.00	0.18 309	7.84 13,322	0.00 0	13.00 22,100	0.00 0	20.84 35,422	20.84
TOTAL Bridge Crossing	1700.00	LF			309	13,322	0	22,100	0	35,422	20.84
TOTAL Water Distribution System					8,317	353,231	3,449	576,018	2,700	935,398	

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10. Road Crossing for Pipeline Syst											
09.10.001. Excavation											
{02054 0000 Selective Demolition}											
{02069 0009 Saw cutting}											
{02069 0009 Asphalt}											
M RSM AA <02069 0010 > Saw cutting, asphalt, up to 3" deep	620.00	LF	COELB89	131.25	0.02 9	0.41 253	0.18 111	0.25 155	0.00 0	0.84 519	0.84
{02228 0010 Excavating, trench or continuous footing (BCY)}											
{02228 1599 Excavate by hand}											
{02228 1624 To 2' deep, piled only}											
MIL AA <02228 1625 > Excavate trench, normal soil, by hand, piled only, to 2' deep	89.00	CY	ULABB2	7.00	0.71 64	14.91 1,327	0.00 0	0.00 0	0.00 0	14.91 1,327	14.91
TOTAL Excavation	89.00	CY			73	1,580	111	155	0	1,846	20.74

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.002. Asphalt, 3"											
(02501 0000 Walks, Roads, Parking, Paving)											
(02505 0010 Asphaltic concrete pavement)											
(02505 0809 Binder course)											
					0.10	2.47	1.33	26.94	0.00	30.73	
M MIL AA <02505 0813 > Asphaltic conc pavement, highway, binder course, 4" thick	12.00	TON	COKCB25	106.25	1	30	16	323	0	369	30.73
TOTAL Asphalt, 3"	12.00	TON			1	30	16	323	0	369	30.73

09.10. Road Crossing for Pipeline Syst	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.003. ABC, 6"											
(02200 0000 Earthwork)											
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02244 0010 Base course, large areas)											
M AF AA <02244 T530 > Base course, gravel, bank run, compacted, 6" D, large areas	16.00	CY	COFGB36C	104.38	0.05	1.37	1.97	11.64	0.00	14.98	
					1	22	31	186	0	240	14.98
TOTAL ABC, 6"	25.00	TON			1	22	31	186	0	240	9.58

09.10. Road Crossing for Pipeline Syst			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.10.004. Backfill & Compaction													
USR AA < >	Processing of excess excav. matl		55.00	CY		0.00	0.00 0	0.00 0	0.00 0	0.00 0	1.25 69	1.25 69	1.25
(02214 0000 Excavation/Backfill/Compaction) (02216 0010 Backfill, structural, dozer or front end loader) (02216 5499 Backfill around foundation)													
MIL AA <02216 5500 >	Backfill, strl, 6" lifts, by hand, no compaction, around foundation		55.00	CY	ULABB2	7.00	0.71 39	14.91 820	0.00 0	0.00 0	0.00 0	14.91 820	14.91
(02214 0000 Excavation/Backfill/Compaction) (02220 0010 Compaction) (02220 8719 Air tamper)													
L MIL AA <02220 8900 >	Compaction, structural/trench, by hand w/air tamp, 6" lift		55.00	CY	ULABB9	40.00	0.13 7	2.61 143	0.30 16	0.00 0	0.00 0	2.90 160	2.90
(02220 0010 Compaction) (02220 8999 Water)													
M MIL AA <02220 9030 >	Compaction, water, wagon, 6000 gal, 3 mile haul		55.00	CY	COFWB59	250.00	0.00 0	0.10 6	0.22 12	0.20 11	0.00 0	0.53 29	0.53
	TOTAL	Backfill & Compaction	55.00	CY			46	969	29	11	69	1,077	19.59
	TOTAL	Road Crossing for Pipeline Syst					121	2,600	187	676	69	3,532	

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.11. Planting Irrigation System											
Braided irrigation system with 50% efficiency											
TOTAL Reach 1 (949 acr-ft)	66.00	ACR			0	0	0	0	204,600	204,600	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 2 (3,130 acr-ft)	226.00	ACR			0	0	0	0	700,600	700,600	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 3 (362 acr-ft)	29.00	ACR			0	0	0	0	89,900	89,900	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 4 (2,113 acr-ft)	152.00	ACR			0	0	0	0	471,200	471,200	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 5 (4,449 acr-ft)	434.00	ACR			0	0	0	0	1345400	1,345,400	3100.00

09.11. Planting Irrigation System	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Reach 6 (6,097 acr-ft)	580.00	ACR			0	0	0	0 1798000	1,798,000	3100.00	
TOTAL Planting Irrigation System					0	0	0	0 4609700	4,609,700		

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12. SRPMIC Irrigation Channel T-Junc											
09.12.001. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.002. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.003. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.004. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.005. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.006. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.007. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.006. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe											
TOTAL Triangular IC 4'TW by 2"D					0	0	0	0	3,500	3,500	

09.12. SRPMIC Irrigation Channel T-Junc	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.12.009. Triangular IC 4'TW by 2"D connect to 12" dia. buried pipe									
TOTAL Triangular IC 4'TW by 2"D			0	0	0	0	3,500	3,500	
TOTAL SRPMIC Irrigation Channel T-Junc			0	0	0	0	31,500	31,500	

09.15. Debris Removal	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09.15. Debris Removal											
USR AA < > Disposal fee	177000	TON		0.00	0.00 0	0.00 0	0.00 0	0.00 0	30.00 5310000	30.00 5,310,000	30.00
{02045 0000 Site Demolition}											
{02046 0009 Site demolition, no hauling}											
{02046 1899 Concrete to 6" thick}											
L USR AA <02046 1900 > Site dml, conc reinforced	118000	CY	CLADB	60.00	0.08 9,829	1.74 205,214	0.33 38,456	0.00 0	0.00 0	2.07 243,670	2.07
{02053 0010 Rubbish handling, add to demolition prices}											
{02053 2999 Loading & trucking, including 2 mile haul}											
{02053 3079 Machine loading truck}											
L MIL AA <02053 3080 > Rubbish handling,2 mile haul, loading & trucking,machine loading truck	118000	CY	COEIB17	15.00	0.27 31,471	6.49 765,454	4.17 492,025	0.00 0	0.00 0	10.66 1,257,479	10.66
TOTAL Debris Removal	118000	CY			41,300	970,668	530,481	0	5310000	6,811,149	57.72

09.16. Cultural Mitigation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Cultural Mitigation					0	0	0	0	300,000	300,000	
TOTAL Construction					613,976	16757540	16465922	1108382	511270386	55,577,673	

14.01. Trail	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14. Recreation											
14.01. Trail											
Trail is 5.13-mi long and 12-ft wide											
14.01.001. Clear & Grub											
(02108 0000 Site Clearing)											
(02110 0009 Clearing)											
(02110 0499 With dozer and brush rake)											
L AF AA <02110 0550 > Clearing, brush w/dozer & brush rake, medium brush	7.46	ACR	CODTB11A	0.50	4.00 30	105.17 785	131.85 984	0.00 0	0.00 0	237.03 1,768	237.03
(02234 0010 Hauling, loose cubic yards)											
(02234 0239 Highway haulers, no loading included)											
(02234 0239 8 CY)											
MIL AA <02234 0260 > Haul & dispose	223.80	CY	COEIB34A	19.38	0.05 12	1.31 294	2.45 540	0.00 0	10.00 2,238	13.76 3,080	13.76
TOTAL Clear & Grub	7.46	ACR			41	1,078	1,531	0	2,238	4,848	649.83

14.01. Trail		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.01.002. Grading												
EP AA <	> GRADER,MOTOR, ARTIC, CAT 16-H					0.00	0.00	81.57	0.00	0.00	81.57	
		844.19	HR	G15CA006	1.00	0	0	68,857	0	0	68,857	81.57
GEN AA <	> SCRAPER, SP,ELEV, 22CY (16.8M3) 25.0T (22.7MT), PS					0.00	0.00	122.40	0.00	0.00	122.40	
		281.40	HR	S10Z5930	1.00	0	0	34,443	0	0	34,443	122.40
MAP AA <	> ROLLER,VIB,DD,S/P, 6.6T, 56"W, SMOOTH DRUMS					0.00	0.00	36.46	0.00	0.00	36.46	
		281.40	HR	R45CA005	1.00	0	0	10,260	0	0	10,260	36.46
GEN AA <	> TRUCK, OFF-HWY, WATER, 6000GAL (22,712L) (W/ 330HP TRACTOR)					0.00	0.00	73.85	0.00	0.00	73.85	
		281.40	HR	T60Z7920	1.00	0	0	20,780	0	0	20,780	73.85
MIL AA <	> Outside Equip. Operator, Heavy HR 32.3300					1.00	33.23	0.00	0.00	0.00	33.23	
		844.19	HR	X-EQOPRHVY	1.00	844	28,054	0	0	0	28,054	33.23
MIL AA <	> Grade checker					1.00	20.67	0.00	0.00	0.00	20.67	
		281.40	HR	X-LABORER	1.00	281	5,816	0	0	0	5,816	20.67
MIL AA <	> Outside Truck Driver, Heavy					1.00	28.68	0.00	0.00	0.00	28.68	
		281.40	HR	X-TRKDVRHV	1.00	281	8,071	0	0	0	8,071	28.68
MIL AA <	> Laborer (foreman)					1.00	20.67	0.00	0.00	0.00	20.67	
		140.70	HR	X-LABORER	1.00	141	2,908	0	0	0	2,908	20.67
TOTAL Grading		12100	CY			1,548	44,850	134,340	0	0	179,190	14.81
TOTAL Trail		36115	SY			1,589	45,928	135,872	0	2,238	184,038	5.10

14.02. Concrete Curb	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.02. Concrete Curb											
(02520 0000 Curbs)											
(02525 0009 Curbs)											
(02525 0249 Curb, cast in place)											
B AF AA <02525 0270 > Curb, CIP, 6" x 18"					0.20	5.80	0.00	4.46	0.00	10.26	
	27086	LF	ACARC2	30.00	5,417	157,069	0	120,804	0	277,873	10.26
TOTAL Concrete Curb	27086	LF			5,417	157,069	0	120,804	0	277,873	10.26

14.03. Trail Head Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.03. Trail Head Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	81.60	0.00	109.16	
x 18", guide & directional signs	4.00	EA	ALABCLAB2	1.50	5	110	0	326	0	437	109.16
TOTAL Trail Head Signs	4.00	EA			5	110	0	326	0	437	109.16

14.04. Parking Lot		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.04. Parking Lot												
(02200 0000 Earthwork)												
(02242 0000 Pavement Base)												
(Material cost accounts for purchasing and delivery (20 miles one-way haul))												
(02243 0009 Sub-base, prepare & roll)												
L MIL AA <02243 0010 >	Base, prepare & roll sub-base, small areas to 2500 SY	550.00	SY	COFGB32A	100.00	0.03	0.85	0.84	0.00	0.00	1.69	
						17	465	465	0	0	929	1.69
(02242 0000 Pavement Base)												
(Material cost accounts for purchasing and delivery (20 miles one-way haul))												
(02244 0010 Base course, large areas)												
B MIL AA <02244 0100 >	Base course, crushed 3/4" stone, compacted, 6"D, large areas	550.00	SY	COFGB36C	300.00	0.02	0.48	0.68	2.66	0.00	3.82	
						9	262	376	1,463	0	2,101	3.82
(02501 0000 Walks, Roads, Parking, Paving)												
(02505 0010 Asphaltic concrete pavement)												
(02505 0849 Wearing course)												
M RSM AA <02505 0850 >	Asphaltic conc pavement, highway, wearing course, 2" thick	150.00	TON	COKCB25B	71.88	0.17	4.09	2.61	60.69	0.00	67.39	
						25	614	391	9,104	0	10,108	67.39
(02501 0000 Walks, Roads, Parking, Paving)												
(02512 0010 Fine grade)												
(02512 0010 For highways)												
L MIL AA <02512 0020 >	Fine grade, for roadway, base or leveling course	1.00	MSY	COFGB11L	0.12	16.67	438.21	294.25	0.00	0.00	732.46	
						17	438	294	0	0	732	732.46
(02579 0000 Pavement Marking)												
(02580 0009 Lines on pavement)												
(02580 0799 Parking stall)												
M MIL AA <02580 0802 >	Lines on pvmt, parking stall, paint, 6" wide	300.00	LF	APTRPORD2	350.00	0.01	0.13	0.00	0.25	0.00	0.38	
						2	39	0	75	0	114	0.38
(02839 0000 Walk/Road/Parking Appurtenances)												
(02841 0010 Parking barriers)												
(02841 0999 Wheel stops, precast concrete)												
B CIV AA <02841 1000 >	Parking barriers, 6" x 10" x 6'-0", wheel stops, precast conc w/dowels	12.00	EA	ULABB2	10.00	0.50	10.43	0.00	27.53	0.00	37.96	
						6	125	0	330	0	456	37.96
(02842 0009 Signs)												
(02842 0009 Reflectorized)												
(02842 0539 Exit)												

14.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL AA <02842 0540 > Signs, reflectorized, UTMCD std, exit, 12" x 18" w/post	2.00	EA	ALABCLAB2	2.00	1.00 2	20.67 41	0.00 0	18.56 37	0.00 0	39.22 78	39.22
(02842 0009 Reflectorized) (02842 0549 Entry)											
M MIL AA <02842 0550 > Signs, reflectorized, UTMCD std, entry, 12" x 18" w/post	2.00	EA	ALABCLAB2	2.00	1.00 2	20.67 41	0.00 0	18.55 37	0.00 0	39.22 78	39.22
TOTAL Parking Lot	2.00	EA			79	2,025	1,526	11,046	0	14,598	7298.85

14.05. Mileage Marker	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.05. Mileage Marker											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12" x 18", guide & directional signs	22.00	EA	ALABCLAB2	1.50	1.33 29	27.56 606	0.00 0	60.33 1,327	0.00 0	87.89 1,934	87.89
TOTAL Mileage Marker	22.00	EA			29	606	0	1,327	0	1,934	87.89

14.06. Educational Plaque	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.06. Educational Plaque											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	11.00	EA	ALABCLAB2	1.50	15	303	0	664	0	967	87.89
TOTAL Educational Plaque	11.00	EA			15	303	0	664	0	967	87.89

14.07. Concrete Bench	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.07. Concrete Bench											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 0009 Precast concrete, w/backs, wood rails)											
M MIL AA <02871 0010 > Benches, park, precast conc, w/backs, wood rails, 4' long	22.00	EA	ALABCLAB2	0.63	3.20 70	66.14 1,455	0.00 0	376.29 8,278	0.00 0	442.43 9,734	442.43
TOTAL Concrete Bench	22.00	EA			70	1,455	0	8,278	0	9,734	442.43

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08. Rest Stop											
Each rest stop includes:											
- 12'x12' shade structure on concrete pad											
- pinic table											
- trash receptacle 2' dia 18" high (2ea)											
- bike stand											
- plaque											
- masonry wall 4' high 60' long											
14.08.001. Shade Structure											
USR AA < > Shade structure on concrete pad					0.00	0.00	0.00	0.00	11000	11000.00	
	6.00	EA		0.00	0	0	0	0	66,000	66,000	11000.00
TOTAL Shade Structure	6.00	EA			0	0	0	0	66,000	66,000	11000.00

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.002. Picnic Table											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 1839 Permanent steel)											
B USR AA <02871 1840 > Picnic Table					12.00	248.04	0.00	1199.00	0.00	1447.04	
	6.00	EA	ALABCLAB3	0.25	72	1,488	0	7,194	0	8,682	1447.04
TOTAL Picnic Table	6.00	EA			72	1,488	0	7,194	0	8,682	1447.04

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.003. Trash Receptacle											
(02870 0000 Site/Street Furnishings)											
(02876 0009 Trash receptacle)											
(02876 0009 Fiberglass, square)											
S RSM AA <02876 0010 > Trash receptacle, fiberglass, 2' square, 18" high	12.00	EA	ALABCLAB2	4.50	0.44	9.19	0.00	108.63	0.00	117.82	
					5	110	0	1,304	0	1,414	117.82
TOTAL Trash Receptacle	12.00	EA			5	110	0	1,304	0	1,414	117.82

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.004. Bike Stand											
(02860 0000 Playfield Equipment)											
(02864 0010 Playground equipment)											
(02864 0199 Bike rack)											
B MIL AA <02864 0200 > Playground eqpt, bike rack, 10' long, permanent	6.00	EA	ULABB1	2.00	1.50 9	31.50 189	0.00 0	335.18 2,011	0.00 0	366.68 2,200	366.68
TOTAL Bike Stand	6.00	EA			9	189	0	2,011	0	2,200	366.68

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.005. Plaque											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	6.00	EA	ALABCLAB2	1.50	8	165	0	362	0	527	87.89
TOTAL Plaque	6.00	EA			8	165	0	362	0	527	87.89

14.08. Rest Stop	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.08.006. Masonry Wall											
(04200 0000 Unit Masonry)											
(04232 0000 Concrete Unit Masonry (CMU))											
(04234 0010 Concrete block, back-up, no scaffolding)											
B M1L AA <04234 0350 > CMU, back-up, 8" x 8" x 16", no scaf/reinf, 2000 psi	1440.00	SF	AMABD8	40.00	0.13 180	4.00 5,761	0.00 0	2.15 3,096	0.00 0	6.15 8,857	6.15
TOTAL Masonry Wall	1440.00	SF			180	5,761	0	3,096	0	8,857	6.15
TOTAL Rest Stop	6.00	EA			274	7,714	0	13,967	66,000	87,680	14613.41

14.09. Gate, Double Swing, 6' High	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.09. Gate, Double Swing, 6' High											
(02835 0010 Fence, CL, gates & posts, posts 1/3 in grnd)											
(02835 6984 Gates, swing)											
(02835 7109 Without barbed wire)											
M MIL AA <02835 7275 > Fence, CL, 6' high, dbl, 20'W, indl, gates, swing, galv, w/o barb wire	6.00	EA	CLABB80B	1.25	3.20	74.04	45.81	464.08	0.00	583.93	
					19	444	275	2,784	0	3,504	583.93
TOTAL Gate, Double Swing, 6' High	6.00	EA			19	444	275	2,784	0	3,504	583.93

14.10. Guard Post, 6" dia. 8' high		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.10. Guard Post, 6" dia. 8' high												
(02839 0000 Walk/Road/Parking Appurtenances)												
(02841 0010 Parking barriers)												
(02841 1999 Bollard, concrete filled steel pipe)												
B MIL AA <02841 2000 >	Parking barriers, 8' L, 6" dia, bollard, ptd, conc filled stl pipe	11.00	EA	CLADB55	2.00	1.50 17	32.19 354	21.89 241	55.64 612	0.00 0	109.72 1,207	109.72
TOTAL	Guard Post, 6" dia. 8' high	11.00	EA			17	354	241	612	0	1,207	109.72

14.11. Street Crossing Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
14.11. Street Crossing Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12"					1.33	27.56	0.00	60.33	0.00	87.89	
x 18", guide & directional signs	11.00	EA	ALABCLAB2	1.50	15	303	0	664	0	967	87.89
TOTAL Street Crossing Signs	11.00	EA			15	303	0	664	0	967	87.89
TOTAL Recreation					7,530	216,313	137,914	160,472	68,238	582,936	

15.01. Museum Restroom		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. Cost Sharing												
15.01. Museum Restroom												
USR AA <	> Restroom					0.00	0.00	0.00	0.00	76.00	76.00	
		615.00	SF		0.00	0	0	0	0	46,740	46,740	76.00
	TOTAL Museum Restroom	1.00	EA			0	0	0	0	46,740	46,740	46740.00

15.02. Habitat Interpretive Center	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.02. Habitat Interpretive Center										
USR AA < > Outdoor Demonstration Area				0.00	0.00	0.00	0.00	12.00	12.00	
	1050.00 SF		0.00	0	0	0	0	12,600	12,600	12.00
TOTAL Habitat Interpretive Center	1.00 EA			0	0	0	0	12,600	12,600	12600.00

15.03. Shade Structure		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.03. Shade Structure												
USR AA <	> Shade structure on concrete pad					0.00	0.00	0.00	0.00	11000	11000.00	
		1.00	EA		0.00	0	0	0	0	11,000	11,000	11000.00
	TOTAL Shade Structure	1.00	EA			0	0	0	0	11,000	11,000	11000.00

15.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.04. Parking Lot											
(02200 0000 Earthwork)											
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02243 0009 Sub-base, prepare & roll)											
L MIL AA <02243 0010 > Base, prepare & roll sub-base, small areas to 2500 SY	275.00	SY	COFGB32A	100.00	0.03	0.85	0.84	0.00	0.00	1.69	
					8	232	232	0	0	465	1.69
(02242 0000 Pavement Base)											
(Material cost accounts for purchasing and delivery (20 miles one-way haul))											
(02244 0010 Base course, large areas)											
B MIL AA <02244 0100 > Base course, crushed 3/4" stone, compacted, 6"D, large areas	275.00	SY	COFGB36C	300.00	0.02	0.48	0.68	2.66	0.00	3.82	
					5	131	188	732	0	1,051	3.82
(02501 0000 Walks, Roads, Parking, Paving)											
(02505 0010 Asphaltic concrete pavement)											
(02505 0849 Wearing course)											
M RSM AA <02505 0850 > Asphaltic conc pavement, highway, wearing course, 2" thick	75.00	TON	COKCB25B	71.88	0.17	4.09	2.61	60.69	0.00	67.39	
					13	307	196	4,552	0	5,054	67.39
(02501 0000 Walks, Roads, Parking, Paving)											
(02512 0010 Fine grade)											
(02512 0010 For highways)											
L MIL AA <02512 0020 > Fine grade, for roadway, base or leveling course	0.50	MSY	COFGB11L	0.12	16.67	438.21	294.25	0.00	0.00	732.46	
					8	219	147	0	0	366	732.46
(02579 0000 Pavement Marking)											
(02580 0009 Lines on pavement)											
(02580 0799 Parking stall)											
M MIL AA <02580 0802 > Lines on pvmt, parking stall, paint, 6" wide	150.00	LF	APTRFORD2	350.00	0.01	0.13	0.00	0.25	0.00	0.38	
					1	19	0	38	0	57	0.38
(02839 0000 Walk/Road/Parking Appurtenances)											
(02841 0010 Parking barriers)											
(02841 0999 Wheel stops, precast concrete)											
B CIV AA <02841 1000 > Parking barriers, 6" x 10" x 6'-0", wheel stops, precast conc w/dowels	6.00	EA	ULABB2	10.00	0.50	10.43	0.00	27.53	0.00	37.96	
					3	63	0	165	0	228	37.96
(02842 0009 Signs)											
(02842 0009 Reflectorized)											
(02842 0539 Exit)											

15.04. Parking Lot	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL AA <02842 0540 > Signs, reflectorized, UTMCD std, exit, 12" x 18" w/post	1.00	EA	ALABCLAB2	2.00	1.00 1	20.67 21	0.00 0	18.56 19	0.00 0	39.22 39	39.22
(02842 0009 Reflectorized) (02842 0549 Entry)											
M MIL AA <02842 0550 > Signs, reflectorized, UTMCD std, entry, 12" x 18" w/post	1.00	EA	ALABCLAB2	2.00	1.00 1	20.67 21	0.00 0	18.55 19	0.00 0	39.22 39	39.22
TOTAL Parking Lot	1.00	EA			40	1,013	763	5,523	0	7,299	7298.85

15.05. Utilities for Restroom	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Utilities for Restroom					0	0	0	0	15,000	15,000	

15.06. Picnic Table	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.06. Picnic Table											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 1839 Permanent steel)											
B USR AA <02871 1840 > Picnic Table					12.00	248.04	0.00	1199.00	0.00	1447.04	
	4.00	EA	ALABCLAB3	0.25	48	992	0	4,796	0	5,788	1447.04
TOTAL Picnic Table	4.00	EA			48	992	0	4,796	0	5,788	1447.04

15.07. Trash Receptacle	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.07. Trash Receptacle											
(02870 0000 Site/Street Furnishings)											
(02876 0009 Trash receptacle)											
(02876 0009 Fiberglass, square)											
B RSM AA <02876 0010 > Trash receptacle, fiberglass, 2' square, 18" high	8.00	EA	ALABCLAB2	4.50	0.44 4	9.19 73	0.00 0	108.63 869	0.00 0	117.82 943	117.82
TOTAL Trash Receptacle	8.00	EA			4	73	0	869	0	943	117.82

15.08. Concrete Bench	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.08. Concrete Bench											
(02870 0000 Site/Street Furnishings)											
(02871 0009 Benches)											
(02871 0009 Precast concrete, w/backs, wood rails)											
M MIL AA <02871 0010 > Benches, park, precast conc,					3.20	66.14	0.00	376.29	0.00	442.43	
w/backs, wood rails, 4' long	5.00	EA	ALABCLAB2	0.63	16	331	0	1,881	0	2,212	442.43
TOTAL Concrete Bench	5.00	EA			16	331	0	1,881	0	2,212	442.43

15.09. Signs	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15.09. Signs											
(02839 0000 Walk/Road/Parking Appurtenances)											
(02842 0009 Signs)											
(02842 0589 Guide and directional signs)											
M USR AA <02842 0590 > Signs, reflectorized w/post, 12" x 18", guide & directional signs	10.00	EA	ALABCLAB2	1.50	1.33 13	27.56 276	0.00 0	60.33 603	0.00 0	87.89 879	87.89
TOTAL Signs	10.00	EA			13	276	0	603	0	879	87.89
TOTAL Cost Sharing					120	2,685	763	13,673	85,340	102,461	
TOTAL Va Shly' Akimel	1.00	EA			621,626	16976538	16604599	1125796911423964		56,263,070	56263070

		QUANTITY UOM	CONTRACT	CONTINGN	PE&D	EDC	S&A	TOTAL COST	UNIT COST
09	Construction		76,033,027	19008257	7,603,303	760,330	4,942,147	108,347,064	
14	Recreation		798,650	199,663	79,865	7,987	51,912	1,138,077	
15	Cost Sharing		140,376	35,094	14,038	1,404	9,124	200,036	
TOTAL	Va Shly' Akimel	1.00 EA	76,972,054	19243013	7,697,205	769,721	5,003,183	109,685,177	109685177

		QUANTITY	UOM	CONTRACT	CONTINGN	PE&D	EDC	S&A	TOTAL COST	UNIT COST
09	Construction									
09.01	Low Flow Channel			1,401,113	350,278	140,111	14,011	91,072	1,996,587	
09.02	Reshaping Salt River Riverbed			20,713,528	5,178,382	2,071,353	207,135	1,346,379	29,516,778	
09.04	Wetland Features			24,910,757	6,227,689	2,491,076	249,108	1,619,199	35,497,828	
09.05	Planting			4,163,453	1,040,863	416,345	41,635	270,624	5,932,921	
09.07	New Water Well			244,350	61,088	24,435	2,444	15,883	348,199	
09.08	Grade Control Structure			7,323,187	1,830,797	732,319	73,232	476,007	10,435,542	
09.09	Water Distribution System			1,281,540	320,385	128,154	12,815	83,300	1,826,194	
09.10	Road Crossing for Pipeline Syst			4,839	1,210	484	48	315	6,895	
09.11	Planting Irrigation System			6,315,507	1,578,877	631,551	63,155	410,508	8,999,598	
09.12	SRPMIC Irrigation Channel T-Junc			43,156	10,789	4,316	432	2,805	61,498	
09.15	Debris Removal	118000.00	CY	9,331,596	2,332,899	933,160	93,316	606,554	13,297,524	112.69
09.16	Cultural Mitigation			300,000	75,000	30,000	3,000	19,500	427,500	
TOTAL	Construction			76,033,027	19008257	7,603,303	760,330	4,942,147	108,347,064	
14	Recreation									
14.01	Trail	36115.00	SY	252,141	63,035	25,214	2,521	16,389	359,300	9.95
14.02	Concrete Curb	27086.00	LF	380,699	95,175	38,070	3,807	24,745	542,495	20.03
14.03	Trail Head Signs	4.00	EA	598	150	60	6	39	852	213.11
14.04	Parking Lot	2.00	EA	20,000	5,000	2,000	200	1,300	28,499	14249.67
14.05	Mileage Marker	22.00	EA	2,649	662	265	26	172	3,775	171.59
14.06	Educational Plaque	11.00	EA	1,325	331	132	13	86	1,887	171.59
14.07	Concrete Bench	22.00	EA	13,335	3,334	1,334	133	867	19,003	863.77
14.08	Rest Stop	6.00	EA	120,126	30,032	12,013	1,201	7,808	171,180	28530.01
14.09	Gate, Double Swing, 6' High	6.00	EA	4,800	1,200	480	48	312	6,840	1140.01
14.10	Guard Post, 6" dia. 8' high	11.00	EA	1,654	413	165	17	107	2,356	214.21
14.11	Street Crossing Signs	11.00	EA	1,325	331	132	13	86	1,887	171.59
TOTAL	Recreation			798,650	199,663	79,865	7,987	51,912	1,138,077	
15	Cost Sharing									
15.01	Museum Restroom	1.00	EA	64,036	16,009	6,404	640	4,162	91,251	91251.32
15.02	Habitat Interpretive Center	1.00	EA	17,263	4,316	1,726	173	1,122	24,599	24599.20
15.03	Shade Structure	1.00	EA	15,071	3,768	1,507	151	980	21,475	21475.49
15.04	Parking Lot	1.00	EA	10,000	2,500	1,000	100	650	14,250	14249.67
15.05	Utilities for Restroom			20,551	5,138	2,055	206	1,336	29,285	
15.06	Picnic Table	4.00	EA	7,930	1,983	793	79	515	11,300	2825.07
15.07	Trash Receptacle	8.00	EA	1,291	323	129	13	84	1,840	230.02
15.08	Concrete Bench	5.00	EA	3,031	758	303	30	197	4,319	863.77
15.09	Signs	10.00	EA	1,204	301	120	12	78	1,716	171.59
TOTAL	Cost Sharing			140,376	35,094	14,038	1,404	9,124	200,036	
TOTAL	Va Shly' Akimel	1.00	EA	76,972,054	19243013	7,697,205	769,721	5,003,183	109,685,177	109685177

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
09 Construction		55,577,673	5,527,767	3,040,272	6,384,571	343,779	5,158,964	76,033,027	
14 Recreation		582,936	58,294	32,062	67,329	3,625	54,404	798,650	
15 Cost Sharing		102,461	10,246	5,635	11,834	637	9,562	140,376	
TOTAL Va Shly' Akimel	1.00 EA	56,263,070	5,596,307	3,077,969	6,463,735	348,042	5,222,931	76,972,054	76972054
CONTINGENCY								19,243,013	
SUBTOTAL								96,215,067	
PE&D								7,697,205	
SUBTOTAL								103,912,273	
EDC								769,721	
SUBTOTAL								104,681,993	
S&A								5,003,183	
TOTAL INCL OWNER COSTS								109,685,177	

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
09	Construction										
09.01	Low Flow Channel			1,022,675	102,268	56,247	118,119	6,360	95,444	1,401,113	
09.02	Reshaping Salt River Riverbed			15,118,842	1,511,884	831,536	1,746,226	94,026	1,411,014	20,713,528	
09.04	Wetland Features			18,182,406	1,818,241	1,000,032	2,100,068	113,079	1,696,931	24,910,757	
09.05	Planting			3,038,912	303,891	167,140	350,994	18,899	283,616	4,163,453	
09.07	New Water Well			178,352	17,835	9,809	20,600	1,109	16,645	244,350	
09.08	Grade Control Structure			5,345,208	534,521	293,986	617,371	33,243	498,858	7,323,187	
09.09	Water Distribution System			935,398	93,540	51,447	108,039	5,817	87,299	1,281,540	
09.10	Road Crossing for Pipeline Syst			3,532	353	194	408	22	330	4,839	
09.11	Planting Irrigation System			4,609,700	460,970	253,534	532,420	28,668	430,215	6,315,507	
09.12	SRPMIC Irrigation Channel T-Junc			31,500	3,150	1,733	3,636	196	2,940	43,156	
09.15	Debris Removal	118000.00	CY	6,811,149	681,115	374,613	786,688	42,359	635,672	9,331,596	79.08
09.16	Cultural Mitigation			300,000	0	0	0	0	0	300,000	
TOTAL	Construction			55,577,673	5,527,767	3,040,272	6,384,571	343,779	5,158,964	76,033,027	
14	Recreation										
14.01	Trail	36115.00	SY	184,038	18,404	10,122	21,256	1,145	17,176	252,141	6.98
14.02	Concrete Curb	27086.00	LF	277,873	27,787	15,283	32,094	1,728	25,933	380,699	14.06
14.03	Trail Head Signs	4.00	EA	437	44	24	50	3	41	598	149.55
14.04	Parking Lot	2.00	EA	14,598	1,460	803	1,686	91	1,362	20,000	9999.77
14.05	Mileage Marker	22.00	EA	1,934	193	106	223	12	180	2,649	120.41
14.06	Educational Plaque	11.00	EA	967	97	53	112	6	90	1,325	120.41
14.07	Concrete Bench	22.00	EA	9,734	973	535	1,124	61	908	13,335	606.15
14.08	Rest Stop	6.00	EA	87,680	8,768	4,822	10,127	545	8,183	120,126	20021.06
14.09	Gate, Double Swing, 6' High	6.00	EA	3,504	350	193	405	22	327	4,800	800.01
14.10	Guard Post, 6" dia. 8' high	11.00	EA	1,207	121	66	139	8	113	1,654	150.32
14.11	Street Crossing Signs	11.00	EA	967	97	53	112	6	90	1,325	120.41
TOTAL	Recreation			582,936	58,294	32,062	67,329	3,625	54,404	798,650	
15	Cost Sharing										
15.01	Museum Restroom	1.00	EA	46,740	4,674	2,571	5,398	291	4,362	64,036	64036.01
15.02	Habitat Interpretive Center	1.00	EA	12,600	1,260	693	1,455	78	1,176	17,263	17262.60
15.03	Shade Structure	1.00	EA	11,000	1,100	605	1,271	68	1,027	15,071	15070.52
15.04	Parking Lot	1.00	EA	7,299	730	401	843	45	681	10,000	9999.77
15.05	Utilities for Restroom			15,000	1,500	825	1,733	93	1,400	20,551	
15.06	Picnic Table	4.00	EA	5,788	579	318	669	36	540	7,930	1982.51
15.07	Trash Receptacle	8.00	EA	943	94	52	109	6	88	1,291	161.41
15.08	Concrete Bench	5.00	EA	2,212	221	122	256	14	206	3,031	606.15
15.09	Signs	10.00	EA	879	88	48	102	5	82	1,204	120.41
TOTAL	Cost Sharing			102,461	10,246	5,635	11,834	637	9,562	140,376	
TOTAL	Va Shly' Akimel	1.00	EA	56,263,070	5,596,307	3,077,969	6,463,735	348,042	5,222,931	76,972,054	76972054

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	AZ PRIV	TOTAL COST	UNIT COST
CONTINGENCY								19,243,013	
SUBTOTAL								96,215,067	
PE&D								7,697,205	
SUBTOTAL								103,912,273	
EDC								769,721	
SUBTOTAL								104,681,993	
S&A								5,003,183	
TOTAL INCL OWNER COSTS								109,685,177	

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09 Construction		613,976	16757540	16465922	1108382511270386		55,577,673	
14 Recreation		7,530	216,313	137,914	160,472	68,238	582,936	
15 Cost Sharing		120	2,685	763	13,673	85,340	102,461	
TOTAL Va Shly' Akimel	1.00 EA	621,626	16976538	16604599	1125796911423964		56,263,070	56263070
OVERHEAD							5,596,307	
SUBTOTAL							61,859,378	
HOME OFC							3,077,969	
SUBTOTAL							64,937,346	
PROFIT							6,463,735	
SUBTOTAL							71,401,081	
BOND							348,042	
SUBTOTAL							71,749,123	
ARIZONA PRIV							5,222,931	
TOTAL INCL INDIRECTS							76,972,054	
CONTINGENCY							19,243,013	
SUBTOTAL							96,215,067	
PE&D							7,697,205	
SUBTOTAL							103,912,273	
EDC							769,721	
SUBTOTAL							104,681,993	
S&A							5,003,183	
TOTAL INCL OWNER COSTS							109,685,177	

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
09	Construction									
09.01	Low Flow Channel			14,607	411,436	611,239	0	0	1,022,675	
09.02	Reshaping Salt River Riverbed			197,117	5598677	7992657	587,754	939,754	15,118,842	
09.04	Wetland Features			240,988	6557129	6766642	4858635	0	18,182,406	
09.05	Planting			58,848	1228496	94,256	1716160	0	3,038,912	
09.07	New Water Well			1,414	36,457	50,356	91,538	0	178,352	
09.08	Grade Control Structure			51,264	1598845	416,656	3253043	76,664	5,345,208	
09.09	Water Distribution System			8,317	353,231	3,449	576,018	2,700	935,398	
09.10	Road Crossing for Pipeline Syst			121	2,600	187	676	69	3,532	
09.11	Planting Irrigation System			0	0	0	0	4609700	4,609,700	
09.12	SRPMIC Irrigation Channel T-Junc			0	0	0	0	31,500	31,500	
09.15	Debris Removal	118000.00	CY	41,300	970,668	530,481	0	5310000	6,811,149	57.72
09.16	Cultural Mitigation			0	0	0	0	300,000	300,000	
TOTAL	Construction			613,976	16757540	16465922	1108382511270386		55,577,673	
14	Recreation									
14.01	Trail	36115.00	SY	1,589	45,928	135,872	0	2,238	184,038	5.10
14.02	Concrete Curb	27086.00	LF	5,417	157,069	0	120,804	0	277,873	10.26
14.03	Trail Head Signs	4.00	EA	5	110	0	326	0	437	109.16
14.04	Parking Lot	2.00	EA	79	2,025	1,526	11,046	0	14,598	7298.85
14.05	Mileage Marker	22.00	EA	29	606	0	1,327	0	1,934	87.89
14.06	Educational Plaque	11.00	EA	15	303	0	664	0	967	87.89
14.07	Concrete Bench	22.00	EA	70	1,455	0	8,278	0	9,734	442.43
14.08	Rest Stop	6.00	EA	274	7,714	0	13,967	66,000	87,680	14613.41
14.09	Gate, Double Swing, 6' High	6.00	EA	19	444	275	2,784	0	3,504	583.93
14.10	Guard Post, 6" dia. 8' high	11.00	EA	17	354	241	612	0	1,207	109.72
14.11	Street Crossing Signs	11.00	EA	15	303	0	664	0	967	87.89
TOTAL	Recreation			7,530	216,313	137,914	160,472	68,238	582,936	
15	Cost Sharing									
15.01	Museum Restroom	1.00	EA	0	0	0	0	46,740	46,740	46740.00
15.02	Habitat Interpretive Center	1.00	EA	0	0	0	0	12,600	12,600	12600.00
15.03	Shade Structure	1.00	EA	0	0	0	0	11,000	11,000	11000.00
15.04	Parking Lot	1.00	EA	40	1,013	763	5,523	0	7,299	7298.85
15.05	Utilities for Restroom			0	0	0	0	15,000	15,000	
15.06	Picnic Table	4.00	EA	48	992	0	4,796	0	5,788	1447.04
15.07	Trash Receptacle	8.00	EA	4	73	0	869	0	943	117.82
15.08	Concrete Bench	5.00	EA	16	331	0	1,881	0	2,212	442.43
15.09	Signs	10.00	EA	13	276	0	603	0	879	87.89
TOTAL	Cost Sharing			120	2,685	763	13,673	85,340	102,461	
TOTAL	Va Shly' Akimel	1.00	EA	621,626	16976538	16604599	1125796911423964		56,263,070	56263070

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
OVERHEAD							5,596,307	
SUBTOTAL							61,859,378	
HOME OFC							3,077,969	
SUBTOTAL							64,937,346	
PROFIT							6,463,735	
SUBTOTAL							71,401,081	
BOND							348,042	
SUBTOTAL							71,749,123	
ARIZONA PRIV							5,222,931	
TOTAL INCL INDIRECTS							76,972,054	
CONTINGENCY							19,243,013	
SUBTOTAL							96,215,067	
PE&D							7,697,205	
SUBTOTAL							103,912,273	
EDC							769,721	
SUBTOTAL							104,681,993	
S&A							5,003,183	
TOTAL INCL OWNER COSTS							109,685,177	

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	ACARC1	3 carpnters			PROD = 100%				CREW HOURS =	420
MIL	B-CARPNTERL	Carpenters	3.00	HR	30.46	3.00	91.38			91.38
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
	TOTAL					4.00	112.05	0.00	0.00	112.05
	ACARC2	5 carpnters			PROD = 100%				CREW HOURS =	903
MIL	B-CARPNTERF	Carpenters	1.00	HR	31.46	1.00	31.46			31.46
MIL	B-CARPNTERL	Carpenters	4.00	HR	30.46	4.00	121.84			121.84
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
	TOTAL					6.00	173.97	0.00	0.00	173.97
	ALABCLAB2	2 laborers			PROD = 100%				CREW HOURS =	21906
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
	TOTAL					2.00	41.34	0.00	0.00	41.34
	ALABCLAB3	3 laborers			PROD = 100%				CREW HOURS =	40
MIL	B-LABORER L	Laborers, (Semi-Skilled)	3.00	HR	20.67	3.00	62.01			62.01
	TOTAL					3.00	62.01	0.00	0.00	62.01
	AMASD8	3 brklayrs			PROD = 100%				CREW HOURS =	36
MIL	B-BRKLAYR L	Bricklayers	3.00	HR	32.54	3.00	97.63			97.63
MIL	B-BRKLAYRHL	Bricklayers, (Semi-Skilled)	2.00	HR	31.20	2.00	62.39			62.39
	TOTAL					5.00	160.03	0.00	0.00	160.03
	APTRPORD2	2 paintords			PROD = 100%				CREW HOURS =	1
MIL	B-PAINTORDL	Painters, Ordinary	2.00	HR	22.74	2.00	45.48			45.48
	TOTAL					2.00	45.48	0.00	0.00	45.48
	CLABB80B	3 laborers + 1 crane, hydr, trk mtd, 14 ton			PROD = 100%				CREW HOURS =	5
MIL	B-LABORER L	Laborers, (Semi-Skilled)	3.00	HR	20.67	3.00	62.01			62.01
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
GEN	C80Z2240 E	CRANE, HYD, TRUCK MTD, 14T	1.00	HR	57.27			1.00	57.27	57.27
	TOTAL					4.00	92.54	1.00	57.27	149.81
*	CLADB	5 laborer + 2 89# Pavement Breaker			PROD = 100%				CREW HOURS =	1967
MIL	A15Z0150 E	AIR COMPRESSOR, 375CFM, 100 PS	1.00	HR	17.09			1.00	17.09	17.09
GEN	A2020400 E	PAVING BREAKER, 66LB (30KG)	2.00	HR	0.90			2.00	1.79	1.79
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	A2020475 E	AIR HOSE,1.0"X 100'L (25MMX 31M	2.00	HR	0.34			2.00	0.68	0.68
	TOTAL					5.00	104.35	5.00	19.55	123.90

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	CLAD855	2 laborers + 1 drill, auger, 14" dia, 30' depth			PROD = 100%				CREW HOURS = 6	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	D30Z2840 E	DRILL, AUGER, 14" DIA, 30' DEE	1.00	HR	24.95			1.00	24.95	24.95
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
GEN	T40Z7000 E	TRK FLATBED, 8'X 20'(2.4MX 6.1M	1.00	HR	1.04			1.00	1.04	1.04
	TOTAL					3.00	64.39	3.00	43.77	108.16
	CODEB12B	1 eqoprcrn + 1 hydr excavator, crawler, 1.50 CY			PROD = 100%				CREW HOURS = 61082	
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	H25Z3185 E	HYD EXCV, CRAWLER, 55,000LBS,	1.00	HR	58.72			1.00	58.72	58.72
	TOTAL					2.00	59.59	1.00	58.72	118.31
	CODEB12E	1 eqoprcrn + 1 hydr excavator, crawler, 0.50 CY			PROD = 100%				CREW HOURS = 33	
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	H25Z3160 E	HYD EXCV, CRAWLER, 24,000LBS,	1.00	HR	24.24			1.00	24.24	24.24
	TOTAL					2.00	59.59	1.00	24.24	83.82
	CODTB10L	1 eqoprmed + 1 dozer, crawler, 76-100 HP			PROD = 100%				CREW HOURS = 56	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	T15Z6440 E	DOZER, CRAWLER, 76-100HP	1.00	HR	27.53			1.00	27.53	27.53
	TOTAL					1.50	42.25	1.00	27.53	69.78
	CODTB10M	1 eqoprmed + 1 dozer, crawler, 341-440 HP			PROD = 100%				CREW HOURS = 36649	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	T15Z6600 E	DOZER, CRAWLER, 341-440HP	1.00	HR	99.64			1.00	99.64	99.64
	TOTAL					1.50	42.25	1.00	99.64	141.89
	CODTB11A	1 eqoprmed + 1 dozer, crawler, 181-250 HP			PROD = 100%				CREW HOURS = 15	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00	HR	65.93			1.00	65.93	65.93
	TOTAL					2.00	52.59	1.00	65.93	118.51
	CODTB15	1 eqoprmed + 1 dozer, crawler, 181-250 HP			PROD = 100%				CREW HOURS = 22070	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	2.00	HR	25.43	2.00	50.86			50.86
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	2.00	HR	45.79			2.00	91.57	91.57
GEN	T40Z6860 E	REAR DUMP BODY, 16-23.5CY (12.2	2.00	HR	2.14			2.00	4.28	4.28
GEN	T15Z6520 E	DOZER, CRAWLER, 181-250HP	1.00	HR	65.93			1.00	65.93	65.93
	TOTAL					3.50	93.11	5.00	161.78	254.89

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	COEIB17	1 trkdvrhv + 1 truck, dump, 12 CY			PROD = 100%				CREW HOURS = 7867	
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	L50Z4640 E	LOADER/BCK-HOE,WH, 0.80CY(0.6M3	1.00	HR	15.12			1.00	15.12	15.12
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	45.79			1.00	45.79	45.79
GEN	T40Z7090 E	REAR DUMP BODY, 12CY (9.2M3)	1.00	HR	1.64			1.00	1.64	1.64
	TOTAL					4.00	97.30	3.00	62.55	159.85
	COEIB34A	1 trkdvrhv + 1 truck, dump, 12 CY			PROD = 100%				CREW HOURS = 12	
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	T50Z7420 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	45.79			1.00	45.79	45.79
GEN	T40Z7090 E	REAR DUMP BODY, 12CY (9.2M3)	1.00	HR	1.64			1.00	1.64	1.64
	TOTAL					1.00	25.43	2.00	47.42	72.85
	COELB89	1 eqoprlt + 1 truck, flatbed, 8' x 20'			PROD = 100%				CREW HOURS = 5	
MIL	B-EQOPRLT L	Equip. Operators, Light	1.00	HR	30.53	1.00	30.53			30.53
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	XMEZ9560 E	WATER TANK, 500 GAL (1,893L)	1.00	HR	1.70			1.00	1.70	1.70
GEN	C60Z1970 E	CONC SLAB SAW, 7" (178MM) DEPT	1.00	HR	3.04			1.00	3.04	3.04
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
GEN	T40Z7000 E	TRK FLATBED, 8'X 20'(2.4MX 6.1M	1.00	HR	1.04			1.00	1.04	1.04
	TOTAL					2.00	53.58	4.00	23.56	77.14
	COFCB10E	1 eqoprmed + 1 roller, vib, tandem, S/P, 6 ton			PROD = 100%				CREW HOURS = 11752	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	R45Z5680 E	ROLLER, VIB, DD, SP 6.0T	1.00	HR	47.68			1.00	47.68	47.68
	TOTAL					1.50	42.25	1.00	47.68	89.94
	COFCB10F	1 eqoprmed + 1 roller, vib, tandem, S/P, 12 ton			PROD = 100%				CREW HOURS = 25011	
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	0.50	HR	20.67	0.50	10.33			10.33
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
	TOTAL					1.50	42.25	1.00	46.53	88.78
	COFCB70A	3 eqoprmed + 1 roller,vib,sd,S/P,22 ton,84" wide			PROD = 100%				CREW HOURS = 22533	
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	R30Z5642 E	ROLLER, STATIC, 3W, SP, 12.0T	1.00	HR	25.38			1.00	25.38	25.38
GEN	R50Z5820 E	ROLLER, VIB, SD, SP 22.0T	1.00	HR	43.15			1.00	43.15	43.15
	TOTAL					6.00	158.76	3.00	103.83	262.59

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	COFGB11L	1 eqoprmed + 1 grader, motor, artic, 28,770 lbs			PROD = 100%				CREW HOURS =	46
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
	TOTAL					2.00	52.59	1.00	35.31	87.90
	COFGB32A	2 eqoprmed + 1 roller,vib,sd,S/P,12 ton,84"x60"			PROD = 100%				CREW HOURS =	8
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	2.00	HR	31.92	2.00	63.83			63.83
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	R50Z5810 E	ROLLER, VIB, SD, SP 12.0T	1.00	HR	49.17			1.00	49.17	49.17
	TOTAL					3.00	84.50	2.00	84.48	168.98
	COFGB36C	3 eqoprmed + 1 dozer, crawler, 251-340 HP			PROD = 100%				CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00	HR	35.31			1.00	35.31	35.31
GEN	T15Z6570 E	DOZER, CRAWLER, 300-340HP	1.00	HR	83.26			1.00	83.26	83.26
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	T60Z7910 E	TRUCK, OFF-HWY, WATER, 5000GAL	1.00	HR	40.14			1.00	40.14	40.14
	TOTAL					5.00	142.85	4.00	205.24	348.09
	COFWB59	1 trkdvrhv + 1 water tanker, 5,000 gal			PROD = 100%				CREW HOURS =	12001
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	T50Z7520 E	TRUCK, HWY 55,000 (24,948KG)GVW	1.00	HR	44.22			1.00	44.22	44.22
GEN	T45Z7280 E	TRAILER, WATER TANKER, 5000GAL	1.00	HR	11.83			1.00	11.83	11.83
	TOTAL					1.00	25.43	2.00	56.04	81.47
	COKBB45	1 eqoprmed + 1 asphalt distributor, 3,000 gal			PROD = 100%				CREW HOURS =	13
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00	HR	25.43	1.00	25.43			25.43
GEN	A25Z0580 E	ASPHALT DISTR, 3,000GAL (11355L	1.00	HR	16.10			1.00	16.10	16.10
GEN	T50Z7580 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00	HR	41.71			1.00	41.71	41.71
	TOTAL					2.00	57.34	2.00	57.81	115.15
	COKCB25	8 laborers + 1 asph finisher, w/screed, 10' wide			PROD = 100%				CREW HOURS =	0
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	20.67	7.00	144.69			144.69
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00	HR	31.92	3.00	95.75			95.75
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00	HR	46.53			1.00	46.53	46.53
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					11.00	262.10	3.00	140.92	403.02

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	COKCB25B	8 laborers + 1 roller,vib,tandem,S/P,12Ton,84"w			PROD = 100%				CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00	HR	20.67	7.00	144.69			144.69
MIL	B-EQOPRMEDL	Equip. Operators, Medium	4.00	HR	31.92	4.00	127.66			127.66
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00	HR	74.74			1.00	74.74	74.74
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	2.00	HR	46.53			2.00	93.07	93.07
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00	HR	19.65			1.00	19.65	19.65
	TOTAL					12.00	294.02	4.00	187.45	481.47
	MPLUPLUM2	2 plumbers			PROD = 100%				CREW HOURS =	4015
MIL	B-PLUMBER L	Plumbers	2.00	HR	43.10	2.00	86.20			86.20
	TOTAL					2.00	86.20	0.00	0.00	86.20
	MPLUQ	3 plumber + 1 20 Ton Crane, Hydraulic+Welder			PROD = 100%				CREW HOURS =	20
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	0.40	HR	31.92	0.40	12.77			12.77
MIL	B-PLUMBER A	Plumbers	1.00	HR	36.23	1.00	36.23			36.23
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.10	1.00	43.10			43.10
MIL	B-PLUMBER F	Plumbers	1.00	HR	44.10	1.00	44.10			44.10
MIL	C75Z2160 E	CRANE, HYD, R/T, 20T, 70' BOOM	0.40	HR	44.29			0.40	17.71	17.71
MIL	W35Z8680 E	WELDER, 300AMP, SKID MTD	1.00	HR	1.45			1.00	1.45	1.45
	TOTAL					4.40	156.87	1.40	19.16	176.03
	MPLUQ1	2 plumbers			PROD = 100%				CREW HOURS =	9
MIL	B-PLUMBER L	Plumbers	1.00	HR	43.10	1.00	43.10			43.10
MIL	B-PLUMBER A	Plumbers	1.00	HR	36.23	1.00	36.23			36.23
	TOTAL					2.00	79.33	0.00	0.00	79.33
	SIWRRODM4	4 rodmen			PROD = 100%				CREW HOURS =	5411
MIL	B-RODMAN L	Rodmen, (Reinforcing)	4.00	HR	40.88	4.00	163.51			163.51
	TOTAL					4.00	163.51	0.00	0.00	163.51
	ULABA1	1 laborer + 1 concrete saw, 6.63" depth			PROD = 100%				CREW HOURS =	120
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
GEN	C60Z1970 E	CONC SLAB SAW, 7" (178MM) DEPT	1.00	HR	3.04			1.00	3.04	3.04
	TOTAL					1.00	20.67	1.00	3.04	23.71
	ULABA2	2 laborers + 1 truck, flatbed, 20,000-25,000 GVW			PROD = 100%				CREW HOURS =	5096
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
MIL	B-TRKDVRLTL	Truck Drivers, Light	1.00	HR	23.05	1.00	23.05			23.05
GEN	T40Z6960 E	TRK FLATBED, 8'X 12'(2.4MX 3.7M	1.00	HR	0.72			1.00	0.72	0.72
GEN	T50Z7400 E	TRUCK, HWY 25,000 (11,340KG)GVW	1.00	HR	17.77			1.00	17.77	17.77
	TOTAL					3.00	64.39	2.00	18.50	82.88

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	ULABB1	3 laborers				PROD = 100%			CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	2.00	HR	20.67	2.00	41.34			41.34
	TOTAL					3.00	63.01	0.00	0.00	63.01
	ULABB2	5 laborers				PROD = 100%			CREW HOURS =	22
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
	TOTAL					5.00	104.35	0.00	0.00	104.35
	ULABB23A	2 laborers + 1 drill, rotary, 16" water well				PROD = 100%			CREW HOURS =	366
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	D35Z2900 E	DRILL, ROTARY,16"(406MM)WTR WEL	1.00	HR	102.46			1.00	102.46	102.46
GEN	T50Z7320 E	TRUCK, HWY 8,800 (3,992KG)GVW	1.00	HR	9.53			1.00	9.53	9.53
	TOTAL					3.00	74.25	2.00	111.98	186.24
	ULABB23B	2 laborers + 1 drill, rotary, 16" water well				PROD = 100%			CREW HOURS =	67
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	1.00	HR	20.67	1.00	20.67			20.67
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	D35Z2900 E	DRILL, ROTARY,16"(406MM)WTR WEL	1.00	HR	102.46			1.00	102.46	102.46
GEN	T50Z7320 E	TRUCK, HWY 8,800 (3,992KG)GVW	1.00	HR	9.53			1.00	9.53	9.53
GEN	P60Z5410 E	PUMP, CENTRF, DEWATER, 6" DIA	1.00	HR	22.42			1.00	22.42	22.42
	TOTAL					3.00	74.25	3.00	134.40	208.66
	ULABB9	5 laborers + 1 air compressor, 100 CFM				PROD = 100%			CREW HOURS =	1535
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	4.00	HR	20.67	4.00	82.68			82.68
GEN	A15Z0120 E	AIR COMPRESSOR, 100CFM, 100PSI	1.00	HR	11.30			1.00	11.30	11.30
GEN	A20Z0480 E	AIR HOSE,1.5"X 100'L (38MMX 31M	1.00	HR	0.53			1.00	0.53	0.53
	TOTAL					5.00	104.35	2.00	11.83	116.18
	ULABC7	6 laborers + 1 crane, hydr, trk mtd, 60 ton				PROD = 100%			CREW HOURS =	1716
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00	HR	21.67	1.00	21.67			21.67
MIL	B-LABORER L	Laborers, (Semi-Skilled)	5.00	HR	20.67	5.00	103.35			103.35
MIL	B-CEMTFINRL	Cement Finishers	1.00	HR	31.82	1.00	31.82			31.82
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00	HR	31.92	1.00	31.92			31.92
GEN	XMEZ9520 E	CONC VIBRATOR, 2.5" (63.5MM) DI	2.00	HR	3.70			2.00	7.40	7.40
GEN	B30Z1050 E	BUCKET, CONCRETE, 1.0CY (0.8M3)	1.00	HR	0.47			1.00	0.47	0.47
GEN	C80Z2280 E	CRANE, HYD, TRUCK MTD, 65T	1.00	HR	94.68			1.00	94.68	94.68
	TOTAL					8.00	188.75	4.00	102.54	291.30

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	U0EHB12G	1 eqoprcrn + 1 crane, crawler, drag/clam, 17 ton			PROD = 100%				CREW HOURS =	1147
MIL	B-EQOPRCRNL	Equip. Operators, Crane/Shovel	1.00	HR	33.23	1.00	33.23			33.23
MIL	B-EQOPROILL	Equip. Operators, Oilers	1.00	HR	26.35	1.00	26.35			26.35
GEN	C85Z2370	E DRAGLINE/CLAMSHELL,CRWLR, 0.50C	1.00	HR	38.25			1.00	38.25	38.25
GEN	B25Z1040	E BUCKET, CLAMSHELL, 0.6CY(0.5M3)	1.00	HR	2.48			1.00	2.48	2.48
	TOTAL					2.00	59.59	2.00	40.74	100.32

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-BRKLAYR	Bricklayer	21.25	0.0%	34.8%	3.91	0.00	32.54	HR	02/26/03	32.22	108
MIL	B-BRKLAYRH	Bricklayer (Semi-Skilled)	20.25	0.0%	34.8%	3.91	0.00	31.20	HR	02/26/03	25.32	72
MIL	B-CARPNTER	Carpenter	19.33	0.0%	38.8%	3.62	0.00	30.46	HR	02/26/03	31.68	5774
MIL	B-CEMTFINR	Cement Finisher	20.00	0.0%	29.1%	6.01	0.00	31.82	HR	02/26/03	28.47	1716
MIL	B-EQOPRCRN	Equip. Operator, Crane/Shovel	22.02	0.0%	27.9%	5.08	0.00	33.23	HR	02/26/03	32.62	62262
MIL	B-EQOPRLT	Equip. Operator, Light	19.91	0.0%	27.8%	5.08	0.00	30.53	HR	02/26/03	28.51	7876
MIL	B-EQOPRMED	Equip. Operator, Medium	20.99	0.0%	27.8%	5.08	0.00	31.92	HR	02/26/03	30.27	165405
MIL	B-EQOPROIL	Equip. Operator, Oiler	16.64	0.0%	27.8%	5.08	0.00	26.35	HR	02/26/03	24.69	62262
MIL	B-LABORER	Laborer (Semi-Skilled)	12.37	0.0%	38.8%	3.50	0.00	20.67	HR	02/26/03	23.81	215602
MIL	B-PAINTORD	Painter, Ordinary	15.45	0.0%	33.0%	2.20	0.00	22.74	HR	02/26/03	27.66	3
MIL	B-PLUMBER	Plumber	27.35	0.0%	25.6%	8.75	0.00	43.10	HR	02/26/03	34.82	8109
MIL	B-RODMAN	Rodman (Reinforcing)	20.91	0.0%	46.0%	10.35	0.00	40.88	HR	02/26/03	36.56	21642
MIL	B-TRKDVRHV	Truck Driver, Heavy	15.92	0.0%	33.8%	4.12	0.00	25.43	HR	02/26/03	24.66	64034
MIL	B-TRKDVRLT	Truck Driver, Light	14.14	0.0%	33.9%	4.12	0.00	23.05	HR	02/26/03	23.25	5106
MIL	X-EQOPRHVY	Outside Equip. Operator, Heavy	22.02	0.0%	27.9%	5.08	0.00	33.23	HR	02/26/03	31.93	844
MIL	X-LABORER	Outside Laborer	12.37	0.0%	38.8%	3.50	0.00	20.67	HR	02/26/03	24.50	422
MIL	X-TRKDVRHV	Outside Truck Driver, Heavy	18.35	0.0%	33.9%	4.12	0.00	28.68	HR	02/26/03	24.81	281

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	** TOTAL ** TOTAL RATE	HOURS
GEN	A15Z0120	AIR COMPRESSOR, 100CFM, 100PSI	0.97	0.28	6.34	2.52	0.03	0.00	1.16	11.30 HR	1535
GEN	A15Z0150	AIR COMPRESSOR, 375CFM, 100 PSI	2.95	0.87	7.09	2.49	0.15	0.03	3.51	17.09 HR	1967
GEN	A20Z0400	PAVING BREAKER, 66LB (30KG)	0.27	0.03					0.59	0.90 HR	3933
GEN	A20Z0475	AIR HOSE,1.0"X 100'L (25MMX 31M)	0.11	0.01					0.22	0.34 HR	3933
GEN	A20Z0480	AIR HOSE,1.5"X 100'L (38MMX 31M)	0.17	0.02					0.34	0.53 HR	1535
GEN	A25Z0580	ASPHALT DISTR, 3,000GAL (11355L)	5.59	1.19		1.80			7.52	16.10 HR	13
GEN	A30Z0640	ASPHALT PAVER, 10.0' (3.1M)W,SP	21.05	5.68	8.08	4.34	1.69	0.30	33.60	74.74 HR	3
GEN	B25Z1040	BUCKET, CLAMSHELL, 0.6CY(0.5M3)	1.11	0.26					1.11	2.48 HR	1147
GEN	B30Z1050	BUCKET, CONCRETE, 1.0CY (0.8M3)	0.20	0.05					0.21	0.47 HR	1716
GEN	C60Z1970	CONC SLAB SAW, 7" (178MM) DEPTH	0.26	0.04	1.67	0.67			0.40	3.04 HR	125
GEN	C75Z2160	CRANE, HYD, R/T, 20T, 70' BOOM	13.56	4.48	6.47	2.42	1.17	0.20	15.98	44.29 HR	8
GEN	C80Z2240	CRANE, HYD, TRUCK MTD, 14T	18.70	6.11	10.43	4.64	0.76	0.13	16.50	57.27 HR	5
GEN	C80Z2280	CRANE, HYD, TRUCK MTD, 65T	28.95	10.65	18.25	5.98	0.92	0.16	29.77	94.68 HR	1716
GEN	C85Z2370	DRAGLINE/CLAMSHELL,CRWLR, 0.50CY	12.06	3.37	6.19	2.46			14.16	38.25 HR	1147
GEN	D30Z2840	DRILL, AUGER, 14" DIA, 30' DEEP	2.47	0.65	12.84	5.11	0.06	0.01	3.81	24.95 HR	6
GEN	D35Z2900	DRILL, ROTARY,16"(406MM)WTR WELL	19.57	8.52	30.77	12.24	0.72	0.13	30.22	102.46 HR	433
EP	G15CA006	GRADER,MOTOR, ARTIC, CAT 16-H	23.15	9.33	13.47	5.67	2.22	0.39	27.33	81.57 HR	844
GEN	G15Z3080	GRADER, MOTOR, 135 HP (101KW)	9.86	3.91	6.61	2.79	0.47	0.08	11.59	35.31 HR	22589
GEN	H25Z3160	HYD EXCV, CRAWLER, 24,000LBS,	7.42	2.12	4.12	1.93			8.64	24.24 HR	33
GEN	H25Z3185	HYD EXCV, CRAWLER, 55,000LBS,	17.96	5.51	8.76	4.10			22.39	58.72 HR	61082
GEN	L50Z4640	LOADER/BCK-HOE,WH, 0.80CY(0.6M3)	3.76	1.14	3.13	1.24	0.72	0.13	5.00	15.12 HR	7867
GEN	P60Z5410	PUMP, CENTRF, DEWATER, 6" DIA	1.60	0.37	12.93	5.14			2.37	22.42 HR	67
GEN	R30Z5642	ROLLER, STATIC, 3W, SP, 12.0T	8.46	2.20	3.39	0.99			10.33	25.38 HR	22533
GEN	R30Z5645	ROLLER, STATIC, 9 TIRES, SP,14T	6.05	1.32	4.17	1.22	0.34	0.06	6.49	19.65 HR	3
MAP	R45CA005	ROLLER,VIB,DD,S/P, 6.6T, 56"W,	10.04	2.14	5.31	2.11			16.86	36.46 HR	281
GEN	R45Z5680	ROLLER, VIB, DD, SP 6.0T	12.59	2.68	8.07	3.21			21.14	47.68 HR	11752
GEN	R45Z5690	ROLLER, VIB, DD, SP 12.0T	12.58	2.68	7.27	2.89			21.12	46.53 HR	25020
GEN	R50Z5810	ROLLER, VIB, SD, SP 12.0T	12.32	2.68	10.54	4.19	0.48	0.08	18.88	49.17 HR	8
GEN	R50Z5820	ROLLER, VIB, SD, SP 22.0T	9.90	2.16	10.97	4.37	0.48	0.08	15.18	43.15 HR	22533
GEN	S10Z5930	SCRAPER, SP,ELEV, 22CY (16.8M3)	40.39	9.93	19.03	7.57	5.53	0.97	38.97	122.40 HR	281
GEN	T15Z6440	DOZER, CRAWLER, 76-100HP	6.42	1.84	4.55	2.02			12.69	27.53 HR	56
GEN	T15Z6520	DOZER, CRAWLER, 181-250HP	15.87	7.11	13.65	4.79			24.50	65.93 HR	22085
GEN	T15Z6570	DOZER, CRAWLER, 300-340HP	19.61	8.78	18.20	6.39			30.28	83.26 HR	3
GEN	T15Z6600	DOZER, CRAWLER, 341-440HP	22.90	10.26	23.04	8.09			35.36	99.64 HR	36649
GEN	T40Z6860	REAR DUMP BODY, 16-23.5CY (12.2-	0.93	0.20					1.01	2.14 HR	44139
GEN	T40Z6960	TRK FLATBED, 8'X 12'(2.4MX 3.7M)	0.34	0.07					0.31	0.72 HR	5096
GEN	T40Z7000	TRK FLATBED, 8'X 20'(2.4MX 6.1M)	0.49	0.10					0.45	1.04 HR	10
GEN	T40Z7090	REAR DUMP BODY, 12CY (9.2M3)	0.71	0.15					0.77	1.64 HR	7878
GEN	T45Z7280	TRAILER, WATER TANKER, 5000GAL	2.92	0.98	3.28	0.96	0.45	0.08	3.15	11.83 HR	12001
GEN	T50Z7320	TRUCK, HWY 8,800 (3,992KG)GVW	1.94	0.42	3.47	1.22	0.34	0.06	2.08	9.53 HR	433
GEN	T50Z7400	TRUCK, HWY 25,000 (11,340KG)GVW	3.48	0.87	6.88	2.25	0.70	0.12	3.47	17.77 HR	5106
GEN	T50Z7420	TRUCK, HWY 45,000 (20,412KG)GVW	10.97	2.40	15.62	5.48	0.97	0.17	10.16	45.79 HR	52017
GEN	T50Z7520	TRUCK, HWY 55,000 (24,948KG)GVW	10.24	2.25	15.62	5.48	0.97	0.17	9.49	44.22 HR	12001
GEN	T50Z7580	TRUCK, HWY 45,000 (20,412KG)GVW	10.88	2.42	12.30	4.32	1.43	0.25	10.10	41.71 HR	13
GEN	T60Z7910	TRUCK, OFF-HWY, WATER, 5000GAL	10.38	3.38	9.12	3.63	1.82	0.32	11.48	40.14 HR	3
GEN	T60Z7920	TRUCK, OFF-HWY, WATER, 6000GAL	18.80	6.13	17.21	6.84	3.45	0.61	20.80	73.85 HR	281
GEN	W35Z8680	WELDER, 300AMP, SKID MTD	0.34	0.06	0.52	0.25			0.28	1.45 HR	20
GEN	XMEZ9520	CONC VIBRATOR, 2.5" (63.5MM) DIA	1.04	0.16	0.69	0.48			1.33	3.70 HR	3433
GEN	XMEZ9560	WATER TANK, 500 GAL (1,893L)	0.26	0.14		1.00	0.09	0.01	0.20	1.70 HR	5

No errors detected...

* * * END OF ERROR REPORT * * *

SUMMARY REPORTS SUMMARY PAGE

PROJECT OWNER SUMMARY - Scope....1
PROJECT OWNER SUMMARY - Facility....2
PROJECT INDIRECT SUMMARY - Scope....3
PROJECT INDIRECT SUMMARY - Facility....4
PROJECT DIRECT SUMMARY - Scope....6
PROJECT DIRECT SUMMARY - Facility....7

DETAILED ESTIMATE DETAIL PAGE

09. Construction
01. Low Flow Channel
001. Excavation & Stockpile....1
002. Spread Excess Mat'l on Site....2
02. Reshaping Salt River Riverbed
001. Cut & Stockpile....3
002. Fill....4
003. Spread Excess Mat'l on Site....5
004. Vegetation Grading....6
04. Wetland Features
001. Excavation & Stockpile, 7' Layer....7
002. 2' Lining of Wetland Clay Mat'l....8
003. 2' Layer of Coarser Mat'l on Top....9
004. Spread Excess Mat'l on Site....10
05. Planting
001. Cottonwood/Willow....11
002. Mesquite....12
003. Sonoran Desert....13
004. Wetland Vegetation....14
07. New Water Well....15
08. Grade Control Structure
001. Concrete....16
002. Excavation & Stockpile, U/S....17
003. Backfill & Compaction, U/S....18
005. Excavation & Stockpile, D/S....19
006. Backfill & Compaction, D/S....20
007. Spread Excess Mat'l on Site, D/S....21
008. Riprap, 15' Drop....22
09. Water Distribution System
001. 12" PVC Pipe....23
002. Pump Station at Alma School Rd....24
003. Bridge Crossing....25
004. Pump Station at Country Club Rd....26
005. Bridge Crossing....27
10. Road Crossing for Pipeline Syst
001. Excavation....28
002. Asphalt, 3"....29
003. ABC, 6"....30
004. Backfill & Compaction....31
11. Planting Irrigation System
001. Reach 1 (949 acr-ft)....32

DETAILED ESTIMATE DETAIL PAGE

002. Reach 2 (3,130 acr-ft)....33
003. Reach 3 (362 acr-ft)....34
004. Reach 4 (2,113 acr-ft)....35
005. Reach 5 (4,449 acr-ft)....36
006. Reach 6 (6,097 acr-ft)....37
12. SRPMIC Irrigation Channel T-Junc
001. Triangular IC 4'TW by 2"D....38
002. Triangular IC 4'TW by 2"D....39
003. Triangular IC 4'TW by 2"D....40
004. Triangular IC 4'TW by 2"D....41
005. Triangular IC 4'TW by 2"D....42
006. Triangular IC 4'TW by 2"D....43
007. Triangular IC 4'TW by 2"D....44
008. Triangular IC 4'TW by 2"D....45
009. Triangular IC 4'TW by 2"D....46
15. Debris Removal....47
16. Cultural Mitigation....48
14. Recreation
01. Trail
001. Clear & Grub....49
002. Grading....50
02. Concrete Curb....51
03. Trail Head Signs....52
04. Parking Lot....53
05. Mileage Marker....55
06. Educational Plaque....56
07. Concrete Bench....57
08. Rest Stop
001. Shade Structure....58
002. Picnic Table....59
003. Trash Receptacle....60
004. Bike Stand....61
005. Plaque....62
006. Masonry Wall....63
09. Gate, Double Swing, 6' High....64
10. Guard Post, 6" dia. 8' high....65
11. Street Crossing Signs....66
15. Cost Sharing
01. Museum Restroom....67
02. Habitat Interpretive Center....68
03. Shade Structure....69
04. Parking Lot....70
05. Utilities for Restroom....72
06. Picnic Table....73
07. Trash Receptacle....74
08. Concrete Bench....75
09. Signs....76

BACKUP REPORTS BACKUP PAGE

CREW BACKUP.....1
LABOR BACKUP.....8
EQUIPMENT BACKUP.....9

* * * END TABLE OF CONTENTS * * *

Volume 3 of 4 – Final Feasibility Report Technical Appendices

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Prepared for:

U.S. Army Corps of Engineers
Southwestern Division
Los Angeles District

Prepared in cooperation with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

FINAL FEASIBILITY REPORT
TECHNICAL APPENDICES

VOLUME 3 OF 4

LIST OF TECHNICAL APPENDICES

APPENDIX H BIOLOGICAL ASSESSMENT
APPENDIX I HYDRO-GEOMORPHIC MODEL ASSESSMENT
APPENDIX J ECONOMICS
APPENDIX K REAL ESTATE
APPENDIX L RECREATION

APPENDIX

H

VA SHLY'AY AKIMEL

Salt River Ecosystem Restoration Study

September 2004

BIOLOGICAL ASSESSMENT

TABLE OF CONTENTS

Section		Page
CHAPTER 1.0 – INTRODUCTION		1
CHAPTER 2.0 – THE PROPOSED ACTION – VA SHLY'AY AKIMEL ECOSYSTEM RESTORATION PROJECT		2
2.1	Project Location	2
	2.1.1 Project Area	2
2.2	Purpose and Need	3
2.3	Description of Proposed Action	3
2.4	Other Alternatives Considered	9
2.5	No Action Alternative	10
CHAPTER 3.0 – SPECIES ACCOUNT AND EVALUATION OF EFFECTS		11
3.1	Sensitive Plant Species	12
3.2	Sensitive Wildlife Species	12
	3.2.1 Birds	13
	3.2.2 Mammals	17
	3.2.3 Fish	18
CHAPTER 4.0 – CONCLUSIONS		21
CHAPTER 5.0 – REFERENCES		22

List of Figures

Figure 1.	Va Shly'ay Akimel Environmental Restoration Project Reach and Sub-Area Delineations	4
Figure 2.	Va Shly'ay Akimel Environmental Restoration Project Proposed Action	5

Appendix A

Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area Maricopa County, Arizona

Chapter 1.0
INTRODUCTION

The Endangered Species Act of 1973, as amended, requires that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of such species. The proposed Va Shly'ay Akimel Environmental Restoration project is one such project and therefore must meet those regulations. The Proposed Action involves the restoration of approximately 1500 acres of wetland, cottonwood/willow, mesquite, and Sonoran desert scrub shrub habitat along an approximately 14-mile reach of the Salt River in Maricopa County, Arizona. The Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa are the local sponsors of this restoration effort.

This Biological Assessment (BA) is prepared for the U.S. Fish and Wildlife Service (USFWS), in compliance with the Endangered Species Act of 1973, as amended. This BA is the U.S. Army Corps of Engineers (Corps) evaluation of the potential effects of the Proposed Action on federally listed species or species proposed for listing. The analysis also evaluates the potential effect on designated and proposed critical habitat for those species, should it occur in the project area. This document is used to determine whether a formal consultation or conference is required. Upon receiving an acceptable BA and a request for consultation from a Federal agency, the USFWS enters into consultation with the Federal agency. Should the determination of the effects of the Proposed Action be "may affect but not likely to adversely affect" then informal consultation begins and culminates with a letter of concurrence from the USFWS. Should the determination of the effects of the Proposed Action be "may affect, likely to adversely affect", formal consultation will begin and culminate with a written Biological Opinion (BO), from the USFWS. The BO determines whether the action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat (i.e., a jeopardy opinion), or the action is not likely to jeopardize the continued existence of a listed species or result in adverse modification of critical habitat (i.e., a non-jeopardy opinion). Both forms of opinion shall include reasonable and prudent measures; if any, to be taken that will result in a reduction in the amount or extent of take.

The objective of this document is to provide the USFWS with the necessary information on the anticipated impacts to federally listed species occurring, or with the potential to occur, in the study area. The study area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. Extensive coordination with the USFWS Arizona Ecological Services Field Office occurred as part of the plan formulation for this project resulting in features that will enhance and increase the potential habitat for listed threatened and endangered species.

Chapter 2.0
PROPOSED ACTION – VA SHLY'AY AKIMEL ECOSYSTEM RESTORATION PROJECT

2.1 PROJECT LOCATION

The study area is located in Maricopa County, Arizona, and includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. The study area is approximately 14 miles long, extending along the Salt River between the Pima Freeway and Granite Reef Dam. The study area is approximately 2 miles wide and comprises approximately 17,435 acres.

2.1.1 PROJECT AREA

The land surrounding the project area is made up of a patchwork of jurisdictional and political boundaries between the City of Mesa, unincorporated areas of Maricopa County, and the SRPMIC.

Several gravel-mining operations are located along the Salt River, and processing operations occur along its banks. These facilities are expected to remain within the project area. The river also contains a large groundwater recharge basin in the central portion of the study area, just east of North Gilbert Road.

The land area north of the Salt River is generally within the SRPMIC reservation. Upland areas south of the river are generally within the City's jurisdiction, but islands of unincorporated areas of the County are also present. A clear contrast is evident between the rural and open character of the upland areas north of the river, within the SRPMIC reservation, and the more urbanized area south of the river, within the City of Mesa's sphere of influence.

The SRPMIC consists of 52,600 acres, located 15 miles northeast of the City of Phoenix. The primary land use is 19,000 acres of natural preserve. The secondary land use is agriculture, which supports a variety of crops, including cotton, melons, potatoes, brown onions, and carrots (Salt River Pima-Maricopa Indian Community 2002). The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands. Gravel mining and processing, two closed landfills, and other industrial operations have a significant influence on land use patterns in the western portion of the study area that is located along the north banks of the river. Other land uses throughout the area along the north banks of the river include a shooting range, a recreational vehicle park, private farms, and a commercial golf course.

The west and central portions of the study area south of the river and within the City of Mesa's sphere of influence are largely made up of very low-density rural residential uses to higher-density suburban residential uses. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern

portion of the study area. The south banks of the river are also scattered with gravel mining and processing operations.

The proposed project will not change the usage within the area significantly. The primary usage of the river to date has been the sand and gravel mining operations. While their future plans have not yet been determined, it is assumed they will remain in some capacity. Recreation is not expected to increase significantly due to the SRPMIC's wishes to limit non-Community member's access to Community property. A more in-depth analysis of the effects of the proposed action can be found in the preliminary draft Environmental Impact Statement (EIS), Chapter 5, provided to your office.

2.2 PURPOSE AND NEED

The purpose of the proposed action is to restore ecosystem functions and processes to improve overall ecological health and return the project area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species, and produce a viable, self-sustaining ecosystem that would require only minimal ongoing human intervention. Additionally, the proposed action would provide other incidental benefits, including improving water quality and supply.

Flood control and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological regime. This alteration, as well as increased agricultural development and urbanization of the metropolitan Phoenix area, has resulted in the substantial alteration of the native cottonwood/willow, mesquite bosque, freshwater marsh, and willow woodland habitat types. Without restoration, habitat values in the study area are expected to further decline within the next 50 years. This will decrease the overall habitat value for wildlife and reduce habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, and other sensitive species.

This project is needed to provide an ecological connection between other riparian restoration projects that are currently underway along the Salt River (See Section 2.4.2, "Relationship to Other Projects," of the EIS). Restoration of the area may also provide limited passive recreational opportunities.

2.3 DESCRIPTION OF PROPOSED ACTION

The proposed project consists of restoring approximately 1500 acres of riparian and scrub shrub habitat along a 14-mile reach of the Salt River. The project is divided into nine reaches and is described in the following paragraphs. See Figures 1 and 2.

Figure 1. Va Shly'ay Akimel Environmental Restoration Project Reach and Sub-Area Delineations.

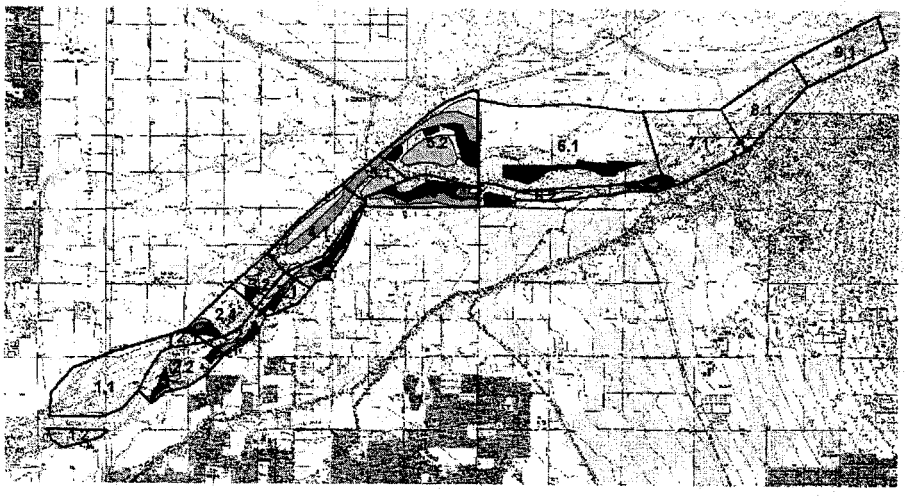
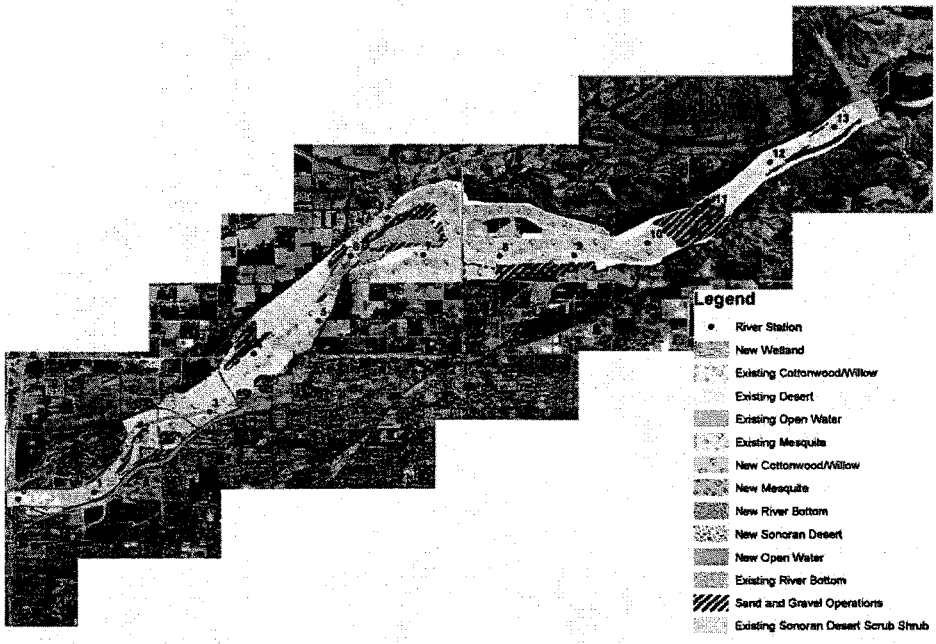


Figure 2. Va Shly'ay Akimel Environmental Restoration Project Proposed Action.



Reach 9 and 8: Reaches 9 and 8 begin at the Granite Reef Dam and continue down to the upstream boundary of the Higley Sand and Gravel plant. These reaches cover an area approximately 2.5 miles long and .5 miles wide. Currently, the habitat is dominated by cottonwood and willow vegetation interspersed with salt cedar (*Tamarisk sp*). Because of the relatively good habitat health, the only activity planned for these reaches is removal of the salt cedar and potential replacement with native species. The habitat is not currently considered viable for any threatened or endangered species (southwestern willow flycatcher), however, if conditions should change before construction begins and it is deemed necessary, surveys will be completed prior to construction. If sensitive species are present, then the invasive species removal will occur outside of the breeding season. To prevent rapid reestablishment of the invasive species, native vegetation will potentially be planted in its place.

Reach 7: The Higley plant is operated by Salt River Sand and Rock, a private company, on land owned by the SRPMIC; it encompasses Reach 7 in its entirety. Because of the disturbance associated with mining operations, no features or enhancements were proposed in this Reach. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. Because the SRPMIC has control of the land being mined, they have direct influence over what areas are mined and how those lands are left once the mining operations are complete. To reduce the affect of the Higley mining operations the quarry operators will be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition in Reach 7, bed load material will continue to flow downstream, maintaining the stability of the channel within Reach 6. At this time, the exact locations of future mining operations are unknown but coordination between the Corps, the SRPMIC and the Sand and Gravel mining operators is ongoing.

Reach 6: Reach 6 covers the area immediately downstream of the Higley plant down to Gilbert Road. Reach 6 covers an area approximately 2.5 miles long and 1 mile wide. Because this reach deals with three distinct feature sets, it has been divided into three sub-reaches. Area 6.1 is on the north side of the river, and stretches the entire length of Reach 6. Area 6.2 is on the south side of the river from Gilbert Road upstream to just below Va Vista Road. Area 6.3 is also on the south side of the river and is from Va Vista Road upstream to the Salt River Project water diversion point.

Large areas of cottonwood and willow (CW) and mesquite (MS) will be established in Area 6.1. The CW is located south of the Groundwater Recharge Underground Storage Project (GRUSP) site and will be irrigated using surface water from the Hennessey Drain. The MS is located on the north bank, immediately outside of the active channel, outside of the 10-year flood plain and will be irrigated using ground water from a new well. In both areas the water will be distributed using a flood irrigation method or the Surface Braided Irrigation Network (SBIN). Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. It is assumed that this infiltrated water is sufficient to maintain the vegetation; these assumptions will be verified during the Preliminary Engineering Design phase.

In Area 6.2, located on the south bank of the river, two areas of CW will be planted; one in an abandoned quarry depression directly east of Gilbert Road and within the 5-year flood plain, and a second narrow strip along the southern edge of the main channel. Both areas will be irrigated using surface water and storm water when available. Flood irrigation is the preferred method of irrigation.

Area 6.3 will have a wetland feature; it will be constructed on the riverbed near the existing Hennessey drain outlet. A berm of coarse rock will be constructed on the upstream side of the wetland. This will provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland will be clay lined to maintain the surface water level and allow for vegetation growth. The wetland will be flanked by a relatively large CW stand to the east, taking advantage of the saturated soil conditions, and will be irrigated using surface water from the Hennessy drain and SBIN or flood irrigation.

Reach 5: Reach 5 begins at Gilbert Road and ends downstream at approximately Horne Road. This reach is approximately 2 miles long and .5 to .75 miles wide, depending upon location. Reach 5 is also divided into three different sub-areas due to land features and water sources present in the area. Area 5.1 covers the area north of the river from Horne Road upstream to the downstream edge of the Gilbert Quarry pit. Area 5.2 encompasses the area including and surrounding the Gilbert Quarry pit found north of the river. And finally, Area 5.3 covers the entire southern portion of Reach 5 from Gilbert Road downstream to Horne Road.

In Area 5.1, the channel will be reshaped and converted to new river bottom. A wetland feature at the Evergreen drain outlet will be established, as will CW. The CW will be irrigated using a new ground water well, and the wetland will be supported by run off from the Evergreen drain outlet.

In Area 5.2, the Gilbert Quarry pit will be reshaped and converted to new river bottom. CW and MS, and a small pocket of Sonoran desert scrub shrub (SD) will be located on the overbank area. The MS and SD will be irrigated using groundwater from the new well. The CW will be irrigated using surface water diverted from an irrigation canal. The water will be distributed using SBIN.

A grade control structure will be placed in Area 5.2, in the main channel at the center point of the old Gilbert quarry. This structure would help protect the Gilbert Road Bridge from head cutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed, approximately 1500 feet, and be designed to the estimated scour depth.

In Area 5.3, located along the south bank, CW will be established adjacent to a newly established small stand of MS. Surface water and storm water will be used to irrigate these areas. Irrigation of the CW and MS will be done by SBIN. The downstream portion of this area will also be reshaped and converted to new river bottom.

Reach 4: Reach 4 begins at Horne Road and continues downstream to approximately Center Street, or the downstream end of the Tri-City landfill. This Reach is roughly 1.5 miles long and .5 miles wide. Reach 4 is divided into two sub-reaches due to the characteristics found within the sub-areas.

Area 4.1 covers the Tri-City landfill. This area is tentatively planned for a SRPMIC run nursery operation, if the land is found suitable; therefore, no vegetation establishment is planned on the landfill land surface. A narrow strip of CW will be established, however, along the north bank, at the edge of the main channel. The area will be irrigated using surface and storm water and the SBIN.

Area 4.2, along the south bank, will support CW, MS and a large wetland feature. Two south bank surface water outlets will supply water to the SBIN used to irrigate the vegetation. The western outlet will support the wetland feature as well as surrounding CW and MS. Area 4.2 is relatively protected from the main channel so flood damages to the channel and the irrigation system are expected to occur less frequently.

Reach 3: Reach 3 is relatively small covering an area approximately .5 miles long and .5 miles wide. It too, is divided into two sub-areas to address the features found on the northern half of the river and the southern half of the river. Area 3.1 covers the southern half and will support a CW stand. A channel will be constructed to drain Area 4.2 to supply water to the CW vegetation of Area 3.1. This water will be dispersed using the SBIN. A sand and gravel pit restricts Area 3.2 and therefore no new features are planned.

Reach 2: Reach 2 is approximately 2 miles long and 1 mile wide. The upstream end of Reach 2 is marked by the Beeline Highway (Arizona 87); the downstream end of Reach 2 is just downstream of Longmore Road. Reach 2 is divided into four sub-areas to address the individual features planned for this area. Area 2.1 is a small area immediately downstream of Alma School Road on the north side of the river. Area 2.2 covers an area beginning at Alma School Road and continuing downstream to just below Longmore Road; it encompasses the area within and south of the main channel. Area 2.3 covers the southern half of the river beginning just downstream of Country Club Road and continuing downstream to approximately Alma School Road. And finally, Area 2.4 covers the same area as Area 2.3, but on the northern half of the river.

Area 2.1 is the smallest of the sub-areas and the only area where new features are not planned. This sub-area currently supports SD that surrounds an existing sand and gravel mining pit. Given the small size of this sub-area, the existing habitat and the restrictions due to the mining operations, establishing new vegetation was not justified.

Area 2.2 will support three new wetland features at Alma School Road downstream of and within the old quarry. The small wetland, on the western end of this Area, will be flanked by CW to the north. The larger wetland, to the east, will be surrounded by a CW stand. The CW will be irrigated using SBIN. A small area, south of the wetlands, will be reshaped and converted to new river bottom.

Area 2.3, along the south bank, will support two wetland features, and small areas of CW and MS. One small stand of CW will surround the wetland; a second larger stand will start in the eastern edge of Area 2.3 and extend into Area 2.2. The wetland will be constructed near the Country Club Storm drain on the existing river bottom and will be constructed to withstand storm water runoff.

Area 2.4 will support a wetland feature surrounded by CW to the west, south, and east. These features will be supported by surface water outlets, and irrigated using a SBIN. Additional water may be supplied by the golf course located north of the Salt River, if it is of sufficient quality.

Reach 1: Finally, Reach 1 begins downstream of Alma School Road and continues downstream to the terminus of the project at the Pima Freeway and Highway 202 Loop interchange. Like the others, Reach 1 is divided into two sub-areas to better identify the features. Area 1.1 covers the majority of Reach 1 extending from the 101 and 202 Loop interchange up to just below Alma School Road on the north side of the river and to Longmore Road on the south side of the river. Area 1.2 represents the percolation ponds owned by the City of Mesa to the south of the hard banking, immediately upstream of the 101 and 202 interchange on the south side of the river.

Area 1.1 will support four wetland features, and three CW stands. One wetland will continue from Area 2.2. A second smaller wetland will be located to the north, within the main channel and will connect with a CW stand to the north. The remaining two wetland features will be created to the west of the existing quarry, upstream of the hardbank. A CW stand will be established within the main channel, at the far west end of Area 1.1. Finally, a small CW stand will be established to the north of the existing quarry. Invasive species, primarily salt cedar, will be removed from this area if deemed necessary, to promote the establishment of native species.

The percolation ponds found immediately outside of the southern bank in Area 1.2, will be planted with CW. This area will be supported using the existing irrigation infrastructure.

2.4 OTHER ALTERNATIVES CONSIDERED

The Corps and local sponsors (SRPMIC and the City of Mesa) developed an initial array of 15 alternatives during the alternatives formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water source, infrastructure). Alternatives were initially developed based on the Corps' federal planning objectives for water resource projects, specific planning objectives developed for the Va Shly'ay Akimel Ecosystem Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local and regional agencies. Details can be found in Chapter 3.3 of the EIS.

Following formulation and refinement of the project alternatives, the alternatives were ranked and screened based on associated habitat benefits and implementation costs. The Hydrogeomorphic (HGM) wetland assessment method was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The HGM method assesses and quantifies the functional values of existing wetland habitat types (e.g., water storage, plant community characteristics) and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives.

Results of the HGM assessment were incorporated into the Corps' standard cost evaluation analysis (ICA) to identify the alternatives that provided the highest habitat benefits per unit cost. The four highest-ranking alternatives were then evaluated in greater detail. A complete description of the alternatives and HGM assessment is provided in the EIS. The local sponsor's then determined that the above-described proposed action was considered their preferred alternative.

2.5 NO ACTION ALTERNATIVE

Under the No-Action Alternative, the Corps would take no action to restore the ecosystem and wildlife habitat within the study area. Plans with potential incidental benefits to improve water quality and water supply also would not be provided by the Corps. Although it is possible that local agencies would implement limited improvements, restoration efforts would not occur on the scale of the proposed project.

Chapter 3.0
SPECIES ACCOUNT and EVALUATION OF EFFECTS

Viable habitat for most species of concern is limited to an area immediately downstream of the Granite Reef Dam in Reach 9 and near the Pima Freeway and Highway 202 Loop interchange in Reach 1. The preferred alternative recommends exotic species removal in both Reaches 9 and 1, with potential replanting of native species to prevent reoccurrence; at the downstream end, new cottonwood/willow will be established on the eastern end of the existing habitat.

The project area has the potential to support the following list of federally threatened, endangered, or proposed species. This list was provided by the USFWS through the Arizona Ecological Services website (http://arizonaes.fws.gov).

Plant Species

Arizona agave (*Agave arizonica*) - endangered
Arizona cliffrose (*Purshia subintegra*) - endangered

Wildlife Species

Bald eagle (*Halieaetus leucocephalus*) – threatened
Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) – endangered
California Brown Pelican (*Pelecanus occidentalis californicus*) – endangered
Mexican spotted owl (*Strix occidentalis lucida*) – threatened
Southwestern willow flycatcher (*Empidonax traillii extimus*) – endangered
Yuma clapper rail (*Rallus longirostris yumanensis*) – endangered
Yellow-billed cuckoo (*Coccyzus americanus*) – candidate/wildlife species of concern
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – endangered
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – endangered
Desert pupfish (*Cyprinodon macularius*) – endangered
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – endangered
Razorback sucker (*Xyrauchen texanus*) – endangered
Gila chub (*Gila intermedia*) – proposed endangered

The assessment of impacts to species within the study area was performed by background literature searches, coordination with resource agencies, and completion of site evaluations and in some cases, wildlife surveys. Literature used in this analysis includes: *Birds of Phoenix and Maricopa County, Arizona; Clearing of phreatophytic vegetation from the Salt and Gila Rivers, Ninety-first Avenue to Gillespie Dam, Maricopa County, Arizona: Draft environmental assessment; Salt-Gila River baseline ecological characterization; Wildlife of special concern in Arizona; Clapper rail (Rallus longirostris) In: The birds of North America*; *Coccyzus americanus*; *Glaucidium brasilianum*; *Bats of the United States; Amphibians and reptiles of western North America;* and *Threatened native wildlife in Arizona.*

3.1 SENSITIVE PLANT SPECIES

Sensitive plants include those species that are listed by Federal or state resource agencies. Species that are proposed to be listed by the USFWS are assessed in a manner similar to actual listed species by the USFWS; however, in the case of proposed species, recommendations of the USFWS are advisory rather than mandatory. There are two listed plant species of concern that occur within Maricopa County: Arizona agave (*Agave arizonica*) and Arizona cliffrose (*Purshia subintegra*).

3.1.1 Arizona agave – No effect

Arizona agave has bright green leaves with dark mahogany margins and yellow flowers. This species of agave is found in the transition zone between oak-juniper woodland and mountain mahogany-oak scrub between 3000 and 6000 feet in elevation. It is usually found on steep, rocky slopes in the New River Mountains and Sierra Ancha. It is possibly found in the Mazatal Mountains and can occur on drainage bottoms or relatively gentle slopes or saddles. This species has experienced a decline in habitat due to herbivory of flowering stalks and historic overuse by livestock, feral burros, and wildlife (http://arizonaes.fws.gov).

The terrain that surrounds the project area is relatively flat with no significant or mountainous landforms in the near vicinity. The project elevation is roughly 1200 feet with no oak-juniper woodland or mountain mahogany-oak scrub present. The required habitat does not exist for this species within the project area. Therefore, the proposed project will have no effect on the Arizona agave.

3.1.2 Arizona cliffrose – No effect

The Arizona cliffrose is an evergreen shrub approximately 5 feet in height. The bark is pale gray and shreddy and the flowers have 5 white or yellow petals. It is found only on Teritiary limestone lakebed deposits at elevations below 4000 feet. The known site within Maricopa County is at Horseshoe Lake, although it may have the potential to occur at other sites where Teritiary limestone lakebed deposits occur. Threats to this species include its localized habitat, urbanization, mining, overuse by cattle and burros and off-road vehicle traffic (http://arizonaes.fws.gov).

The project site occurs within a river channel bed and does not support the necessary soil substrate or habitat for this species. Therefore, the proposed project will have no effect on the Arizona cliffrose.

3.2 SENSITIVE WILDLIFE SPECIES

Sensitive wildlife species include those federally or state-listed threatened or endangered species, those species proposed for Federal or state listing, and Federal candidate species. There are thirteen federally listed species that occur within Maricopa County: bald eagle

(*Halieaetus leucocephalus*), cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*), California Brown Pelican (*Pelecanus occidentalis californicus*), Mexican spotted owl (*Strix occidentalis lucida*), southwestern willow flycatcher (*Empidonax traillii extimus*), Yuma clapper rail (*Rallus longirostris yumanensis*), the proposed yellow-billed cuckoo (*Coccyzus americanus*), lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*), Sonoran pronghorn (*Antilocapra Americana sonoriensis*), desert pupfish (*Cyprinodon macularius*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), razorback sucker (*Xyrauchen texanus*), and the proposed Gila chub (*Gila intermedia*).

3.2.1 Birds

3.2.1.1 Bald eagle – May affect, not likely to adversely affect

The bald eagle was reclassified from endangered to threatened in July 1995 and in 1999 was proposed to be removed from the list of Endangered and Threatened Wildlife in the lower 48 states of the U.S. Although the nesting populations are increasing throughout the U.S., the bald eagle is still threatened by habitat loss, human encroachment on nesting sites, reduction in native fish species, illegal shooting, and heavy metals (http://arizonaes.fws.gov). Bald eagles nest in large trees near lakes and streams, and hunt for waterfowl and fish in wetlands and along rivers and lakes. They also feed on small mammals and carrion. Bald eagles have been reported nesting along the Salt River east of Phoenix since the 1930s (Witzeman et al. 1997). Although they do not nest in the project study area due to lack of suitable habitat, they occur in the area as winter visitors and migrants (Benham-Blair Associates 1980) and have been observed foraging along the rivers near the project study area (CH2M HILL et al. 1997).

The open water marsh near the project study area (immediately downstream of the Pima Freeway and Highway 202 Loop interchange) may be suitable foraging habitat for bald eagles. However, the area of open water currently found at the furthest downstream portion of the study area is very small in size, approximately 1 acre, and linear in shape (pers. comm., A. Gibbons, Jones & Stokes). A second open water area further upstream, but still within Reach 1 of the proposed project is approximately seven acres in size during the wet season. Due to the relatively small size and likely very low fish populations found within the open water currently on-site these areas are not likely a significant source of foraging habitat, considering the higher quality habitat further downstream.

In the furthest downstream area of existing open water, exotic vegetation species will be removed and potentially replaced with native vegetation creating insignificant effects to the eagle. Other construction activity includes new wetlands approximately .75 miles upstream. Standard construction practices will be utilized to minimize siltation, turbidity, and release of contaminants within surface waters. Multiple wetlands within the greater project area could increase the overall foraging habitat of this species by approximately 200 acres, providing a beneficial effect. Due to the temporary disturbance associated with construction near the existing open water, and the significant increase in wetland

features, the proposed project may affect but is not likely to adversely affect any potentially existing bald eagles.

3.2.1.2 Cactus ferruginous pygmy-owl – No effect

The cactus ferruginous pygmy-owl is a small reddish-brown owl with a cream-colored belly streaked with reddish-brown. The pygmy-owl's diet includes birds, lizards, insects, and small mammals. It is non-migratory throughout its range. Historically, the cactus ferruginous pygmy-owl occurred as far north as the confluence of the Salt and Verde Rivers but recent observations have been limited to Pima and Pinal Counties. This species occurs in riverbottom woodlands, and palo verde cacti-mixed scrub associations of the Sonoran desert. In southern Arizona, the pygmy-owl is currently found primarily in Sonoran desert scrub vegetation with some locations in riparian drainages and semi-desert grassland vegetation communities. It will nest in saguaro cacti or tree cavities below 4000 feet in elevation (http://arizonaes.fws.gov). Pygmy-owls have declined in part because of urban development, reduction of suitable habitat, and competition from other cavity-nesting birds (Arizona Game and Fish Department 1996, Arizona Game and Fish Department 2001a).

The proposed project will establish approximately 24 acres of new scrub, 380 acres of new mesquite and 880 acres of new cottonwood/willow habitat; significantly increasing the suitable habitat for this species. Because the project site is currently limited to creosote dominated scrub shrub, with only 4 acres of existing mesquite, and little mature cottonwood, and because no observations of cactus ferruginous pygmy-owls have been recently recorded within 50 miles of the project area (CH2M HILL et al. 1997, Witzeman et al. 1997), it has been determined that this project will have no effect on the cactus ferruginous pygmy-owl.

3.2.1.3 California brown pelican – No effect

The California brown pelican is a large bird with a white head and neck, often washed with yellow. It has a grayish-brown body with a blackish belly. During the breeding season, the hindneck is dark chestnut and a yellow patch appears at the base of the foreneck. These birds forage by diving for fish in larger bodies of water. It is considered an uncommon transient in Arizona on many Arizona lakes and rivers. The pelican has recently been observed on Tempe Town Lake; and there are tentative plans to conduct a relocation effort to move the Tempe Town Lake pelicans back to habitat more suitable for their needs (pers. comm., M. Martinez, USFWS).

During a recent Yuma clapper rail survey conducted in May 2003, two pelicans were observed flying over the project sight. However, the pelicans were not seen using the habitat and are not expected to nest in the area. Because the California brown pelican was not seen using the project site and is known to use Tempe Town Lake, an area approximately 4 miles from the project site, it has been determined that the proposed action will have no effect on this species.

3.2.1.4 Mexican spotted owl – No effect

The Mexican spotted owl is a medium sized owl with large dark eyes and no ear tufts. Its plumage is brown with numerous white spots and posterior underparts have short, horizontal bars or spots. It generally nests in older forests of mixed conifer or ponderosa pine/gambel oak type, in canyons. In forested habitat, uneven-aged stands with a high canopy closure, high tree density, a sloped terrain and cool microclimates appear to be of importance. The spotted owl's nests are found in live trees, snags, and on canyon walls between 4100 and 9000 feet (http://arizonaes.fws.gov). Currently, the Mexican spotted owl is patchily distributed in Arizona and occurs only in the eastern portion of the state.

The proposed project is found in the arid, western portion of Arizona and is completely void of the required habitat; therefore the project will have no effect on the Mexican spotted owl.

3.2.1.5 Southwestern willow flycatcher – No effect

The southwestern willow flycatcher is a small migratory bird with a grayish-green back and wings, a white throat, a light gray-olive breast, and a pale yellowish belly. Two wingbars are visible. It prefers nesting in dense willow riparian habitats and is also found in areas of saltcedar in the Sonoran Life Zone (e.g., the lower Big Sandy River, lower Santa Maria River, Bill Williams Delta, upper Gila River, Grand Canyon, and middle Salt River). Nests are found in thickets of trees and shrubs about 13-23 feet in height, among dense and homogenous foliage at elevations below 8500 feet. Historically, the southwestern willow flycatcher nested along the Salt, Gila, and Agua Fria Rivers (CH2M HILL et al. 1997). Currently, there are just over 900 breeding pairs documented in the Southwest and recent statewide surveys indicate that fewer than five nesting pairs occupy most sites. Individuals in Arizona are found in the middle Salt River and upper Verde River, among sites along other rivers (http://arizonaes.fws.gov) and are currently considered an uncommon transient in Maricopa County, with only a few historic summer records (Witzeman et al. 1997). The flycatcher has declined for a variety of reasons, including habitat loss and fragmentation resulting from flood control projects, development, and intensive grazing. Brown-headed cowbird nest parasitism may also have contributed to the species' decline (Arizona Game and Fish Department 1996).

The project area has approximately 130 acres classified as willow, cottonwood/willow, and willow saltcedar habitat. However, these acres are sparse, patchy and the cottonwoods are almost exclusively a single row of trees (pers. comm., A. Gibbons, Jones & Stokes). To date, focused surveys have not been completed due to lack of suitable habitat (pers. comm., A. Gibbons, Jones & Stokes; T. Corman, AGFD). Prior to construction, if suitable habitat has developed in any project area scheduled for disturbance (likely in the form of salt cedar thickets), the Corps will re-evaluate, in coordination with the USFWS, and conduct surveys if necessary.

The proposed project will increase the cottonwood/willow habitat by approximately 880 acres, creating a significant positive benefit for this species by creating habitat for potential future populations. Because of the current lack of suitable habitat, and proposed

increase in cottonwood/willow, the proposed project will have no effect on the southwestern willow flycatcher.

3.2.1.6 Yuma clapper rail – No effect

The Yuma clapper rail is a long marsh bird with long legs and a short tail. Its bill is long, slender, and curved downward slightly. It is mottled brown on a gray background; its flank and underside are dark gray with narrow vertical white stripes (http://arizonaes.fws.gov). This inland clapper rail occurs in cattail, sedges, and bulrush marshes along the Colorado River, the lower Gila and Salt Rivers below the Verde/Salt River confluence, and Pichacho Reservoir (Arizona Game and Fish Department 1996, Eddelman and Conway 1998) and is often associated with dense riparian and marsh vegetation. This species has declined because of the loss and fragmentation of river marshes. Toxic levels of heavy metals, such as selenium, could also have contributed to the species' decline (Arizona Game and Fish Department 1996). Its current distribution is along the Colorado River, from Lake Mead to Mexico; on the Gila and Salt rivers upstream to the area of the Verde confluence; at Picacho Reservoir; and on the Tonto Creek arm of Roosevelt Lake (http://arizonaes.fws.gov). The Yuma clapper rail is known to occur as a rare and local summer resident in cattail marshes in the Salt River south and west of Phoenix (Witzeman et al. 1997).

There is sufficient marshland habitat for this species to occur within the downstream portion of the project study area, therefore, a USFWS protocol level survey was conducted in May 2003. A copy of the survey report can be found in Appendix A of this document. Surveys resulted in no indication of Yuma clapper rails found within the project area and vicinity. Therefore, the proposed action will have no effect.

3.2.1.7 Yellow-billed cuckoo – No effect

The yellow-billed cuckoo is a medium-sized bird with a slender, long-tailed profile. It has a fairly stout and slightly down-curved bill, which is black with yellow on the basal half of the lower mandible. The bird is grayish-brown above and white below with rufous primary flight feathers. The tail feathers are boldly patterned with black and white below. In Arizona, the yellow-billed cuckoo is found locally in streamside cottonwood and willow groves, and prefers to nest in willow or mesquite thickets (Arizona Game and Fish Department 2001b). Historically, this species was widespread and locally common in Arizona; currently, based on preliminary results of a statewide survey, one hundred sixty-eight pairs and 80 individuals were located in Arizona in 1999 (http://arizonaes.fws.gov). The primary reason for population decline is the loss, degradation, and fragmentation of riparian habitat.

Prior to 1998, approximately thirteen cuckoo territories were found along the Salt River, although none were located within this proposed project site. Additional surveys have been completed by state agencies since 1998. Results showed one pair of cuckoos between upstream of the Granite Reef Dam and the confluence of the Salt and Gila rivers (pers. comm., B. Wilson, Jones & Stokes). Consequently, the yellow-billed cuckoo is considered an uncommon local summer resident (Witzeman et al. 1997). Although

candidate species do not benefit from the same protection as listed species, their current rarity warrants protection. Due to lack of suitable habitat, and no findings within the project area during recent surveys, it is determined that the proposed project will have no effect on the yellow-billed cuckoo.

3.2.2 Mammals

3.2.2.1 Lesser long-nosed bat – No effect

The lesser long-nosed bat, previously known as Sanborn's long-nosed bat, is medium-sized with yellowish-brown or pale gray above and cinnamon-brown below. It has a slender elongated nose with a small nose-leaf on the tip, and a minute tail. It is found mainly in desert scrub habitat, and roosts in caves, abandoned mines, and unoccupied buildings at the base of mountains where agave, saguaro, yucca, and organ pipe cacti are present (http://arizonaes.fws.gov; Harvey et al. 1999). It forages at night on nectar, pollen, and fruit of panicultate agaves and columnar cacti. Considerable evidence exists for the interdependence of *Leptonycteris* bat species and certain agaves and cacti (http://arizonaes.fws.gov). The lesser long-nosed bat population has declined for reasons that include: human disturbance at breeding and roosting sites, habitat loss, and excessive harvest of certain agaves and cacti; however, the population appears stable (Arizona Game and Fish Department 1996).

This bat is a summer resident (April – September) of central and southeastern Arizona. Although there are records for this species from the Phoenix area, the project area does not support roosting sites, nor does it support the necessary foraging vegetative species. Desert areas within the project site are dominated by creosote bush with scattered white bursage and other small shrubs, and limited areas of creosote bush, saguaro, yellow paloverde, cholla and barrel cactus. Because the proposed project site does not support the necessary foraging species or roosting sites for the lesser long-nosed bat, the project will have no effect.

3.2.2.2 Sonoran pronghorn – No effect

The Sonoran pronghorn are long-legged, small-bodied artiodactyls (hoofed animals with an even number of toes on each foot). Their upper parts are tan; the underpart, rump and two bands across the neck are white. Both sexes have horns, although they are larger in males. All Sonoran pronghorn populations occur in Sonoran desert scrub vegetation communities; creosote and white bursage comprise the major vegetation in the Lower Colorado River Valley subdivision. Plant species along major watercourses include ironwood, blue palo verde, and mesquite; species in the Arizona Upland include foothill palo verde, catclaw acacia, chain fruit cholla, teddy bear cholla, buckhorn cholla and staghorn cholla. Typical habitat ranges between 2,000 and 4,000 feet in elevation within broad intermountain alluvial valleys separated by block-faulted mountain and surface volcanics (http://arizonaea.fws.gov). Historical ranges within southwest Arizona included south of the Bill Williams River and east to the Santa Cruz River. Currently, an extant population exists in southwestern Arizona. The primary cause of pronghorn

population decline includes barriers to movement caused by roads, canals, and fences, and conversion of habitat to other uses (http://arizonaes.fws.gov).

The proposed project study site is at approximately 1200 feet in elevation and is surrounded by development and urban areas to the south. Therefore, the project site does not contain suitable habitat and will have no effect on the Sonoran pronghorn.

3.2.3 Fish

3.2.3.1 Desert pupfish – No effect

The desert pupfish is a small fish with a smoothly rounded body shape and narrow, vertical dark bars on its sides. Breeding males are blue on the tops and sides, and have yellow fins. Females and juveniles are tan to olive colored on their backs and silvery on their sides. These fish are found in shallow water of desert springs, small streams, and marshes below 5,000 feet in elevation. The pupfish also tolerates high salinities and high water temperatures. This species was once common in desert springs, marshes, backwaters, and tributaries of several large rivers in Arizona but is currently restricted to one natural population in Quitobaquito Spring Pond in Pima County due to the introduction of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, stream channelization, and habitat modification (http://arizonaes.fws.gov). Reintroductions have been made in Maricopa County in the past but were unsuccessful. Additional reintroductions were made northwest of Lake Pleasant and others are planned (pers. comm., J. Voeltz, AGFD). While the pupfish was found in the Salt River 50 years ago, it would be highly unlikely for it to be within the project area due to predatory species (pers. comm., D. Duncan, USFWS) and limited habitat.

The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). No populations of desert pupfish were found. The project proposes to remove exotic vegetation from the Granite Reef Dam and the Pima Freeway/Highway 202 Loop interchange areas. Native vegetation will be planted, if necessary, in areas where exotics were removed to improve the likelihood of native vegetation establishment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat.

Because no fish were found above Granite Reef Dam during recent surveys, no other population is known to allow for immigration into the project site, and the presence of predatory species would make their survival highly unlikely, the proposed project will have no effect on the desert pupfish.

3.2.3.2 Gila topminnow – No effect

The Gila topminnow is a small guppy-like, live-bearing fish that lacks dark spots on its fins. It occurs in small streams, springs, and cienegas below 4500 feet in elevation primarily in shallow areas with aquatic vegetation and debris for cover. This species can also tolerate relatively high water temperatures and low dissolved oxygen. Historically it was one of the most common fish found throughout the Gila River drainage in Arizona. However, due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification, it is restricted to the Santa Cruz River system and other small streams in several counties, including Maricopa (http://arizonaes.fws.gov).

The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). These surveys have come back negative for the Gila topminnow. While lower quality potential habitat exists immediately below the Granite Reef Dam and at the Pima Freeway and Highway 202 interchange, and it could be argued that the Gila topminnow could find its way into the project area if there was an overtopping of Granite Reef Dam, the negative surveys indicate that there currently is not a population source upstream. Therefore, we can assume this species is not present.

The project proposes only to remove exotic vegetation from the Granite Reef Dam area and the Pima Freeway/Highway 202 Loop interchange area and replace it with native vegetation, if necessary, to ensure native species recruitment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because no Gila topminnows have been discovered in recent surveys conducted upstream of the Granite Reef Dam, and because overtopping of the dam is the only reasonable way for this species to enter into the project area, we can conclude that the fish is not present in the proposed project area and therefore the project will have no effect.

3.2.3.3 Razorback sucker – No effect

The razorback sucker has a head that is flattened on top with a stout body with olive-brown above to yellowish on the belly. A long, high, sharp-edged keel-like hum is found behind the head. This fish is found in backwaters, flooded bottomlands, pools, side channels and other slower moving habitats below 6000 feet in elevation. Historically the sucker was found near strong currents in all major rivers and larger streams in the Colorado River Basin. Currently, in the Lower Basin, populations are isolated to Lakes Mohave, Mead, and the lower Colorado River below Havasu. Alteration of river conditions and loss of habitat caused by dam construction, irrigation dewatering and channelization, as well as the introduction of exotic fish, are all responsible for this species decline (http://arizonaes.fws.gov). Several areas of critical habitat have been designated but none are found within Maricopa County.

Reintroductions have been done in the Salt and Verde rivers with ongoing introductions near Childs, AZ (pers. comm., J. Voeltz, AGFD). Because of the recent introductions and the potential for suitable habitat for the razorback sucker, this species could survive within the proposed project area, if it where to migrate there. It is likely that the only way the razorback sucker could be found within the project area is if the fish were found above the Granite Reef Dam and if the dam overtopped, carrying the razorback within the flood flows. The Arizona Department of Fish and Game has conducted regular fish surveys from the Granite Reef Dam upstream to the Stewart Mountain Dam, with the most recent complete survey done in March 2003 and spot surveys completed as recently as October 2003 (pers. comm., S. Bryan, AGFD). These surveys came back negative for the razorback sucker. There is therefore no probable source of fish to enter into the project area.

The project proposes only to remove exotic vegetation from the Granite Reef Dam area and the Pima Freeway/Highway 202 Loop interchange. Native vegetation will be planted in these areas, if necessary, to ensure native species recruitment. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because recent surveys showed there are no razorback suckers in the Salt River above the Granite Reef Dam, eliminating the population sources for immigration, the proposed project will have no effect.

3.2.3.4 Gila chub – No jeopardy

The Gila chub is a small-finned, deep-bodied chubby member of the minnow family. It is dark colored with diffuse lateral bands that are rarely present. They are commonly found in pools, springs, cienegas, smaller streams, and artificial impoundments between 2,000 and 3,500 feet in elevation. Common riparian plants associated with these populations include willow, tamarisk, cottonwoods, seep-willow, and ash. Historically, the chub's range likely included suitable habitat throughout the entire Gila River basin, except the Salt River drainage above Roosevelt Lake. Currently, they have been recorded in approximately 30 rivers, streams, and spring-fed tributaries throughout the Gila River basin, although none have been recorded in Maricopa County. Roughly 90% of suitable habitat has been degraded or destroyed due to extensive grazing, mining operations, increased recreation usage and the introduction of exotic species (http://arizonaes.fws.gov). Proposed critical habitat sites have been identified, but none exist within Maricopa County.

The Gila chub is currently only proposed for listing and therefore, an effect determination is not required. Instead, a jeopardy or no jeopardy determination is required. Because the Gila chub has not been recorded in Maricopa County within recent surveys and its lowest habitat elevation range is approximately 800 feet above the elevation of the proposed project, it can be determined that the proposed project will not jeopardize the continued existence of this species.

Chapter 4.0
CONCLUSIONS

Extensive coordination occurred with the USFWS throughout the plan formulation, HGM habitat analysis, and species survey and BA phases, as they relate to the Va Shly' ay Akimel Ecosystem Restoration project. Coordination also occurred with Arizona Game and Fish Department. As a result, project features that would most likely increase and improve habitat conditions for a variety of species, including those listed as federally endangered or threatened, were given greatest consideration. Given the rarity of riparian ecosystems within the arid southwest, the proposed project attempted to establish as many acres of wetland, and cottonwood/willow as was practicably feasible, given the limitations of available surface water and current land use. Additional acres of new mesquite and desert scrub shrub are also planned to complete the upper slopes of desert riparian systems.

Through examination of the project site, current literature searches, survey results, and discussions with USFWS and Arizona Game and Fish Department personnel, the proposed project was determined to have either "no effect" or "no adverse affect" on the 15 federally listed threatened, endangered, proposed, or candidate species. The determinations are as follows:

Arizona agave (*Agave arizonica*) – No effect
Arizona cliffrose (*Purshia subintegra*) – No effect
Bald eagle (*Halieaetus leucocephalus*) – May affect, not likely to adversely affect
Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) – No effect
California brown pelican (*Pelecanus occidentalis californicus*) – No effect
Mexican spotted owl (*Strix occidentalis lucida*) – No effect
Southwestern willow flycatcher (*Empidonax traillii extimus*) – No effect
Yuma clapper rail (*Rallus longirostris yumanensis*) – No effect
Yellow-billed cuckoo (*Coccyzus americanus*) – No effect
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – No effect
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – No effect
Desert pupfish (*Cyprinodon macularius*) – No effect
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – No effect
Razorback sucker (*Xyrauchen texanus*) – No effect
Gila chub (*Gila intermedia*) – No jeopardy

This BA serves as the documentation of these determinations and will be accompanied by a cover letter asking for written concurrence of the above determinations by the USFWS, and therefore a conclusion of Section 7 consultation. The Corps understands that should the project or project site conditions change in a way that may adversely affect threatened or endangered species, or the determinations made in this document, the USFWS would be notified and Section 7 Consultation would be reinitiated.

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YUMA CLAPPER RAIL SURVEY REPORT

APPENDIX

Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area Maricopa County, Arizona

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Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area, Maricopa County, Arizona

Project Location

The U.S. Army Corps of Engineers (Corps) is proposing restoration of the Salt River between Granite Reef Dam and the interchange of the Loop 101 and Loop 202 in Maricopa County, Arizona. The area proposed for restoration has been designated by the Corps the "Va Shly'ay Akimel Project Study Area." Project boundaries encompass both banks of the Salt River channel between dam and Loop 101/202 to a distance of ½-mile to either side of the *thalweg*, or deepest portion of the river channel. Suitable habitat for the Yuma clapper rail is located within the boundaries of the project area in Township 1 North, Range 5 East, Section 18 (Figure 1).

Survey Area

Elevation of the project area is approximately 1,200 feet above mean sea level, and topography in the vicinity is predominantly flat. The project area is located within the Lower Colorado River Subdivision of the Sonoran Desertscrub biotic community (Brown et al. 1994). However, the project area is within an urban setting and the river bottom exhibits signs of long-term disturbance, including roads, landfills, mining operations, and illegal trash dumping.

During the planning process for the restoration project, it was determined that suitable habitat for the Yuma clapper rail is present in wetlands located adjacent to the interchange of the Loop 101 and Loop 202. The wetland has year-round water present and vegetation in the survey area is dominated by cattail (*Typha domingensis*). Table 1 details plant species occurring in and around the surveyed wetland during field activities.

Table 1. Plants Documented in the Salt River During Surveys

Species Name (Common Name)	Scientific Name
Bermuda-grass	*Cynodon dactylon*
Rabbits-foot	*Polypogon monspeliensis*
Fountain-grass	*Pennisetum ciliare*
Mexican sprangletop	*Leptochloa dubia*
Curly-dock	*Rumex crispus*
Cattail	*Typha domingensis*
Yellow nut-sedge	*Cyperus esculentus*
Bulrush	*Scirpus validus*
Bulrush	*Scirpus paludosus*
Knotweed	*Polygonum argyrocoleon*
Water speedwell	*Veronica anagallis-aquatica*
Salt heliotrop	*Heloptropium curassavicum*
Euphorbia	*Euphorbia albomarginatus*
Desert bedstraw	*Stephanomeris pauciflora*
Sweetbush	*Bebbia juncea*
Sowthistle	*Sonchus asper*
London rocket	*Sisymbrium irio*
Brittle-bush	*Encelia farinosa*
Cockle-bur	*Xanthium strumarium*
Turpentine-bush	*Apolopappus* sp.
Arrowweed	*Pluchea sericea*
Goodding's willow	*Salix gooddingii*
Fremont cottonwood	*Populus fremontii*
Salt-cedar	*Tamarix ramosissima*
California fan palm	*Washingtonia filifera*

Survey Information

Yuma Clapper Rail (*Rallus longirostris yumanensis*)

Life History

The Yuma clapper rail is a grayish-brown marsh bird with long legs and a short tail; adults of the species are typically 35–41 centimeters (14–16 inches) tall. During the breeding season, adult Yuma clapper rail males display a tawny-orange or burnt-orange breast and orangish beak while females display a brick-orange breast. (Arizona Game and Fish Department 2001)

The current range for the Yuma clapper rail includes the Lower Colorado River drainage from the Gulf of California in Mexico north to Topock Marsh in the Havasu National Wildlife Refuge (NWR), Arizona. In Arizona, this subspecies also occurs in several major river drainages in the central and southwestern portions of the state, including the Bill Williams River drainage, the Lower Gila River drainage, and the lower Salt and Verde River drainages (Arizona Game and Fish Department 2001).

Breeding occurs after territories are established in March or April. Breeding activities are known to occur at Mittry Lake, Bill Williams River drainage, Topock Gorge and Topock Marsh in the Havasu NWR, and Cibola NWR (Arizona Game and Fish Department 2001). Average clutch size is 8 to 10 eggs with incubation lasting about 21–23 days. Hatching success is usually high, but mortality among young is usually high as well. Family groups of clapper rails stay together for approximately 24–30 days post-hatching. Chicks become independent from their parents at 35–42 days, and first flight usually takes place 63–70 days post-hatching (Terres 1980).

This subspecies is the only clapper rail to breed in freshwater marshes. They also inhabit brackish water marshes and river sidewaters. They prefer tall, dense cattail and bulrush marshes found in the Lower Colorado River Subdivision of the Sonoran Desert Biome at an elevation between below sea level to approximately 400 meters (1,300 feet) above mean sea level. Clapper rails prefer to feed on crustaceans, including amphipods, but will also feed on fish, frogs, clams, spiders, large insects, and aquatic plant seeds. On the Colorado River, introduced crayfish are the most common food consumed in bulk (Arizona Game and Fish Department 2001).

The decline in numbers of this species has been attributed to river channelization, dredging, drying and flooding of marshes, wildfires, and toxic levels of heavy metals.

Survey Methodology and Results

Yuma clapper rail surveys were conducted May 21, May 23, May 28, and May 30, 2003. Biologists Ron Van Ommeren and Amy Gibbons, Jones & Stokes, conducted all surveys under U.S. Fish and Wildlife Service (USFWS) permit number TE013086-0.

Observation Methodology

Topographic maps and a site visit were used to determine the boundaries of the survey area. A total of 30 call points were established, approximately 100 feet apart, and GPS coordinates of these points were logged for quality control purposes (Table 2). These points are shown in Figures 2 and 3.

Table 2. GPS Coordinates for Survey Call Points (UTM)

Call Point	Easting	Northing
1	0417270	3700084
2	0417257	3700111
3	0417255	3700141
4	0417258	3700170
5	0417255	3700200
6	0417258	3700232
7	0417287	3700239
8	0417293	3700221
9	0417288	3700197
10	0417289	3700160
11	0417284	3700126
12	0417289	3700099
13	0417319	3700104
14	0417315	3700136
15	0417315	3700168
16	0417311	3700198
17	0417314	3700231
18	0417316	3700266
19	0417349	3700131
20	0417347	3700159
21	0417346	3700193
22	0417377	3700187
23	0417407	3700174
24	0417408	3700206
25	0417377	3700214
26	0417351	3700229
27	0417376	3700248
28	0417413	3700238
29	0417441	3700252
30	0417381	3700145

All surveys were conducted in compliance with the USFWS *Yuma Clapper Rail Survey Protocol* (U.S. Fish and Wildlife Service 2000). Call playback tapes were used at the 30 call points in an effort to elicit a response from resident Yuma clapper rails. In addition to recording responses, a log was kept of other species of birds that were seen or heard at the call sites (Table 3).

Table 3. Bird Species Documented in the Salt River During Surveys

Species Name (Common Name)	Scientific Name
Abert's towhee	*Pipilo aberti*
American avocet	*Recurvirostra americana*
American coot	*Fulica americana*
Black phoebe	*Sayornis nigricans*
Black-crowned night-heron	*Nycticorax nycticorax*
Brown pelican	*Pelecanus occidentalis*
Brown-headed cowbird	*Molothrus ater*
Cliff swallow	*Petrochelidon pyrrhonota*
Common moorhen	*Gallinula chloropus*
Common yellowthroat	*Geothlypis trichas*
Costa's hummingbird	*Calypte costae*
Double-crested cormorant	*Phalacrocorax auritus*
Gambel's quail	*Callipela gambelii*
Great blue heron	*Ardea herodias*
Great egret	*Adrea alba*
Great Horned owl	*Bubo virginianus*
Great-tailed grackle	*Quiscalus mexicanus*
Green heron	*Butorides virescens*
House finch	*Carpodacus mexicanus*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Mourning dove	*Zenaida macroura*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Red-winged blackbird	*Agelaius phoeniceus*
Rock dove	*Columba livia*
Snowy egret	*Egretta thula*
Song sparrow	*Melospiza melodia*
Turkey vulture	*Cathartes aura*

Survey Results

The survey did not result in a response from a Yuma clapper rail. However, two brown pelicans, a species federally listed as endangered, were observed in flight in the project area.

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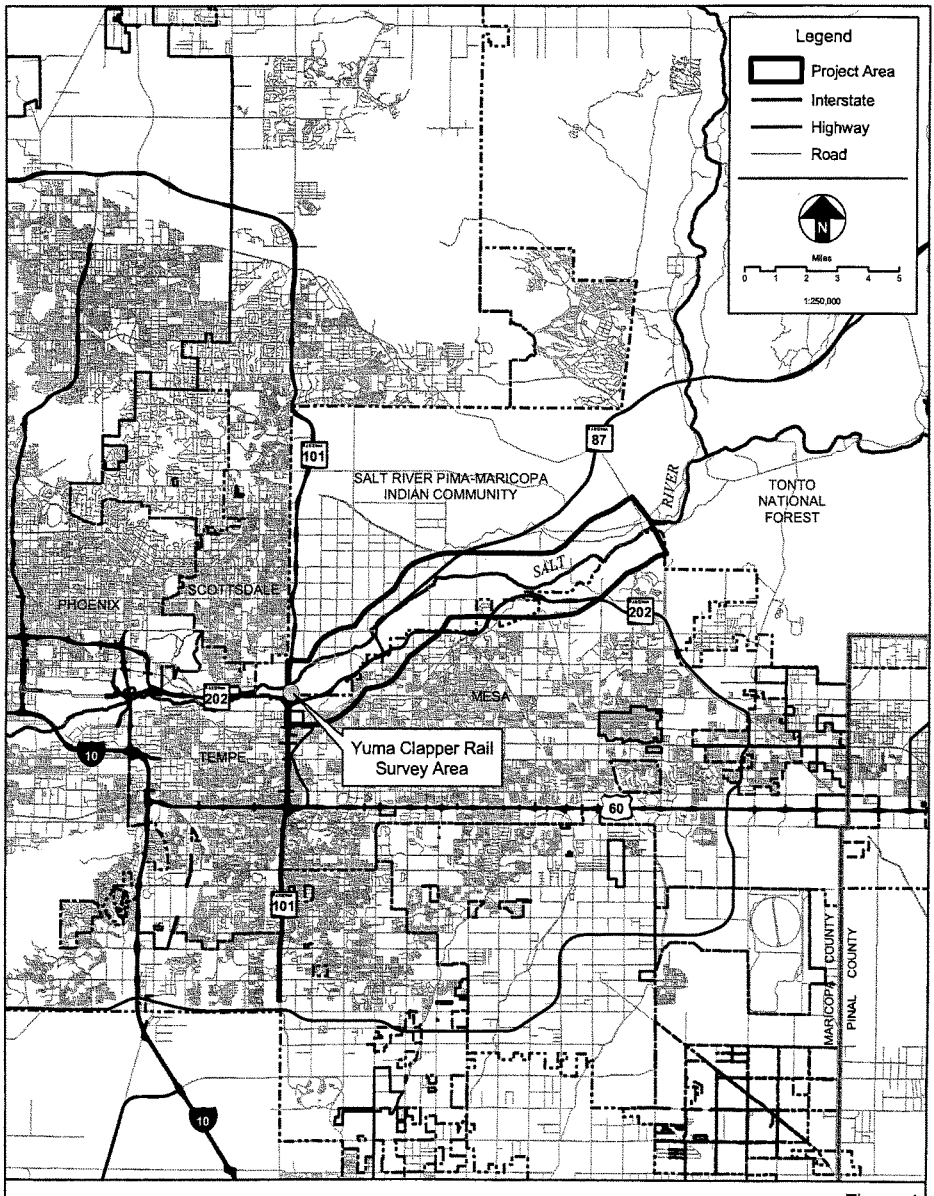

Figure 1
Vicinity Map
Va Shly'ay Akimel Project Study Area

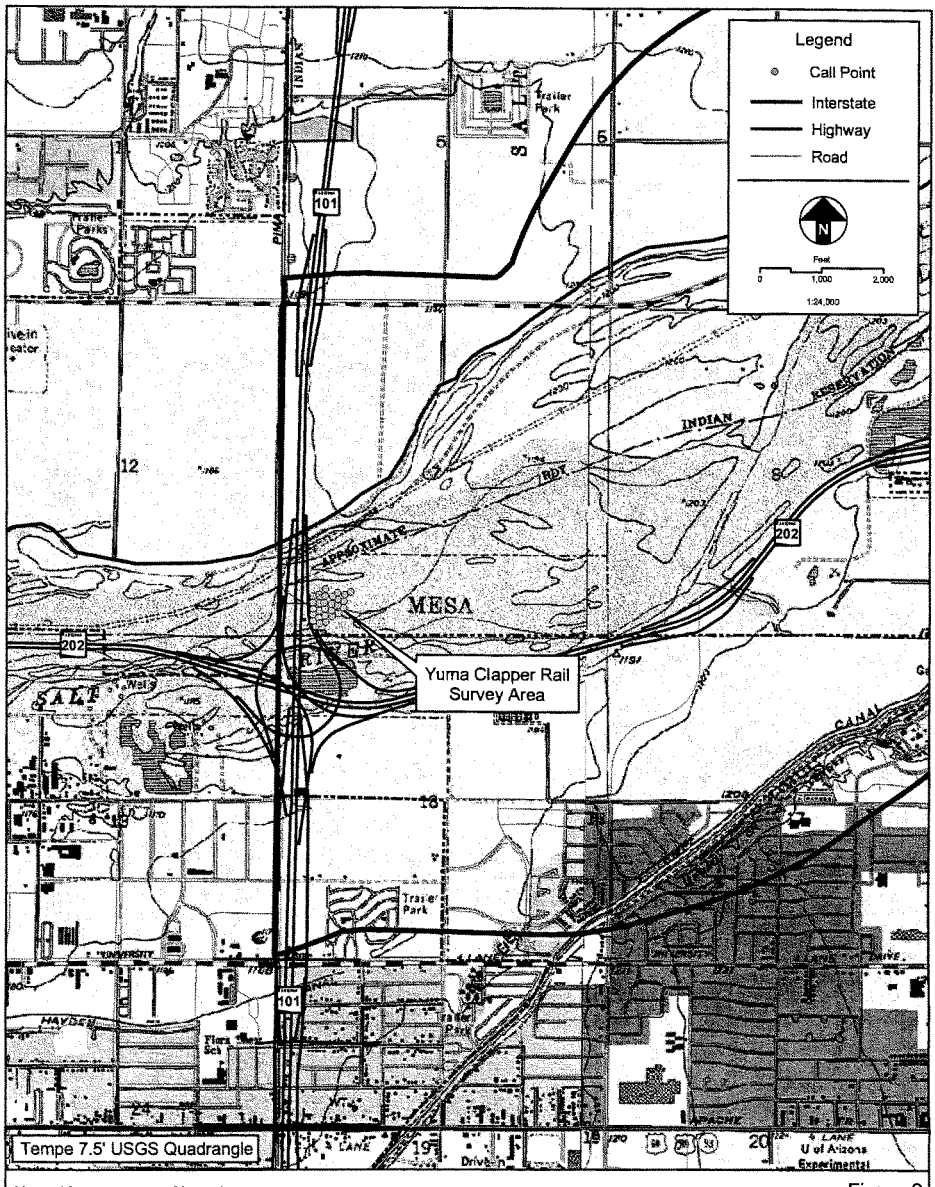

Figure 2
Call Point Location Map
Va Shly'ay Akimel Project Study Area

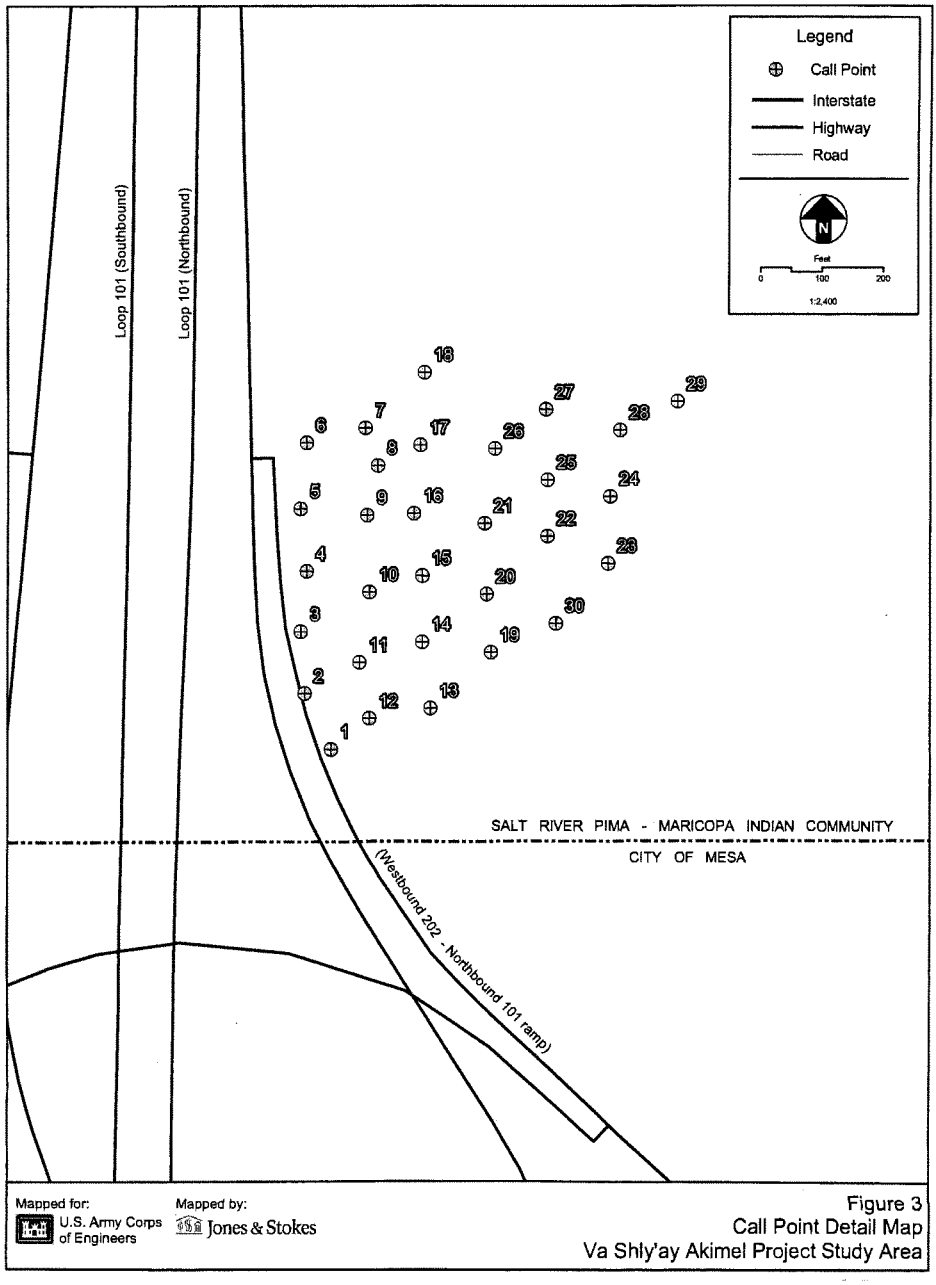

Figure 3
Call Point Detail Map
Va Shly'ay Akimel Project Study Area

APPENDIX

VA SHLY'AY AKIMEL **I**

Salt River Ecosystem Restoration Study September 2004

HYDRO-GEOMORPHIC MODEL ASSESSMENT

Prepared in coordination with:

U.S. Army Corps of Engineers
Los Angeles District

U.S. Army Corps of Engineers
Engineer Research and Development Center

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Executive Summary

This report contains the analysis, results, and documentation of the Va Shly'ay Akimel HGM assessment. The Va Shly'ay Akimel study area is an approximately 17 mile degraded reach of the Salt River located approximately 10 miles east of Phoenix Arizona (see Fig. 2-1). The non-federal sponsors for this feasibility study are the Salt River Pima Maricopa Indian Community and the City of Mesa.

Ecosystem restoration benefits resulting from the proposed alternatives were determined using an HGM assessment. The specific HGM assessment tool was the Arizona Riverine Model developed with the input of regional experts (page 12, and Table 2-6). In the summer of 2002 the Va Shly'ay Akimel E-team (Table 2-7) met to discuss baseline (e.g., without project) conditions and to estimate the future (e.g., with project) conditions for the HGM model analysis. During the alternative formulation phase of the project the E-team identified 15 alternatives ranging from a xero-riparian dominated ecosystem to a meso-riparian dominated system with extensive vegetation establishment (page 59 and Tables 3-1, 3-3). Each alternative was further subdivided based on irrigation method (drip (1) or surface braided inflow (2)) giving a total of 30 alternatives. Details of each alternative are available in the AFB document.

The HGM assessment evaluated future changes in quantity (acres) and quality (functional capacity) of the aquatic, wetland, and terrestrial ecosystems. Average Annual Functional Capacity Units (AAFCU's) were calculated for the 50-year life of the project. All 30 alternatives were evaluated using USACE cost evaluation procedures as irrigation method affected cost but not AAFCU's produced by the alternative.

The top three alternatives based upon results of the HGM analysis, were F (1035 AAFCU's and 447 acres habitat gain), O (963 AAFCU's and 442 acres habitat gain), and G 943 AAFCU's and 457 acres habitat gain) (page 66 and table 5-1). All three of these alternatives exceeded the performance target of 915 AAFCU's. The top three alternatives based on Incremental Cost Analysis (ICA) were A2 ($4.00/AAFCU and 373 AAFCU's), O2 ($10.00/AAFCU's and 963 AAFCU's), and F2 ($15.00/AAFCU and 1035 AAFCU's) (Table 5-2).

Based upon HGM, ICA analyses, and sponsor input, alternative O2 is the recommended plan. Alternative O2 exceeds performance targets for three of the five priority vegetation communities identified by the E-team (cottonwood by 733 acres, river bottom by 350 acres, and mesquite by 80 acres) (page 21). Alternative O2 exceeded the performance target for AAFCU's by 48 AAFCU's. Although alternative O2 produces 72 fewer AAFCU's than alternative F2 the cost per AAFCU is also $5.00 less per AAFCU than F2. The sponsors expressed a strong preference for Alternative O2.

Table of Contents

Topic **Page No.**

Executive Summary i
Table of Contents ii
List of Tables iv
List of Figures v

CHAPTER 1: Introduction 1
CHAPTER 2: Methods 3
Introduction to the HGM Process 3
Ecosystem Evaluation Using HGM 12
Build a Multi-Disciplinary Evaluation Team (E-Team) 12
Defining the Va Shly'ay Akimel Project 15
Geographic Location, Counties, Watersheds, and Primary Water Resources 15
Lead District 17
Project Evolution and Purpose 17
Presettlement Conditions of the Region 18
The Ecosystem Restoration Approach 18
Setting Planning Objectives and Goals 19
Objectives 19
Goals 20
Selection of Project Life and Target Years 23
Cover Typing 23
Selecting and Modifying the HGM Models 26
Variables Used in the HGM FCI Models 28
FCI Model Selections 30
Conducting the Field Sampling 31
Variables Measured in the Field 32
Variables Obtained Without Field Sampling 36
Landscape Level Variables 37
Site Specific Variables 39
Field Sampling Locations 43
Field Sampling Protocol 43
Performing Data Management and Statistical Analysis 44
Calculating Baseline Conditions 45
Generating Without Project Conditions and Calculating the Outputs. 46
Specific Without Project Trends 47
Calculating Annualized Units for the Without Project Condition 48

Topic **Page No.**

Generating With Project Conditions and Calculating the Outputs 49
Developing RVIs and Performing Tradeoffs 49
Reporting the Results of the Analyses 51
Software Used In the Va Shly'ay Akimel Ecosystem Restoration Project 51
Introduction to the Cost Analysis Process 52
CHAPTER 3: Va Shly'ay Akimel Project Results (Salt River) 55
Project Description 55
Location 55
Purpose 55
Measures Under Consideration 56
Alternatives Under Evaluation 58
Baseline Conditions 59
Baseline Acres and Cover Types 59
Baseline Variable Values for Each Cover Type 60
Baseline Evaluation 60
Future Conditions 61
Without Project Conditions 61
With Project Conditions 63
Evaluation of Alternatives 64
Overall Review of the HGM Results 64
Top Four Biological Winners Using HGM 66
Individual HGM Model Results 66
Cost Analysis 70
Project Costs 70
Top Three Cost Effective Solutions Based On HGM Results 70
Top Three Incrementally Effective Solutions Based On HGM Results 71
CHAPTER 4: Trade-Offs 72
The Va Shly'ay Akimel Environmental Restoration Trade-Offs Process 72
CHAPTER 5: Summary and Conclusions 74
Overall Results Summarized 74
Summary of the Plans Under Consideration 74
The Biological Plan 74
The Incremental Plan 81
The Recommended Plan 86
Objectives Met 86
Literature Cited 87
Glossary 90

Appendix A: Va Shly'ay Akimel Versus Reference Sites Baseline FCIs, TY 51 WOP FCUs & AAFCUs A1–A5

Topic **Page No.**

Appendix B: Va Shly'ay Akimel Performance Targets B1-B6

Appendix C: Va Shly'ay Akimel Without Project Results C1-C8

Appendix D: Va Shly'ay Akimel With Project Results D1-D12

List of Tables

Table **Page No.**

2-1 Hydrogeomorphic Wetland Classes on a Continental Scale 4
2-2 Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source and Hydrodynamics 6
2-3 Components of a Model Variable 7
2-4 Wetland Functions Evaluated in HGM and Their Descriptions 8
2-5 Reference Wetland Terms and Definitions 10
2-6 Attendees to "The HGM Approach for the Arizona Streams Restoration Model Development Meeting", March 26-28, 2001, Tucson, Arizona 13
2-7 Va Shly'ay Akimel Evaluation Team 14
2-8 Va Shly'ay Akimel study objectives and constraints refined during an E-Team meeting October, 17, 2002 19
2-9 Cover types and baseline acreages for the Va Shly'ay Akimel study area 25
2-10 Goals and objectives per PWAA 26
2-11 FCI models, variables, and performance target 27
2-12 Variable names and descriptions used in the Va Shly'ay Akimel ER-FS HGM assessment 28
3-1 Va Shly'ay Akimel ER-FS alternative list 58
3-2 Baseline HGM Functional Capacity Indices (FCI) and Functional Capacity Units (FCU) for the Va Shly'ay Akimel ER project 61
3-3 Va Shly'ay Akimel ER-FS with project alternative conditions 64
3-4 Net AAFCUs for each HGM model per alternative for the Va Shly'ay Akimel ER-FS 65
3-5 The top three cost effective solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s 70
3-6 The top three ICA solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s 71
4-1 The Va Shly'ay Akimel Environmental Restoration Study top three alternatives based upon CEA, ICA, and HGM analyses 73
5-1 Net AAFCU gains, final FCI scores, and gains in habitat acres for the top three biological alternatives for the Va Shly'ay Akimel restoration study 74
5-2 Net AAFCU gains, final FCI scores, gains in habitat acres, average annual cost, and cost per AAFCU for the top three ICA alternatives for the Va Shly'ay Akimel restoration study 81

List of Figures

List of Figures

Page No.

2-1 Location map for the Salt River Va Shly'ay Akimel Project identifying key features and project sub-areas 15
2-2 Potential primary water resources for the project 16
2-3 Example variable subindex (VSI) curve 45
3-1 General location map for the Salt River Va Shly'ay Akimel Project identifying key features and project sub-areas 55
3-2 Va Shly'ay Akimel without project changes in FCIs over time for all 10 HGM functions evaluated 62
3-3 Without project Annual Average Functional Capacity Units (AAFCU) summary plot 63
5-1 AAFCUs per function for performance targets and top three biological alternatives for the Va Shly'ay Akimel restoration study 75
5-2 Final FCI's per function for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study 76
5-3 Acres per habitat type for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study 77
5-4 Diagram of alternative F, Va Shly'ay Akimel restoration study 78
5-5 Diagram of alternative O, Va Shly'ay Akimel restoration study 79
5-6 Diagram of alternative G, Va Shly'ay Akimel restoration study 80
5-7 AAFCUs per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study 82
5-8 Final FCI's per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study 83
5-9 Acres per habitat type for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study 84
5-10 Diagram of alternative A, Va Shly'ay Akimel restoration study 85

CHAPTER 1 - Introduction

The U.S. Army Corps of Engineer Los Angeles District is actively engaged in the Va Shly'ay Akimel Ecosystem Restoration Feasibility Study (ER-FS). The study area is located on the Salt River extending approximately 17 river miles from the Granite Reef Dam to the Pima Freeway 101. The non-federal sponsor(s) for this feasibility study include the Salt River Pima-Maricopa Indian Community and the City of Mesa, Arizona. Activities to be completed by the Corps during the feasibility study include investigating and evaluating all reasonable alternatives to provide for the restoration of Sonoran-desert riparian vegetation and associated native wildlife, to increase flood protection, and where possible, to provide increased passive recreation and educational opportunities afforded by ecosystem restoration facilities.

To determine the ecosystem restoration benefits resulting from the proposed wetland alternatives in the Va Shly'ay Akimel Project, HydroGeoMorphic Wetland Assessment procedures (HGM) were completed. The HGM assessment was designed to evaluate the future changes in quantity (acres) and quality (functional capacity) of aquatic, wetland, and terrestrial ecosystems. Outputs, Average Annual Functional Capacity Units (AAFCUs) were calculated in terms of annualized changes anticipated/estimated over the 50-year life of the project. Results for each alternative were compared using the standard U.S. Army Corps of Engineers (USACE) cost evaluation procedures. Early in the evaluation process, an evaluation team (E-Team) was convened. This E-Team was comprised of project mangers, planners, and technical experts from both the private and public sectors, and academia. Also included on the E-Team were individuals who represented the non-federal sponsors and actively participated in the HGM assessment.

The Va Shly'ay Akimel ER-FS HGM assessments in their entirety, in addition to the results of the cost analyses are presented in the following chapters. The body of this report is divided into five (5) chapters:

Chapter I: Introduction
Chapter II: Methods
Chapter III: Va Shly'ay Akimel HGM Results
Chapter IV: Trade-Offs
Chapter V: Summary and Conclusions

In addition, three (3) chapters that lend support to this report, (Literature Cited, Glossary, and Appendix A) are included at the end of the text.

Chapter 2 presents the HGM tool and describes the methods used to develop the models and conduct the HGM assessment. A description is provided that details the selection, development, verification, and deployment of the functional model(s) used to assess the

efficacy of the proposed Va Shly'ay Akimel ER-FR. The E-Team is introduced in this chapter and the decisions and assumptions made during the HGM development and evaluation processes are fully documented. Technical terminologies utilized in the description and application of the HGM tool are also included in this chapter.

Chapter 3 provides the results of the analysis of the proposed Va Shly'ay Akimel ecosystem restoration effort. First, a description of the baseline habitat conditions is provided including the documentation of sampling techniques, delineation of cover types and Partial Wetland Assessment Areas (PWAA's), data handling techniques, decisions made in the utilization of data in the analysis, and the derivation of baseline functional capacity units per PWAA. Next the assumptions and projected data used in the HGM are presented with the results of the analyses detailed at the end of the chapter. Details of the functional habitat gains are summarized in a series of "Results" tables located within this chapter.

Chapter 4 discusses the trade-offs process and used for the Va Shyl'ay Akimel Environmental Restoration Study. Although the biological study Team did not adopt the formal trade offs process, during the HGM process alternatives were compared based upon the model outcomes with respect to wetland functions achieved, plant communities present, and the overall species mixture of the proposed system. This chapter discusses the rational used in foregoing the formal trade off process in lieu of assumptions made at the variable level of the model development process.

Chapter 5 provides an overall project summary of the results and conclusions of the HGM analysis. Included is a summary of the top three biological (HGM), and top three incrementally cost effective alternatives.

CHAPTER 2 - Methods

Setting ecosystem restoration objectives and performance criteria on the recovery of "non-use" benefits, such as ecosystem functions and wildlife habitat, were critical to the overall planning process. The basic premise behind species and community restoration is the recovery of limiting habitat features, defined by their primary components, such as food, water, cover, or reproduction. The primary goal of this study focuses on the restoration of such components within the study area. To measure the success of the ecosystem restoration proposals, the best available science was used. In most ecosystem restoration studies, benefits are measured using quantifiable techniques rather than qualitative assessments. It was important that the technique selected to quantify benefits be repeatable, efficient, and effective, as results could be questioned by outside interests, and there was a finite amount of time available for the study schedule and participants. Although many rapid assessment techniques were applicable, for reasons described in the next section, the USACE Los Angeles District selected the HGM (HydroGeoMorphic Assessment of Wetlands) to quantify the anticipated habitat benefits gained/lost by proposed ecosystem restoration alternatives for the Va Shly'ay Akimel ER-FS.

Introduction to the HGM Process

Wetland ecosystems often occur under a broad range of climatic, geographic, geologic, and physiographic situations. In turn wetland systems often exhibit a wide range of physical, chemical, and biological attributes and processes (Ainslie et al. 1999; Ferren, Fiedler, and Leidy 1996; Ferren et al. 1996a, b; Mitch and Gosselink 1993; Semeniuk 1987; Cowardin et al. 1979). Wetlands do however, posses a number of common attributes including significant periods of inundation or saturation, the presence of hydrophilic vegetation, and hydric soils. The challenge is to develop assessment methods that are both accurate and practical, that not only take into account similar traits, but also the variability. There are existing "generic" methods designed to assess multiple wetland types throughout the United States that are relatively rapid, but lack the resolution necessary to detect significant change(s) in wetland function.

Reducing the level of variability exhibited by the wetlands being considered is one way to achieve an appropriate level of resolution within an available timeframe (Smith et al. 1995). The HydroGeoMorphic Assessment of Wetlands (HGM) approach was developed specifically to accomplish this task (Ainslie et al. 1999; Brinson 1993). HGM identifies groups of wetlands that function similarly using three criteria: 1) Geomorphic Setting, 2) Water Source, and 3) Hydrodynamics. These criteria are assumed to fundamentally influence how the wetlands function. Geomorphic Setting refers to the landform and position of the wetland in the landscape. Water Source refers to the primary water source in the wetlands, e.g. precipitation, overbank flooding, or groundwater. Hydrodynamics refers to the level of energy and the direction that water moves in the wetland. Based on

these three criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. As a first approximation, the HGM approach uses seven wetland classes (groups) as described below in Table 2-1 (Smith et al. 1995).

Table 2-1
Hydrogeomorphic Wetland Classes on a Continental Scale

Wetland Class	Class Description
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depression wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries, and are under the influence of sea level. They intergraded landward with riverine wetlands where tidal current diminishes and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between tidal fringe and riverine classes is where bi-directional flows from tides dominate over unidirectional ones controlled by the floodplain slope of the riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in the higher elevation marsh areas where flooding is less frequent, and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to the land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evapotranspiration. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.

Table 2-1 continued.

Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation. They normally occur on the sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of groundwater/interflow water source. Fens are a common example of slope wetlands
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flat woods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peat lands, differ from mineral soil flats in part because their elevation and topography are controlled by the vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peat lands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and the wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from the riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

The level of variability in the continental-scale wetland hydrogeomorphic classes presented above is still usually too immense to develop assessment models that can be rapidly applied while still being sensitive enough to detect changes in function at a level of resolution appropriate to the USACE planning process in Arizona. As such, the three classification criteria (geomorphic setting, water source, and hydrodynamics), were applied at a smaller, regional geographic range to identify regional wetland subclasses. Examples of such regional wetland subclasses are provided in Table 2-2.

Table 2-2
Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina Bays	California vernal pools
Fringe (tidal)	Ocean	Bi-directional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bi-directional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Uni-directional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat Bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands

The resulting regional riverine wetland subclasses adopted for the Va Shly'ay Akimel project were all associated with low gradient perennial and ephemeral river systems in Arizona. Within these regional subclasses, homogenous zones exhibiting analogous vegetative species, geographic similarities, and physical conditions that make the area unique were defined as a Partial Wetland Assessment Area (PWAA). In all, 19 PWAA's were defined for the Va Shly'ay Akimel Project on the basis of species recognition and dependence, soil types, and topography. The dominate vegetative cover types were used within the PWAAs included Cottonwood – Willow, Wetland Marsh, Mesquite, and Scrub-Shrub. River Bottom was defined as the active channel and included pool/riffle aquatic areas, and open areas characterized by sand, cobble, and/or gravel. During the planning and project formulation processes, various combinations of PWAA's were located within the project area and used to develop a range of restoration alternatives.

In the HGM process, a Variable Sub index (VSI) is a mathematical relationship that reflects a wetland function's sensitivity to change in a limiting factor or variable within the PWAA. In HGM VSIs are depicted using functional capacity curves where the VSI value ranges from 0.0 to 1.0. A VSI = 0.0 represents a variable that is extremely limiting while a VSI = 1.0 represents a variable in abundance for the wetland under consideration. Hence the VSI is used to bridge the gap between measured variables and the functional value of an existing or proposed PWAA.

HGM model variables represent the characteristics of the wetland ecosystem (and surrounding landscape) that influence the capacity of a wetland ecosystem to perform a function. HGM model variables are ecological quantities that consist of five components (Schneider 1994). These include: 1) a name; 2) a symbol; 3) a measure of the variable and procedural statement for quantifying or qualifying the measure directly or calculating it from other measurements; 4) a set of values [i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)] that are generated by applying the procedural statement; and 5) units on the appropriate measurement scale. Table 2-3 provides several examples.

Table 2-3
Components of a Model Variable.

Name (Symbol)	Measure/Procedural Statement	Resulting Value(s)	Units (Scale)
Redoximorphic Features (VREDOX)	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	Present / Absent	Unitless (nominal scale)
Floodplain Roughness (VROUGH)	Manning's Roughness Coefficient (n) observe wetland characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	Unitless (interval scale)
Tree Biomass (VTBA)	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m^2), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (ratio scale)

HGM model variables occur in a variety of states or conditions in reference wetlands (Ainslie et al. 1999). The state or condition of the variable is denoted by the value of the measure of the variable. For example, tree basal area, the measure of the tree biomass variable could be large or small. Similarly, recurrence interval, the measure of overbank flood frequency variable could be frequent or infrequent. Based on its condition (i.e., value of the metric), model variables are assigned a variable sub index. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable sub index of 1.0 is assigned. As the condition diverges from the reference standard condition (i.e., the range of conditions that the variable occurs in reference standard wetland), the variable sub index is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it

receives a progressively lower sub index reflecting its decreasing contribution to functional capacity. In some cases, the variable sub index drops to zero. For example, when no trees are present, the sub index for tree basal area is zero. In other cases, the sub index for a variable never drops to zero. For example, regardless of the condition of a site, Manning's Roughness Coefficient (n) would always be greater than zero.

A desired result of the Va Shly'ay Akimel ER-FS process was to assess the functional values of wetland habitat types (PWAAs) currently existing within the project area. Further, estimates of these functional values were needed for PWAAs at selected times in the future considering the Without Project scenario and With Project alternatives. Wetlands perform a wide variety of functions, although not all wetlands perform the same functions, nor do similar wetlands perform the same functions to the same level of performance. The ability to perform a function is influenced by the characteristics of the wetland and the physical, chemical, and biological processes within the wetland.

Wetland characteristics and processes influencing one function often also influence the performance of other functions within the same wetland system. The eleven (11) functions evaluated with HGM Functional Capacity Index (FCI) models used in the Va Shly'ay Akimel ER-FS are found in Table 2-4.

Table 2-4
Wetland Functions Evaluated in HGM and Their Descriptions.

Wetland Function (symbol)	Description
Function 1: Maintenance of Channel Dynamics (CHANNELDYN)	Physical processes and structural attributes that maintain characteristic channel dynamics. These include flow characteristics, bedload, in-channel coarse woody debris inputs, channel dimensions, and other physical features (e.g. bank vegetation, slope).
Function 2: Dynamic Surface Water Storage/Energy Dissipation (WATSTORENR)	Dynamic water storage and dissipation of energy at bankfull and greater discharges. These are a function of channel width, depth, bedload, bank roughness (coarse woody debris, vegetation, etc.), presence and number of in-channel coarse woody debris jams, and connectivity to off-channel pits, ponds, and secondary channels.
Function 3: Long Term Surface Water Storage (WATSTORLNG)	The capability of a wetland to temporarily store/retain surface water for long durations; associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, and/or channelized flow from uplands, or direct precipitation.

Table 2-4, continued.

Function 4: Dynamic Subsurface Water Storage (WATSTORSUB)	Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.
Function 5: Nutrient Cycling (NUTRIENT)	Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
Function 6: Detention of Imported Elements and Compounds (ELEMENTS)	The detention of imported nutrients, contaminants, and other elements or compounds.
Function 7: Detention of Particles (DETPARTICL)	Deposition and detention of inorganic and organic particulates (> 0.45 µm) from the water column,; primarily through physical processes.
Function 8: Maintain Characteristic Plant Communities (PLANTS)	Species composition and physical characteristics of living plant biomass. The emphasis is on the dynamics and structure of the plant community as revealed by the species of trees, shrubs, seedlings, saplings, and herbs and by the physical characteristics of the vegetation.
Function 9: Maintain Spatial Structure of Habitat (HABSTRUCT)	The capacity of the wetland to support animal populations and guilds by providing heterogeneous habitats.
Function 10: Maintain Interspersion and Connectivity (INTERSPERS)	The capacity of the wetland to permit aquatic organisms to enter and leave the wetland via permanent ephemeral surface channels, overbank flow, or unconfined hyporheic gravel aquifers. The capacity of the wetland to permit access of terrestrial or aerial organisms to contiguous areas of food and cover.
Function 11: Maintain Protection Zone from Urban Encroachment (BUFFER)	Land use immediately adjacent to the wetland should be compatible and afford a gradual transition from the wetland habitat to developed areas.

HGM is an accounting system that can be used to estimate the functional value of the study area wetland habitat(s) relative to the functional value of reference wetland habitat(s). In the HGM process, the currency denoting functional value is defined as Functional Capacity Units (FCU's). A functional capacity unit considers two factors: 1) the quality of the wetland habitat and 2) the quantity of the wetland habitat providing the functional value(s).

The quality of the habitat is measured as the Functional Capacity Index (FCI). The FCI is derived from limiting environmental factors (variables) associated with the various functions attributable to wetland ecosystems. It is a function made up of arithmetic, geometric, or multiplicative combinations of the VSI scores for each Cover Type within each PWAA. VSI scores were obtained using a combination of field measurements made in the project area and at reference site locations. Due to time and economic constraints, and the need to estimate future conditions, several limiting environmental factors are obtained through the use of literature searches, aerial photographic analysis, historical and contemporary mapping and GIS products.

Reference wetlands are wetland sites selected from a reference domain (a defined Geographic area), selected to "represent" sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/disturbed as well as those sites with minimal disturbance (Ainslie et al. 1999). The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM approach. Reference sites provide the standard for comparison in the HGM approach. Unlike other methods which rely on data from published literature or best professional judgment, the HGM approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of the HGM approach is that the highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term disturbance (Smith et al. 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest, sustainable functional capacity. Reference standards are derived from these wetlands and used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions in order to scale model variables from 0.0 to 1.0, the range used for each variable sub index. To assist the user, a list of key terms related to the reference wetland concept in the HGM methodology is listed in Table 2-5.

Table 2-5
Reference Wetland Terms and Definitions

Term	Definition
Reference Domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected.
Reference Wetland	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alteration.
Reference Standard Wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that the wetlands is both sustainable and characteristic of the least human altered wetland sites in the least altered human landscapes. By definition, the functional capacity index for all functions in the reference standard wetlands are assigned a 1.0.
Reference Standard Wetlands Variable Condition	The range of conditions exhibited by model variables in reference standard wetlands. By wetland variable definition, reference standard conditions receive a variable sub index score of 1.0.

Table 2-5, continued.

Site Potential – Mitigation Project Context	The highest level of function possible, given local constraints of disturbance history, land use, mitigation project or other factors.
Project Target – Mitigation Project Context	The level of function identified or negotiated for a restoration or creation project.
Project Standards – Mitigation Project Context	Project standards, performance criteria, and/or specifications used to guide the restoration or creation activities (mitigation context) toward the project target. Project standards should specify reasonable contingency measures if the project target is not being achieved.

A FCI score varies between 0.0 and 1.0 because the value is determined as the ratio of the study area conditions to those measured or estimated at a reference wetland standard. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes. Conversely, an index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An HGM model developed for a given subclass of wetlands is essentially an assimilation of several FCI models to evaluate overall site functionality. All FCI models are described using a single FCI formula. Some examples of HGM FCI models include floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance.

The quantity is merely the number of acres of a cover type or partial wetland assessment area (PWAA) receiving the FCI score. When the FCI is multiplied by the number of acres present, the results is the relative value (FCU) of the wetland habitat being considered. More precisely, the resulting FCU value provides a means of assessing the gains or losses in functional value for a single target year of interest. In order to assess the functional value of restored wetland habitats relative to reference wetlands over time, gains and losses are averaged over the life of the project. This resulting meter is termed the AAFCU or average annual functional capacity units.

In summary, HGM combines both the wetland functionality (FCIs) developed with measured/estimated variables and areal extent of a site to generate a measure of change referred to as Functional Capacity Units (FCUs). Once the FCI and PWAA quantities have been determined, the FCU values can be mathematically derived with the following equation: FCU = FCI x Area (measured in acres). When the HGM process is employed, one FCU is equivalent to one optimally functioning wetland acre. HGM can be used to evaluate future conditions and the long-term effects of proposed alternatives by generating FCUs for wetland functions over several target years (TYs). In such cases, future wetland conditions are estimated for both Without Project and With Project conditions. Projected long-term effects of the project are reported in terms of Average

Annual Functional Capacity Units (AAFCUs) values. Based on the AAFCU results, alternative designs can be formulated and trade-off analyses can be simulated to optimize ecosystem restoration efforts.

Ecosystem Evaluation Using HGM

The process of applying the HGM methodology involves 12-steps. The following sections will define each step and provide a narrative of how it was applied specifically to the Va Shly'ay Akimel ER-FS. To begin, the 12 steps involved in the application of HGM while assessing this ecosystem project were:

1. Build a multi-disciplinary Evaluation Team (E-Team).
2. Define the project.
3. Determine goals and objectives, project life, and Target Years.
4. Cover type mapping of the site(s).
5. Select, modify, and/or create model(s).
6. Conduct field sampling.
7. Perform data management and statistical analyses.
8. Calculate Baseline Conditions.
9. Generate Without Project Conditions and calculate outputs.
10. Generate With Project Conditions and calculate outputs.
11. Develop relative value indices and perform trade-offs.
12. Report the results of the analyses.

Build a Multi-Disciplinary Evaluation Team (E-Team)

In HGM, an interagency, interdisciplinary evaluation team (E-Team) must be established to lead the model selection and model development phase of the project. Most importantly, this team must be composed of individuals that are well-versed in the natural history, ecology, and institutional constraints of the project area so that baseline and future conditions of the site(s) can be established.

The Va Shly'ay Akimel ER-FS activities were coincident with four other ecosystem restoration project feasibility studies in Arizona. Three of these projects are located in and around the Tucson, Arizona metropolitan area in reaches of the Santa Cruz and the Rillito Rivers. The fourth is located downstream of the Va Shly'ay Akimel project on the Salt River in the Phoenix, Arizona metropolitan area. Evaluation teams were developed for each of these projects and team commitments were established at a 3-day meeting held in Tucson, Arizona March 26 – 28, 2001. The goal of this meeting was to develop an Arizona Riverine Model based upon the HGM methodology. The overall evaluation team was comprised of individuals from agencies, project stakeholders, private

consultants, and academia. Together these individuals brought together the necessary technical expertise to support planning efforts requiring disciplines related to botany, soils, hydrology, and wildlife ecology. In addition, the project team included individuals responsible for project design and management. Those individuals that attended the March 2001 Tucson meeting are provided in Table 2-6 located below.

Table 2-7 provides a listing of the E-Team members that attended the Tucson Meeting, but were assigned specific tasks relating to the Va Shly'ay Akimel ER-FS. These individuals participated in the model selection and modification activities conducted at the Tucson meeting, but were also responsible for assisting the Va Shly'ay Akimel study managers with the selection of reference wetlands, collection of field data, data management and reduction, mathematical calculations, and alternative formulation specific to the study area. Field data were collected on two sampling events during the week of April 22, 2002. In June of 2002, the team met to discuss Baseline and Without Project results. The team then met in August, 2002 to project future With-Project conditions for the HGM models.

Table 2-6
Attendees to "The HGM Approach for the Arizona Streams Restoration Model Development Meeting", March 26-28, 2001, Tucson, Arizona.

Name	Organization /Company Name	Discipline	Name	Organization /Company Name	Discipline
Nick Adel Meyer	CE LA District	Hydrologist/Hydraulic Engr.	Robert MacAller	RECON	Biologist
Sam Arrowood	CE LA District – PHX	Study Manager	Kevin MacKay	Jones & Stokes	Ecosystem Restoration Planner
Kathy Bergmann	CE LA District – PHX	Study Manager	Ralph Marra	Tucson Water Department	Hydrologist/ Groundwater
Mark Briggs	Briggs. Inc.	Ecologist & Soils	Mike Martinez	USFWS	Biologist
Kelly Burks-Copes	CE ERDC	Facilitator	Glenn Mashburn	CE LA District	Hydraulic Engr.
Karen Dada	City of Phoenix	Study Manager	Mark Meyers	Marana	Biologist
Carla Danforth	Pima County	Hydrologist	Lynn Orchard	Pima County	Hydrologist
Dawn Daw	SRPMIC	Biologist	Dixie Padilla	SRPMIC	Range Manger
Steve Dibble	CE LA District – Env Coord.	Archeologist	Becky Pearson	Pima County	Civil Engineer
Kayla Eckert	CE LA District – PHX	Study Manager	Phil Pearthree	AZ Geological Survey	Hydrologist/ Geomorphologist

Table 2-6, continued.

Scott	CE LA District	Study Manager	Phil Rosen	Pima County	Ecologist &

Estergard	– PHX				Soils
Mike Fink	CE LA District – PHX	Biologist	Sherry Ruther	AZ G&F	Ecologist
Julia Fonseca	Pima County	Ecologist & Soils	Linda Smith	Tucson Water Department	Planner
Debra Fein	SRPMIC	Biologist	Pam Sponholtz	AZ G&F	Fisheries Biologist
Jonathan Fuller	JE Fuller & Assoc.	Hydrologist/ Geomorphologist	Julie Stromberg	Arizona State University	Botanist
Sara Gerke	Wass Gerke & Assoc., Inc.	Hydrologist	Michele Waltz	Jones & Stokes	Project Manager
Douglas Green	Arizona State University	Soils	Jennifer Ward	Marana	Study Manager
Tom Helfrich	Pima County	Hydrologist	Roland Wass	Wass Gerke & Assoc., Inc.	Aquatic Biologist & Soils
Collum Hunter	City of Mesa	Biogeochemical	Antisa Webb	CE ERDC	Facilitator
Martin Karpiscak	University of Arizona (OAL)	Biologist/Botanist & Soils	Bill Werner	AZ G&F	Ecologist
Ken Kingsley	SWCA	Biologist	Lori Woods	RECON	Biologist
Michael Langley	Jones & Stokes	Biologist			

Table 2-7
Va Shly'ay Akimel Evaluation Team

Name	Organization /Company Name	Discipline	Name	Organization /Company Name	Discipline
Nick Adelmeyer	CE LA District	Hydrologist/Hydraulic Engr.	Sarah Laughlan	CE LA District	Biologist
Kelly Burks-Copes	CE ERDC	Facilitator	Mike Martinez	USFWS	Biologist
Dawn Daw	SRPMIC	Biologist	Glenn Mashburn	CE LA District	Hydraulic Engr.
Kayla Eckert	CE LA District – PHX	Study Manager	Ralph Marra	Tucson Water Department	Hydrologist/ Groundwater
Debra Fein	SRPMIC	Biologist	Dixie Padilla	SRPMIC	Range Manger
Sara Gerke	Wass Gerke & Assoc., Inc.	Hydrologist	Michele Waltz	Jones & Stokes	Project Manager
Douglas Green	Arizona State University	Soils	Roland Wass	Wass Gerke & Assoc., Inc.	Aquatic Biologist & Soils
Collum Hunter	City of Mesa	Biogeochemical	Antisa Webb	CE ERDC	Facilitator
Michael Hrzic	CE LA District	Hydrologist/Hydraulic Engr	Bill Werner	AZ G&F	Ecologist

Defining the Va Shly'ay Akimel Project

The following information (geographic location, project purpose, presettlement conditions, and the overall ecosystem restoration approach) gathered by the LA District, Phoenix Planning Group has been used to the define the overall Va Shly'ay Akimel ER-FS project.

Geographic Location, Counties, Watersheds, and Primary Water Sources
The Va Shly'ay Akimel study area is located in south central Arizona, in the eastern portion of Maricopa County. The project study area is entirely within the Lower Salt watershed (USGS Cataloging Unit: 15060106). The project reach is bounded on the upstream by Granite Reef Diversion Dam and on the downstream by the Pima Freeway 101. The Salt River is ephemeral throughout this 17 mile reach.

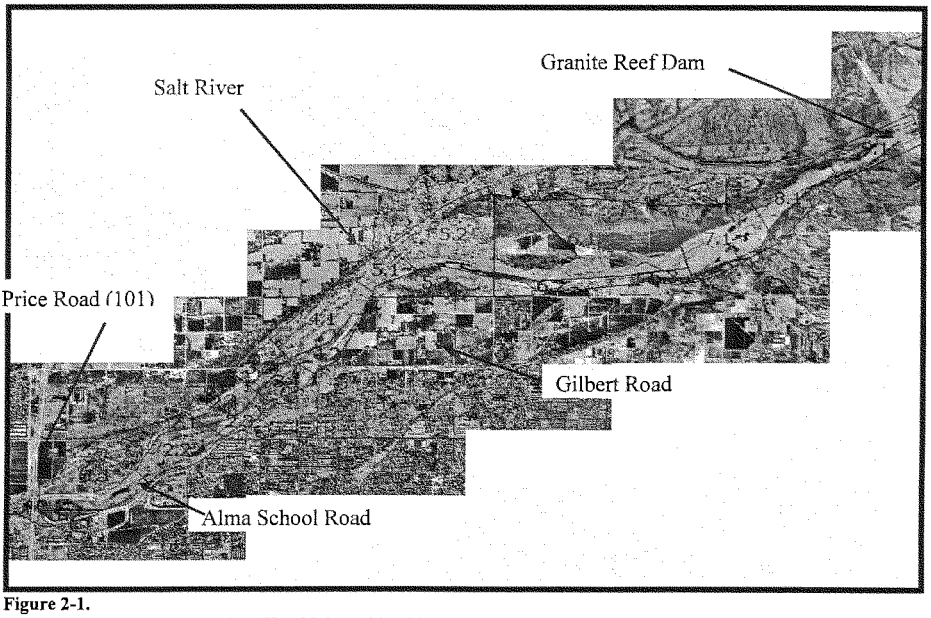


Figure 2-1.
Location Map for the Salt River Va Shly'ay Akimel Project identifying key features and project sub-areas.

The primary water resources for this project include five potential water sources: 1) Salt River Project water from the Hennessey drain and diversion channels, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water and 5) surface water available for use by the Pima Maricopa Indian Community, as shown in Figure 2-2. The current alternatives rely solely on surface

water. According to the Pima Maricopa Indian Community staff, a sufficient amount of this water can be allocated to this project. Therefore, only surface water outlet sources are considered. This does not however, preclude the necessity of a secondary water source in future alternative iterations.

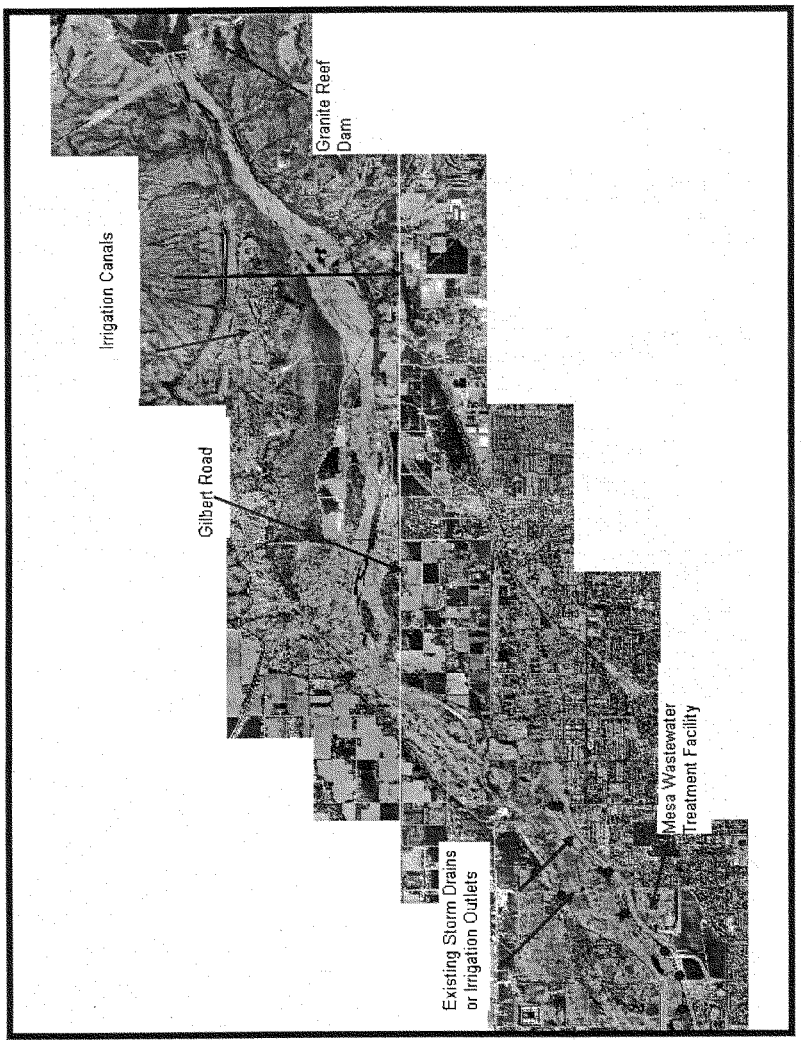


Figure 2-2

Potential primary water resources for the project.

Lead District
The Va Shly'ay Akimel ER-FS falls under the purview of the USACE Los Angeles District, South Pacific Division. The Environmental Coordinator is Mr. Steve Dibble, and the Study Manager is Ms. Kayla Eckert. The local sponsors are the Salt River Pima Maricopa Indian Community (SRPMIC) and the City of Mesa, Arizona. Study efforts are being conducted in coordination with USACE, SRPMIC, City of Mesa, other federal agencies, state resource agencies, and concerned members of the public.

Project Evolution and Purpose
Problems and opportunities were identified, defined, and assessed through coordination with local and regional agencies, the public involvement process, site assessments, interpretation of prior studies and reports, and review of existing water projects. Several significant problems and opportunities specific to the Va Shly'ay Akimel project reach are provided below:

- Degraded river and adjacent overbank areas, due to upstream water resources development, has eliminated native riparian plant species and wildlife habitat. Perennial base flow conditions critical to the needs of native vegetation no longer exists in the river corridor through the study area.

- The average depth to groundwater beneath the river channel is much greater than historic conditions. Riparian vegetation that depends on groundwater has largely disappeared from the river channel.

- Lack of natural flood regime. Hydrologic changes in the river system have impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and recruiting riparian vegetation.

- Land Use changes, including landfills and mineral extraction (sand and gravel mining), have degraded and contributing towards continued degradation of the river corridor.

- There is an opportunity to take advantage of existing open-water bodies in the river and adjacent properties as potential restoration sites.

- There is an opportunity to link other upstream and downstream restoration projects to provide a continuous habitat and flood control corridor. These include the authorized Rio Salado and Tres Rios projects.

The purpose of this feasibility study is ecosystem restoration on the Salt River. Riparian habitats are the most valuable wildlife habitats found within Arizona. Approximately 70-80% of all wildlife species in the state are obligate or totally dependent on these habitats for their survival. The cottonwood-willow (*Populus fremontii-Salix gooddingii*) community, in riparian systems, is by far the most valuable of all the community types to wildlife, especially birds.

Historically the Salt River was ephemeral and supported significant amounts of riparian and wetland vegetation. Unfortunately, much of the cottonwood-willow community has been lost or degraded over the past century. The opportunity exists to restore riparian habitat along the Salt River from the Granite Reef Diversion Dam to Price Road (101). Historical records contain descriptions of the cottonwood-willow community along the Salt River, which has since been lost to water management activities. Today the Salt River in the Va Shly'ay Akimel study area is ephemeral and dominated by facultative or obligate upland species. Exceptional hydro riparian areas exist in the upper most and downstream most sections and despite intensive land use and hydraulic alterations still persists as vestiges of important riparian areas. The Va Shly'ay Akimel project intends to restore new and augment these existing riparian areas.

Of the roughly 260,000 acres of floodplain in the state, only 4% or about 10,000 to 11,000 acres support this valuable wildlife community. Therefore, any opportunity to revegetate floodplain habitats with this community is a valuable addition to the landscape and the wildlife.

Presettlement Conditions of the Region
Along the Va Shly'ay Akimel reaches of the Salt River, water once flowed perennially and supported substantial growth of cottonwoods, willows, and mesquites. Historical accounts of conditions on the Salt River by Hiram C. Hodge (1877) describe a tree-lined, narrow river approximately 200-ft wide and 2 to 4-feet deep during low water periods. During the past 150 years, the lower Salt River underwent modifications attributable to both natural and anthropogenic functions and activities.

The Ecosystem Restoration Approach
By definition, an ecosystem can be described as an integrated unit, identified as a biotic community conjoined with its physical environment. Inherent within this definition is the concept of a structural and functional system, unified through life processes. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which the physical, chemical, and biological processes form interactive subsystems. Ecosystem restoration efforts can be directed at different-sized ecosystems within the nested set, spanning multiple states, more localized watersheds, or smaller complexes of habitat. The Va Shly'ay Akimel project provides a unique opportunity for ecosystem restoration. The study site is small enough to adequately assess the biotic communities and implement meaningful restoration efforts, yet large enough to function as an important biological area in an urban setting, providing habitat and corridor to species in and around the study site.

Discharges to the Va Shly'ay Akimel reach of the Salt River are controlled by a series of dams located upon the upper Salt and Verde River systems. These dams create reservoir storage and are integral to the social and economic development of the downstream communities. However, coupled with mineral extraction, recreation, illegal dumping, and stressors arising from adjacent land uses the altered hydrology of the reach has resulted in degradation of riparian habitat and its associated habitat benefits in the project reach. The fact that the project reach has been altered from a perennial to an ephemeral system drives the Va Shly'ay Akimel ES-FS. As such, for those areas within the project that have access to an existing or proposed perennial water sources, hydro riparian cottonwood and willow communities could be established or existing one augmented. At areas within the project reach that lack a perennial water source, facultative upland vegetation native to the Sonoran desert could be restored and/or created.

Setting Planning Objectives and Goals

Objectives

The Va Shly'ay Akimel project planning objectives were developed by the LA District USACE Phoenix office. The objectives developed reflect the problems and opportunities and represent desired positive changes in the Without Project conditions. The first planning objective is to increase the native riparian plant and wildlife habitat values, diversity and functions from the Granite Reef Dam to the Pima Freeway 101. Elements of diversity include establishing multiple native riparian plant species, providing sufficient open space for wildlife, and providing open-water aquatic and wetland features for wildlife benefits. Another objective of this project is to attract wetland and riparian avian species to the study area. Further, this project should establish and augment the presence of native species diversity in the study area, while suppressing undesirable and nonnative vegetation, fish, and wildlife species.

During October, 2002, members of the Va Shly'ay Akimel E-Team and the study managers developed a refined list of objectives and identified constraints to guide the formulation of alternatives. The six (6) objectives are provided in Table 2-8.

Table 2-8
Va Shly'ay Akimel study objectives and constraints refined during an E-Team Meeting October 17, 2002.

Objective	Constraint(s)
Mimic the mosaic of riparian habitat found in HGM Arizona reference sites.	Do not introduce non-native species. Do not worsen vector problems. Do not cause erosion problems. Do not increase regulatory burden. Do not increase bird strike hazards.
Reduce flood damages on the Salt River between Granite Reef Dam and the Pima Freeway (101) through the year 2050.	Do not worsen flood hazards. Minimize structural solutions.

Table 2-8, continued.

Increase the number of sustainable acres of Cottonwood-Willow forests.	Accept the loss of existing habitat by offsetting losses with creation of new cottonwood-willow forest at a level of 0.5 acres.
Increase the number of sustainable acres of Mesquite Bosque in the project reach.	No net loss of mesquite habitat.
Increase the number of sustainable acres of desert riparian scrub shrub habitat.	Accept some loss of this habitat type due to creation of new habitat types.
Increase the number of sustainable acres of emergent wetlands.	Accept loss of up to 50% of river bottom and offset losses with the creation of new river bottom that includes emergent marsh features.
Convert 656.3 acres of degraded sand and gravel, agricultural, desert and river bottom areas into sustainable riparian habitat.	Coordinate with Salt River Sand and Rock to the level that the Tribal Council desires. Do not degrade the river's economic benefits to the community.
Secure the local project sponsor's commitment to water supply for the life of the project.	Remain sensitive to SRPMIC citizens concerns regarding use of treated effluents. Do not limit use to existing drains and outfalls. Do not degrade or otherwise negatively impact groundwater resources. Do not ignore limited water resources.
Provide appropriate level of recreation consistent with environmental restoration.	Do not increase public access "too much". Provide appropriate level of access and egress to/from the river corridor.
Reestablish culturally significant resources.	Do not degrade existing cultural sites.
Increase public awareness of the Salt River ecology.	
Establish a comprehensive Operations and Maintenance manual including a monitoring and adaptive management plan.	
Establish appropriate connectivity and coordination with downstream ecorestoration project(s).	

Goals

The primary goal in the Va Shly'ay Akimel ER-FS is ecosystem restoration. The ecosystem restoration goal consists of hydraulic, vegetation, then eventually species restoration. First, hydraulic connections between the river and washes, channels, basins,

and adjacent vegetation communities would be restored to the extent practicable. These restoration efforts should mimic historic, natural conditions harvesting water, trapping sediments, facilitating water absorption, and providing water to vegetation. Next, the vegetation communities, both in and adjacent to the river channel, should be enhanced and additional planting should occur. Irrigation would be necessary to help establish some vegetation communities. With the restoration of the vegetation communities, habitat structure should improve with a commensurate increase in the wildlife species in the area. This approach to restoration, focusing on the wetland functions as well as the habitat and vegetation structure, eventually will lead to a more natural ecosystem with wetland functions, habitat structure, and dynamic processes that are currently degraded.

As part of the process of setting project goals, performance targets were established for HGM model functions that indicate the quality of the functions. These are discussed in greater detail in the section titled, "Selecting and Modifying the FCI Models for HGM Analysis" of this report.

The Va Shly'ay Akimel Team considered various desert riparian vegetation communities and eventually identified five (5) that were deemed important to the success of this ecosystem restoration effort. These communities include:

Rank	Community
1	Cottonwood/Willow Forest
2	Mesquite
3	Emergent Wetlands
4	Lower Sonoran Desert (Scrub/shrub)
5	River Bottom

The general physical requirements for implementation of each habitat type are as follows:

1) Cottonwood/Willow (CW) – CW stands are restricted to the near over bank area of streams and rivers, or other areas with saturated soil conditions. They require a water table, or saturated soil conditions, less than 10-ft below the ground surface and have annual water demands ranging from 4 to 8.5 ft/yr. For the purpose of this study, the assumed water demand is an average of 6.3 ft/yr. Soils range from finer sediments to sandy soils that are low in nutrients, allowing for maximum water retention and therefore a higher survival rate of seedlings in select areas. In areas where grading may be required, uneven grading is most beneficial, allowing for depressions where sediment can collect and shelter seeds for establishment. Due to the relatively high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands will rely on a local Surface Braided Irrigation Network (SBIN) for its water needs.

2) Mesquite (MS) – MS are commonly found 5-20 feet above the river channel where soil moisture is sufficient. They require a water table, or semi-saturated soil conditions, 10-30 ft below surface elevation, and can withstand occasional saturated conditions 1-3 feet below surface. The annual water demand for MS is between 2.0 and 4.0 ft/yr. For the purpose of this study, assume a water demand average of 3.0 ft/yr. Soils can be fine to gravelly with some rocky areas and are typically rich due to nitrogen fixation. A drip irrigation system may be necessary to establish the MS. However, once established, the MS will rely on a SBIN for its water needs. Previous restoration efforts have shown that MS can survive on natural precipitation alone, even when groundwater is not available. However, this cannot be assumed true for all locations. Therefore, a site specific evaluation should be performed before determining if or how much supplemental water is required.

3) Emergent Wetland (WT) - WT areas can consist of open water, submerged vegetation or muddy shorelines, all requiring a high water table level at or near the surface. The annual water demand is between 6 and 16 ft/yr. For the purpose of this study, assume a water demand average of 12.5 ft/yr.

   Due to the porous soils found in this project area, lining the WT will be required to maintain surface water in areas not underlain by low permeability soils. Excavation and layering of a silt clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is recommended. The proposed soil structure would reduce disturbance of the soil-clay layer by reducing piping of fine material and reducing turbulent forces acting on the layer.

   Storm drain outlets located near WT will require erosion control and energy dissipation measures at the outlets to prevent scouring. To distribute water from the WT laterally, a series of drainage ditches will be constructed from the WT and incorporated into other areas that require irrigation. The ditches will be semicircular in shape with a top width of 4 ft and maximum depth of 2 ft. The drains will increase lateral dispersion of runoff to maximize the storm water benefit.

   The WT will also be designed with an outlet channel leading to the main channel. The preliminary design of the outlet channel calls for a 20 ft bottom width, 4 ft maximum depth, 2:1 side slopes, 300 ft in length and large cobble bottom. Design Q =. Not all proposed WT would require an outlet channel.

4) Sonoran Desert (SD) – The specific vegetation species can vary depending upon the site's soil aggregate type. However, proposed vegetation types will not require saturated soil conditions and will have an annual water demand between 0.5 to 2.5 ft/yr. For the purpose of this study, assume an average water demand of 2.0 ft/yr. The SD may need to be periodically inundated the first 1-5 yrs to

establish the vegetation. Once established, SD should be sustained by annual precipitation or with periodic inundation during extreme drought periods.

5) River Bottom (RB) - RB will require only surface material reshaping including, partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. River bottom areas may also require hydro-seeding with a variety of native river bottom shrub species to help establish vegetation. These plants will be sustained with natural precipitation and any tail water that may enter the river from other feature irrigation systems. Irrigation is not recommended.

In general, wetlands and cottonwood willow forests require more water than Sonoran desert and mesquite bosques, the latter which typically occur adjacent to river channel and are subject to periodic inundation. The goal is to restore these vegetation communities to a functioning "PWAA" with hydrologic connections to the river and other ecosystem functions. Additional details regarding performance targets are discussed in the section titled "Cover Typing and PWAAS".

Selection of Project Life and Target Years

Given the project goals and objectives, a "project life" of 50 years was designated for the Va Shly'ay Akimel ER-FS. A series of target years within this 50-year setting were designated to generate projections of both Without Project and With Project activities. Target years for the study include TY0 (baseline conditions), TY1 (year of construction), TY6 (year the planting efforts would be completed), TY26 (year to capture significant anticipated ecosystem changes), and TY51 (end of project). TY26 was added to capture significant anticipated changes in vegetative cover, structure, and hydraulic functions in the study area as the habitat develop and mature.

Cover Typing

The goal of the Va Shly'ay Akimel ecosystem restoration study is to restore significant ecosystem functions, structure, and dynamic processes that have been degraded. In the HGM process, the study area is divided into manageable sections and quantified in terms of hectares or acres, in order to evaluate the habitat conditions for a species or community. Such sections are called cover types or PWAAs. A cover type is a parcel of land (or water) that has similar physical, chemical, and biological characteristics contained within its borders. A PWAA is an area of land (or water) that has similar physical, chemical, and biological characteristics, as well as a hydrologic connection to the ecosystem. In HGM the basic difference between a PWAA and a cover type is that the PWAA has a functioning hydraulic connection to the ecosystem. For example, a mesquite bosque area that is periodically inundated by water flow from the river channel

is considered to be a mesquite PWAA, whereas a mesquite bosque area that is disconnected from the hydraulics of the river channel (i.e., behind a soil cement levee) and is not inundated, is considered a mesquite cover type outside the PWAA. The purpose in distinguishing between PWAA's and cover types in HGM is to emphasize the functional hydrologic connection between ecosystem components. Frequently in HGM, cover types (i.e., buffer, ag crop, etc.) are listed in tables along with PWAA's for convenience, but it is important to remember the difference.

In HGM, the functionality of each PWAA is determined by measuring variables that are associated with functions. Some examples of HGM variables include course woody debris, porosity, subsurface inflow, flood-prone area, and depth to saturated soil. In most instances, these variables are measured using aerial photographs, maps, or on-site sampling activities.

For the Va Shly'ay Akimel ER-FS, PWAA's and cover types were delineated. The list of existing cover types in the study area along with the baseline acreages is listed in Table 2-9. In addition, PWAAs were identified that reflect the desired functioning vegetation communities in the restoration alternatives. These "newly developed" PWAAs are also listed in Table 2-9.

Table 2-9
Cover types and baseline acreages for the Va Shly'ay Akimel study area.

No.	Code	PWAA Description	Baseline Acres (TY0)
1	AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70
2	BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00
3	CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50
4	DESERT	Desert Areas - Bare Earth, Cacti, Rabbitbush, Acacia	961.90
5	DITCHES	Ditches	56.50
6	MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10
7	NEWBUFFER	Newly Planted Upland Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00
8	NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00
9	NEWMESQUIT	Newly Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00
10	NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00
11	NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00
12	NEWSCRUB	Newly Planted Scrub-Shrublands in the Active Channel	0.00
13	OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50
14	PARKS	Parks and Recreation Areas	9.60
15	RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60
16	SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60
17	SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.10
18	SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90
19	URBAN	Existing Residential, Industrial and Transportation Avenues	341.60
		TOTAL:	5870.60

After the PWAAs were identified, the E-Team attempted to set quantifiable restoration performance measures for the proposed study (Table 2-10). In most instances, these success criteria focused on the recovery of a specific PWAA, defined on the basis of quantity recovered (measured in acres), and obtainable habitat quality (measured in terms of Variable Suitability Indices or VSIs).

Table 2-10
Goals and objectives per PWAA.

PWAA Code	PWAA Description	Target Acreages	Notes
CTWWFOR	Existing Cottonwood-Willow Forests in Active Channel	63.0	Accept 10% loss of Existing CTWWFOR Acreage
MESQUITE	Existing Mesquite Woodlands – on the Terraces and in Active Channel	4.0	Preserve/Protect Existing Mesquite
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests	150.0	Convert from SANDGRAVEL
NEWMESQUIT	Newly Developed Mesquite Woodlands on Terraces and in Active Channel	300.0	CONVERT from SANDGRAVEL, DESERT
NEWRVRBOTM	Newly Developed River Bottom Areas within the Active Channel – Largely Unvegetated (Includes Emergents)	75.0	Convert from SANDGRAVEL
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	1,000.0	Convert from SANDGRAVEL
RIVERBOTTOM	Existing River Bottom Areas within the Active Channel – Largely Unvegetated (Includes Emergents)	334.0	Accept no net loss of RIVERBOTTOM
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel	2056.0	Preserve Existing SCRUBSHRUB

Selecting and Modifying the HGM Models

In HGM assessments, FCI models for HGM subclasses are only just beginning to become available for application. The ERDC-EL team is currently leading a research work unit under the Ecosystem Management and Restoration Research Program (EMRRP) for the

development of HGM subclass models. The subclass model used for the Va Shly'ay Akimel study is the Arizona Riverine Overbank Model. In HGM, wetland functions are identified and expressed in terms of a mathematical model, or FCI model. Several FCI models are usually selected for a HGM assessment and justifications are given that address the applicability of the FCI model to the wetland functions, as well as, the regional model. Some models selected are often associated directly with the proposed restoration improvements for the project, such as plant communities, or habitat structure. Other models may be selected that focus on water functions, such as water storage or channel dynamics, or biogeochemical functions such as nutrient cycling or detention of particles.

Models can be single formula, considering only a few variables, or multiple- formula, considering many variables. An example of a single formula model would be the dynamic subsurface water storage function, which considers the depth to saturated soil. An example of a multiple formula model would be the dynamic surface water storage and energy dissipation function which considers water variables such as frequency of flooding and the flood-prone area, as well as, habitat variables such as total vegetation volume and course woody debris. For the Arizona Riverine Overbank HGM Model, 11 FCI models were selected that can be sorted into three general "groups". Four FCI models were selected that focus on water functions, three models were selected that focus on biogeochemical functions, and four models were selected that focus on habitat functions. These FCI model functions are listed in Table 2-11, along with the associated variables for each function formula, while Appendix 1 provides details of the mathematical calculations used for each function. It is important to note that many of the variables are applicable to several of the functions in all three of the groups.

Table 2-11
FCI function models, variables, and performance target.

Code	Name	Variable Association	Performance WP TY 51 Target (FCI)	Performance WP TY51 Target (AAFCUs)	Anticipated WP TY 51 AAFCU Gains
CHANNELDYN	Function 1: Maintenance of Channel Dynamics	FPA Q SED	0.28	689	0
WATSTORENR	Function 2: Dynamic Surface Water Storage/Energy Dissipation	FPA FEQ TOPO	0.57	1324	369
WATSTORLNG	Function 3: Long Term Surface Water Storage	PORE SUBIN TOPO	0.09	234	163
WATSTORSUB	Function 4: Dynamic Subsurface Water Storage	DEPSATSED	0.08	194	63

Table 2-11, continued.

NUTRIENT	Function 5: Nutrient Cycling	CWD DEC'AY FWD	0.50	1152	346
ELEMENTS	Function 6: Detention of Imported Elements and Compounds	FREQ LITTER PORE	0.33	821	95
DETPARTICL	Function 7: Detention of Particles	FPA FWD SED	0.50	1157	456
PLANTS	Function 8: Maintain Characteristic Plant Communities	SPECRICH TVV WIS	0.70	1617	264
HABSTRUCT	Function 9: Maintain Spatial Structure of Habitat	FWD LITTER VEGSTRATA	0.45	1040	151
INTERSPERS	Function 10: Maintain Interspersion and Connectivity	FREQ TOPO TRIB	0.40	926	72
			Average Net AAFCUs	**915**	**198**

Variables Used in the HGM FCI Models

Thirty-five (35) HGM variables was considered for use in the Arizona Riverine HGM Model development. Some of the variables were deemed not necessary and/or redundant so the Master List for the Va Shly'ay Akimel ER-FS resulted in a total of 27 variables as shown in Table 2-12 along with a brief description. The variables that were changed or deleted from the original list of 35 are provided in Appendix A, along with the justifications for their removal or modification.

Table 2-12
Variable names and descriptions used in the Va Shly'ay Akimel ER-FS HGM assessment.

Variable Code	Variable Description	Variable Code	Variable Description
AGSA	Algal Growth Surface Area as an indicator of past inundation.	LITTER	Abundance of leaf litter and other detrital matter in the FPA.
BUFFCOV	Percent of native vegetation cover in the buffer.	PORE	Soil pore spaces available for storing subsurface water. Performance is related to soil texture and permeability.

Table 2-12, continued.

BUFFLENGTH	Percent of area with sufficient buffer.	Q	Alterations of hydroregime that affect the assessment area.
BUFFWIDTH	Width of Buffer (m).	SED	Extent of sediment delivery to the water/wetland from culturally accelerated sources.
CONTIG	Contiguous vegetation cover between waters/wetlands and uplands (%).	SHRUB	Abundance as measured through vegetation volume of shrubs (multiple stems, woody species).
CWD	Abundance of dead and down woody debris ≥ 2.5" in diameter (coarse) .	SPECRICH	Species richness.
DEC'AY	The presence of coarse woody debris in various stages of decomposition.	SUBIN	Subsurface flow into the water/wetland via interflow and return flow.
DEPSATSED	Depth of saturated sediments (m).	SURFIN	Surface inflow to the wetland via sheetflow.
FPA	Floodprone area as defined by the projection of a horizontal plane at a level twice the bankfull thalweg depth.	TOPO	Macro (large scale) and microtopographic (small scale) relief. Macrotopography generally refers to large-scale features such as secondary channels and in-channel ponds. Microtopography generally refers to small-scale features such as pit-and-mound and hummock-and-hollow patterns.
FREQ	Frequency of inundation.	TREE	Abundance as measured through vegetation volume of trees.
FWD	Abundance of dead and down woody debris < 2.5" in diameter (fine).	TRIB	Presence of connected tributaries.
HERB	Abundance as measured through vegetation volume of herbaceous species.	VEGSTRATA	Number of vegetation layers present.
INVASIVES	Abundance of invasive species.	WIS	Wetland indicator score.
LANDUSE	Type of adjacent landuse.		

FCI Model Selections

The team identified five (5) communities (PWAAs) and four (4) wetland functions that were deemed important to the success of the wetland subclasses. These PWAAs and FCI models were selected on the basis of their representation of ongoing critical ecosystem processes within each PWAA. Table 2-12 above lists the functions, associated variable, and performance target for FCIs. The five priority PWAAs and the four priority FCI model functions selected by the Team include:

Rank	Community
1	Cottonwood/Willow Forest
2	Mesquite
3	Wetlands
4	Lower Sonoran Desert (Scrub/shrub)
5	River Bottom

Rank	Function
1	Function 1 – Characteristic Channel Dynamics
2	Function 3 – Long-Term Surface Water Storage
3	Function 9– Maintain Spatial Structure of Habitat
4	Function 8 – Maintain Characteristic Plant Communities

Performance targets for the study are also listed in Table 2-12. The reference sites for Va Shly'ay Akimel ER-FS projected included an area at the confluence of the Salt and Verde River systems and a reach of the Hassayampa River located on preserve lands immediately downstream of Wickenburg, Arizona. Detailed locations and photographs of the Salt/Verde and Hassayampa reference wetland sites are included in Appendix A as are those for three other Arizona reference sites.

Overall, the existing baseline conditions in the study site ranged from very poor to mediocre. Only Function 8: Maintain Characteristic Plant Communities, had an FCI $\geq$ 0.50. The remaining functions had FCIs that ranged from 0.047 (Function 3) to 0.422 (Function 2: Dynamic Surface Water Storage/Energy Dissipation). At the Hassayampa reference site, FCI values ranged from 1.0 for Function 1, to 0.467 for Function 5: Nutrient Cycling, which was the only function exhibiting an FCI < 0.50. The second reference site, the Salt River confluence with the Verde River, produced two functional models exhibiting FCIs less than 0.50; Function 3 and 4. All remaining functions for the

Salt River reference site ranged from 0.554 to 0.778. Given this information, it is reasonable to expect that there is a lot of room for improvement at the study site; however, realistic performance targets must be set. For example, with such poor existing study site conditions, and only fair conditions at one of the reference sites (Salt/Verde Confluence), it would be unrealistic to think that restoring conditions to a 0.9 or 1.0 FCI is possible. It is reasonable to assume that the study site can be restored to a level of quality close to the reference site, which would be improving the existing conditions two, three, or in some cases, four times better than the existing conditions. Setting what seems to be somewhat modest performance targets of 0.5 for the FCIs, will still be a dramatic improvement compared to the current study site conditions. In addition, restoration would greatly increase the habitat and wildlife value of the area, not to mention the importance of the area as a wildlife corridor for migratory birds, as well as, species traversing the project area from surrounding habitat types and downstream restored environments.

Conducting the Field Sampling

Adequate site characterization is the critical foundational stem in the HGM process. A variety of methods to measure environmental variables exist, to produce a successful HGM, methods used to characterize the project area and reference reaches should have the following features:

1. Repeatability – different individuals after adequate training should produce data that will lead to similar conclusions about a site.
2. Based in scientific literature – The method should have a solid foundation in the scientific literature, this ensures data produced and used in the HGM process are creditable with the scientific community, free as possible from bias, and defendable in the legal arena.
3. Quantitative – Quantitative data are easier to compare across study sites and through time.
4. Appropriately sensitive – The method should focus on data that are sensitive to the objectives of the study and change on a temporal scale that is appropriate. Data that are too sensitive to environmental conditions will introduce excess noise into the model limiting the usefulness of the model. Biomass of annual species offers a good example of a variable that is very sensitive to environmental conditions. Biomass of annuals can vary several fold depending upon environmental conditions prior to sampling.
5. Inexpensive and easy to measure – In as much as possible, the method should involve a minimum of time and expense to produce the desired data.

The above considerations inevitably involve trade-offs for example, the best method to collect species richness data may be costly and involve multiple site visits. This would

conflict with the objective of the current HGM sampling which was to produce a "snapshot" of the study site and reference reaches. Methods that produce data with the best mix of the above features can be selected by consultation with experts experienced in the local area.

The data collected for the variables were specific to functions within the Arizona Riverine HGM model. The variables can be divided into two major groups, data that were collected without field sampling and data that required sampling in the field. Data collected without field sampling include information on historical conditions, landscape scale habitat conditions, land use characteristics, ownership, pattern of ownership and jurisdictional boundaries. Field level characterization for the Va Shly'ay Akimel study included gathering data on water quality geochemistry, hydrology, fluvial geomorphology, substrate, flora and fauna. Special attention was given to adjacent land use, habitat alteration, and presence of invasive species. Much of the data collected was stored in a GIS for later use in the planning effort.

Basic site characterization and data collection are the first steps in inventorying an ecosystem restoration site (USACE 2000; Fischenich 1999). Characterization for the Va Shly'ay Akimel study included gathering data concerning water quality, geochemistry, hydrology, fluvial geomorphology, substrate conditions, flora, and fauna, and to the greatest extent possible, identifications of underlying stressors in the region. In particular, land use activities, physical habitat alterations, and invasive species were identified. In addition to the physical and chemical characteristics of the study area, land ownership and regulatory jurisdictions played an important role in determining opportunities for restoration. Much of this information is geographically based, and is stored in a geographic information system (GIS). As part of the basic site characterization, historical data on landscape-scale habitat conditions, land use characteristics, and ownership patterns was reviewed. Site- and landscape-level data were collected in the spring of 2002. These datasets were used to characterize the baseline conditions of the Va Shly'ay Akimel study area.

Variables Measured in the Field

Many FCI variables were measured during the field sampling effort. These variables are described in detail in the Master Variable List provided in Appendix A. Protocols used in obtaining these data are also listed in these tables. Specific methods, techniques and assumptions made in measuring these VSI/FCI variables is discussed below, as is the logic behind a given variables use to capture the wetland function. PWAAs in which the variables were measured are also provided.

The variable AGSA was determined by estimating the percent of a 1-meter quadrant with algae, algal remnants, or water present. AGSA is used in two FCI functions NUTRIENTS AND ELEMENTS. The logic being that algal growth is an indicator for moisture at the land surface. If there is water present long enough for algal mats to grow, then the water is there long enough for vegetation to take up nutrients in the system. AGSA was measured in the following PWAAs: CRWWFOR, RIVERBOTTOM,

MESQUITE, SCRUBSHRUB.

BUFFCOV was measured as the percent cover of native vegetation versus bare-ground and/or non-native vegetation within a 1-meter quadrat. BUFFCOV is used in the BUFFER function where buffer cover is important for protecting animals as they travel from one wetland area to another or to upland areas. Native vegetation is highly preferable to non-native vegetation. BUFFER is the only PWAA in which this variable is measurable.

CWD or coarse woody debris was measured as class data. In all there were seven classes:

0 = No data
1 = CWD 9-15%
2 = CWD 6-8%
3 = CWD > 15%
4 = CWD 1-2%
5 = CWD 0 - < 1%, recoverable
6 = CWD 0 - < 1%, not recoverable

The CWD variable is used in four (4) FCI functions. In WATSTORENR, coarse woody debris along with microtopography and trees serve as indicators of roughness as a surrogate for Manning's "n" values. In the function NUTRIENT, coarse woody debris in various stages of decay indicates that the function is on-going and sustainable. The variable DETPARTICL considers coarse woody debris because they provide surface roughness which reduces water velocity. Low velocity areas allow organic and inorganic particles to settle out of suspension and be retained. CWD is also an important variable of the function HABSTRUCT. Coarse woody debris detain coarse and fine particulate matter, and therefore influences channel morphology (e.g. pool-riffle complexes). Coarse woody debris also provides energy sources and substrates for microbial activity that is important in nutrient cycling and other biogeochemical processes. Coarse woody debris also provide habitat. PWAAs in which CWD was measured include CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

FWD is another class data. In this case, 8 classes were utilized to describe the range of FWD found in a given PWAA. These data are provided below:

0 = No data
1 = 38-68% FWD
2 = 25-37% FWD
3 = > 73% FWD
4 = 13-24% FWD
5 = 3-12% FWD
6 = 0-2% FWD, recoverable
7 = 0-2% FWD, unrecoverable

FWD is used in three functions, NUTRIENT, DEPARTICL, and HABSTRUCT. FWD in various stages of decay indicates that the function NUTRIENT is on-going and sustainable. In the function DETPARTICL, FWD provide surface roughness which reduces velocity. Organic and inorganic particulates can then settle out and be detained. Fine woody debris contribute to HABSTURCT in that they provide energy sources and substrates for microbial activity that is important in nutrient cycling and other

biogeochemical processes. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB are PWAAs where this variable was measured.

The variable HERB was measured by recording the number of decimeter hits within each meter interval as delineated on a long rod. A hit is defined as any vegetation within a 10-cm radius of the rod, per vertical decimeter. Estimates of volume above 10-m in height are recorded as either three (3) or seven (7) hits per interval. Such estimates can be based on comparison with lower intervals where hits can be directly measured. Four (4) functions utilize this variable. NUTRIENT is impacted in that herbaceous vegetation cycles nutrients through soil and water nutrient uptake, biomass accumulation and litter production. ELEMENTS considers herbaceous vegetation because the vegetation is a long term sink for elements and compounds. Vegetation slows the velocity of water which must move around it and provides roughness to the systems, hence HERB influences the function DETPARTICL. The roughness dissipates hydrologic energy and allows for particulate settling to occur. HERB is also a component of the function PLANTS. In arid regions, the abundance of biomass or vegetation is a key factor in influencing animal abundance and diversity. For example, bird species abundance and diversity in arid regions increases with vegetation volume. Vegetation volume provides a 3-dimesnional measure of abundance and serves as a rough surrogate for above-ground vegetation biomass. It thus provides more information about structural habitat value than does 2-dimensional cover estimates. PWAAs in which HERB was measured included CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

The variable LITTER uses eight (8) data classes which are shown below:

0 = No data	4 = 9-17% Litter cover
1 = 28-46% Litter cover	5 = 2-8% Litter cover
2 = 18-27% Litter cover	6 = 0-1% Litter cover, recoverable
3 = < 46% Litter cover	7 = 0-1% Litter cover, unrecoverable

In the functions NUTRIENT and ELEMENTS, this variable is considered because the litter/detrital layer of debris provides energy and substrates for microbial processes which result in the conversion of elements and compounds. LITTER is also an important variable of the function HABSTRUCT in that the litter layer is important for cover, food, and nesting of various vertebrates and invertebrates. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where LITTER was assessed.

The SHRUB variable was measured using the methods described for the variable HERB. The number of decimeter hits within each vertical meter interval was recorded and subsequently converted to class data as shown below:

0 = No data	4 = 849 – 1697 stems/acre
1 = 2547 – 4245 stems/acre	5 = 170 – 848 stems/acre
2 = 1698 – 2546 stems/acre	6 = 0 – 169 stems/acre, recoverable
3 = > 4245 stems/acre	7 = 0 – 169 stems/acre, unrecoverable

In the function NUTRIENT, shrubs cycle nutrients soil and water uptake, biomass accumulation, and litter production. SHRUB measurements are also used in the function ELEMENTS because shrubs are long-term sinks for elements and compounds. Shrubs slow the velocity of water moving through and around them and provide roughness to the system which dissipates energy and facilitates particulate settling. Therefore, the function DETPARTICL considers the variable SHRUB. SHRUB is also in the function PLANTS because in arid regions, the abundance or biomass of vegetation is a key factor influencing animal abundance and diversity. SHRUB was measured in the following PWAAs: CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

SPECRICH was measured by counting, and if possible identifying, the number of plant species present. Although this project only measured SPECRICH in the late spring, herbaceous sampling should be conducted twice per year, once in the summer dry season, and once in the summer rainy season. SPECIRICH was used only in the PLANTS function. It was used in PLANTS because some measure of plant species diversity is needed if one is to assess the function of maintaining characteristic plant communities. Riparian ecosystems can be species-rich. Maintaining or enhancing regional biodiversity is a key riverine function. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where SPECRICH was measured.

The variable TOPO refers to both macro and microtopographical features. TOPO was measured in the field using the classes indicated below:

0 = No data
1 = Macro and microtopic relief
2 = Homogenous surfaces with macro and microtopic relief
3 = Homogenous surface and lacks macro and microtopic relief
4 = Steep bank, recoverable
5 = Steep bank, unrecoverable

Six (6) functions utilize the TOPO variable. WATSTORENR and WATSTORLNG consider it because topographic features such as pits and ponds provide areas that can store water as well as provide roughness. The function DETPARTICL considers this variable because macro and microtopographic relief provide surface roughness and complexity to the system. Flowing water must move into, over, through, or around these features. Velocity is reduced, facilitating detention of particulates. TOPO is also a variable used in the functions PLANTS, HABSTRUCT, and INTERSPERS. Topographical complexity offers a variety of ecozones and ecotones that supply the habitat needs of wetland and edge-adapted species. PWAAs in which TOPO was measured include: CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB.

The variable TREE was measured in the field using a technique similar to that described for the variable HERB. TREE was measured by recording the number of decimeter hits within each vertical meter interval on a long rod. A hit was defined as any vegetation

within a 10-cm radius of the rod, per vertical decimeter. Estimates of TREE in vegetation greater than 10-m tall was done by estimate. These estimates were based upon comparisons with lower intervals where hits could be directly measured. Five (5) functions utilize the variable TREE. WATSTORENR considers it because coarse woody debris along with microtopography and trees serve as indicators of roughness as a substitute for Manning's "n" values. The function NUTRIENT uses TREE because trees cycle nutrients through soil and water nutrient uptake, biomass accumulation, and litter production. Trees are long-term sinks for elements and compounds, hence the function ELEMENTS considers the variable TREES. The function DETPARTICL uses the variable TREES because trees slow the velocity of water, dissipating energy, and facilitating particle deposition and detention. PLANTS also uses this variable because tree density, as determined from reference standards, is characteristic of healthy systems. Tree density will vary with degree of perturbation. CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB were the PWAAs where the variable TREE was measured.

The last variable measured in the field was VEGSTRATA. VEGSTRATA was measured by recording the number of layers present in selected areas of the CTWWFOR, RIVERBOTTOM, MESQUITE, and SCRUBSHRUB PWAAs. The layers included:

Tall (> 10-m) broad-leaved tree	Short microphyllous shrub
Short broad-leaved tree	Vine
Tall microphyllous tree	Epiphyte
Short microphyllous tree	Bunch grass
Tall (> 1-m) broad-leaved shrub	Non-bunch grass
Short broad-leaved shrub	Forb
Tall (> 1-m) microphyllous shrub	Lichens or biotic soil crusts

HABSTRUCT is the only function to utilize this variable. As the number of vegetation layers at a site increases, so do the number of niches for bird species. The use of 1-m height increments may provide a more sensitive measure of this diversity-related structural property than does the use of only 3-l'ayers (e.g., ground, shrub, tree).

Variables Obtained Without Field Sampling
Some variables could be obtained through various historical records, aerial photographs, or mathematical calculations rather than through active field sampling. The FCI variables that were not measured with field sampling techniques are located below:

BUFFLENTH	PORE
BUFFWIDTH	Q
CONTIG	SED
DEPSATSED	SUBIN
FPA	SURFIN
FREQ	TRIB
LANDUSE	WIS

Certain variables were quantified without field sampling. Data to quantify these variables were derived from air photos, flow records, ownership and similar data types. FCI variables quantified without field sampling are discussed below. Variable quantified with out field sampling were divided into landscape level and site specific variables. Each variable includes a brief justification for its use, which function the variable was used in class boundaries for the variable (if applicable), and a list of applicable PWAAs. Additional information on these variables can be found in (Table X).

Landscape Level Variables

Buffer length (BUFFLENGTH) – The percent of area with sufficient buffer length This variable was measured to capture the concept of the buffer as a protective zone against encroachment on the riparian zone by other land uses. Specific function using this variable: FXN 11: BUFFER. In the BUFFER function, the length of buffer is one component that determines the effectiveness of the function. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = no data
1 = 100% of the reach has right and left bank buffers
2 = Only one side of the reach has 100% buffering
3 = 75% of the reach has right and left bank buffers
4 = Only one side has 75% buffering
5 = 50% of the reach has right and left bank buffers
6 = Only one side has 50% buffering
7 = 25% of the reach has right and left bank buffering
8 = Only one side has 25% buffering
9 = 0% of the reach has right and left bank buffers

BUFFER is the only PWAA that Buffer length is measured.

Buffer width (BUFFWIDTH) – Width of buffer in meters. Buffer width measures the width of the buffer as a measure of the potential effectiveness of the buffer to protect the riparian area from impacts by adjacent land use. Specific function using this variable: FXN 11: BUFFER. Buffer width is one component that determines the effectiveness of the function. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Buffer width classes used were:

LANDUSE is 1.0 (ideal) and buffer width is 100, score = 1.0
LANDUSE is 1.0 and buffer width is 0, score = 0.9
LANDUSE is less than optimum the formula is LANDUSE X BUFFER
LANDUSE is 0 and BUFFER width is 100m the score is 0.0

BUFFER is the only PWAA that Buffer width is measured.

Contiguousness (CONTIG) – The percent of contiguous vegetation cover. This variable provides a measure of the connectivity through the riverine system. Specific function using this variable: FXN 10 INTERSPERS. Data were derived from air photos and maps then manipulated within a GIS framework. CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB were the PWAAs that contiguousness was applied.

Flood prone area (FPA) – Flood prone area is defined as the area that is twice the bank full thalweg depth. Flood prone area is a class variable that captures impacts of channel modification and/or degradation on channel dynamics (erosion transportation, and deposition of sediment), and particle detention. Specific functions using this variable: FXN 1: CHANNELDYN, FXN 2: WATSTORENR, and FXN 7: DETPARTICL. Data were derived from historical information, elevation maps and then manipulated within a GIS framework. Classes used were as follows:

0 = no data
1 = FPA not clearly modified
2 = FPA confined on one side
3 = FPA confined to an arroyo and bank to bank width is recoverable
4 = FPA confined to an arroyo and bank to bank width is not recoverable
5 = FPA confined to t concrete channel

Applicable PWAAs for flood prone area are CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Land use (LANDUSE) – Type of adjacent land use. Land use measures impacts of adjacent land use on the riverine system. Adjacent land use impacts the buffer length and width needed for protection. Specific function using this variable: FXN 11: BUFFER. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes in the land use variable were:

0 = no data
1 = Active sand and gravel operations
2 = Commercial and/or industrial
3 = Paved roads
4 = Multi-family residential (apartments, duplexes)
5 = Single-family residential (individual houses)
6 = Gravel roads, dirt roads, bike paths, and infrequently visited structures
7 = Inactive sand and gravel operations
8 = Agricultural cropland
9 = Open space (parks golf courses, etc)
10 – Pristine, uninhabited areas

Buffer is the only PWAA that land use was measured.

Tributaries (TRIB) – This variable measures the presence of tributaries and their degree of connectivity to the mainstem. The tributaries variable addresses the ecological function of tributaries in the area (connectivity, corridors, etc). Specific function using this variable: FXN 10: INTERSPERS, the number of tributaries can influence the degree of interspersion in a riparian system. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = No data
1 = All tributaries (channel and riparian corridor are unmodified and connect to the mainstem
2 = Some tributaries are modified (consolidated, redirected, or channelized) but still connected the mainstem
3 = Tributaries are highly modified or channelized or not connected to the mainstem

Applicable PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Site Specific Variables
Depth of saturated sediment (DEPSATSED) – Depth to saturated sediment in meters. This variable captures the concept of sediments as a site for water storage and availability of stored water during periods of reduced flows. Specific function using this variable: FXN 4: WATSTORSUB. Data were derived from historical information and ground water maps and treated as a class variable. Depth to saturated sediment classes depend upon the PWAA, the classes used are:

For the CTWWFOR PWAA
0 = no data
1 = 0 m
2 = 1 to 3 m
3 = > 3 m

For the MESQUITE PWAA
0 = no data
1 = 0 m
2 = 1 to 7 m
3 = > 7 m

For the RIVERBOTTM PWAA
0 = no data
1 = 0 m
2 = 0.01 to 0.25 m
3 = > 0.25 m

PWAAs where depth of saturated sediment was measured are CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Frequency of inundation (FREQ) – Frequency of inundation of a site. This variable addresses the concept of inundation as an important driver in biogeochemical, biological an physical processes. Specific functions using this variable: FNX 1: CHANNELDYN, FXN 3: WATSTORLNG, and FXN 6: ELEMENTS. Data were derived from historical information, elevation maps and then manipulated within a GIS framework as a class variable. The following classes were used:

0 = no data
1 = Perennial flow
2 = Intermittent flow.
3 = Saturated
4 = Temporally flooded by seasonal high flow (Q1 to Q2)
5 = Temporally flooded at bankfull flow (Q2 to Q10)
6 = Temporally flooded at large flood (Q10 to Q25)
7 = Temporally flooded at major flood (Q25 to Q100)
8 = Temporally flooded at super flood (>Q100)

Frequency of inundation was determined for CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Soil pore space (PORE) – This is the pore space available for storing subsurface water. The variable addresses the concept of infiltration on a site. Specific functions using this variable: FXN 3: WATSTORLNG and FXN 6: ELEMENTS. Data were derived from published soil surveys, field samples and historical data. Data were treated as a class variable, classes used were:

0 = No data
1 = Soil texture is a sand to sandy loan with no restrictive layers
2 = Soil texture is finer than sandy loam and has a restrictive layer
3 = Soil texture is finer than a restrictive layer
4 = The modal soil profile is highly compacted in the upper 24"
5 = Presence of a non-porous layer

Applicable PWAAs were CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Alteration to hydro regime (Q) – Alteration of hydrologic regime in the assessment area. This variable captures the concept that flow alterations can impact channel dynamics of a site. Specific function using this variable: FXN 1: CHANNELDYN. Data were derived from air photos, maps, and historical information then manipulated within a GIS framework and treated as a class variable. Classes used were as follows:

0 = No data
1 = No additions, diversions, of damming of flow affecting the assessment area
2 = Evidence of additions, diversions or damming of flow, but now evidence of significant impacts to channel pattern, dimension, and profile
3 = Evidence of additions, diversions or damming of flow, and there is evidence of changes in vegetation abundance. No evidence of increase sediment or scour
4 = Evidence of additions, diversions or damming of flow, and there is evidence of increase in sediment scour
5 = Evidence of additions, diversions or damming of flow, and there is evidence of significant impact to channel pattern, dimension, and profile. Variable is recoverable.
6 = Permanent alterations to hydroregime are evident.

Alteration to hydroregime was determined in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Sediment delivery (SED) – Extent of sediment delivered to the site from culturally accelerated sources. Sediment delivery addresses rates of sedimentation in excess of that expected in less disturbed systems. Specific functions using this variable: FXN 1: CHANNELDYN and FXN 7: DETPARTICL. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. Sediment delivery classes were as follows:

0 = No data
1 = No sediment disturbance
2 = Disturbance evident
3 = Disturbance and delivery evident
4 = Disturbance extreme and vegetation mortality
5 = Area filled

Sediment delivery was applicable in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Subsurface flow (SUBIN) – Subsurface flow into the area via interflow and return flow. This variable captures concept of subsurface movement of water that can influence nutrient fluxes and water storage on a site. Specific functions using this variable: FXN 3: WATERSTORLNG and FXN 6 ELEMENTS. Data were derived from maps and historical information then manipulated within a GIS framework and treated as a class variable. The following classes were used:

0 = No data
1 = Undisturbed, subsurface flow evident
2 = Undisturbed and subsurface inflow is observed

3 = Disturbed soils and plant communities
4 = Utilized for agricultural activities
5 = Fill
6 = Impervious surface
7 = Concrete channel

Applicable PWAAs include: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Surface inflow (SURFIN = SURFINRILL + SURFINLAT) – Surface inflow via sheet flow. This variable captures the concept that water can be delivered to the site via surface runoff occurring when precipitation rate exceeds infiltration rate. Specific function using this variable: FXN 6: ELEMENTS, transformations, leaching or deposition of elements are linked to water delivery. Data were derived from 10 m belt transect in the field and by air photos and maps. Data were treated as a class variable, classes used were:

0 = No data
1 = Any of the following indicators are present and similar to the reference site: rills on adjacent upland slopes,, lateral tributaries entering the floodplain and not connected to the channel
2 = Both indicators are present, but less than the reference standard
3 = Both indicators are absent
4 = Both indicators are absent and channelization prevents sedimentation on the wetland surface.

Applicable PWAAs include: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Topography (TOPO = MACROTOPO+MICROTOPO) – Topography measures large scale and small scale topography of the flood prone area. Topography accounts for water storage, detention of sediments, habitat features, and interspersion of habitats that are associated with topographic irregularities of the floodplain. Specific functions using this variable: FXN 2: WATSTORENR, FXN 3: WATSTORLNG, FXN 7: DETPARTICL, FXN 8: PLANTS, FXN 9: HABSTRUCT, and FXN 10 INTERSPERS. Data were derived from air photos and maps then manipulated within a GIS framework and treated as a class variable. This variable was also measured in the field. The following topography classes were used:

0 = No data
1 = Macro and microtopographic relief
2 = Homogenous surfaces with macro and microtopographic relief
3 = Homogenous surface and lacks macro and microtopographic relief
4 = Steep bank, recoverable
5 = Steep bank not recoverable

Topography was applicable in the following PWAAs: CTWWFOR, RIVERBOTTM, MESQUITE, and SCRUBSHRUB.

Wetland indicator score (WIS) – This is the wetland indicator score for each species in SPECRICH. Wetland indicator score captures the concept of plant species as indicators of the degree of wetness on a site. Increasing number of wetland species is an indicator a healthy wetland community. Specific function using this variable FXN 8: PLANTS. Wetland indicator scores are derived by conversion of SPECRICH data. WIS are found on the US Fish and Wildlife Service web site. Scores are as follows:

1 = Obligate
2 = Facultative wet
3 = Facultative
4 = Facultative upland
5 = Upland

Field Sampling Locations

Field data were collected in April 2002 at two reference sites: 1) Salt River confluence with the Verde River and 2) Hassayampa River Preserve south of Wickenburg, Arizona. Although these were the focal sites for the Va Shly'ay Akimel E-Team, data from all 5 Arizona reference sites were used in this HGM assessment. The three additional sites are located in southern Arizona and area associated with the San Pedro river, Tanque Verde Wash, and Tumacacori.

Field Sampling Protocol

Certain variables in the HGM required field sampling to quantify. A variety of methods were used to obtain the data; a brief description of the field sampling protocol follows.

The sampling team consisted of 4 individuals. Each team had one member experienced with HGM data collection. Other team members had expertise in a field related to the sampling effort. Each team had a designated recorder for the sampling day to record data reported by team members. Prior to sampling observers standardized their estimates of cover with each other, discussed the kinds of species present, and discussed their impressions of the site. To minimize observer error, the same observers estimated the same components on all transects.

At each PWAA, a 100 m long transect was established generally parallel to the river channel (fig. X). In some PWAAs the transect had to curved or was broken into two 50 m transects. Along the 100 m transect a series of 10m X 10m quadrat was established

creating a belt transect. Each 100 m transect had 10, 10m X 10m quadrats. At the center of the quadrat the recorder notes the presence of rills on adjacent slopes. Within the 10m X 10m quadrat the following were recorded as reported by team members:

1. number of vegetation layers
2. species composition
3. microtopographic features (small scale pits and hummocks)
4. logs and stage of decay

Within the 10 m quadrat, a 1m X 1m quadrat was randomly located. Within this quadrat the following data was recorded:

1. percent coarse woody debris (% CWD)
2. percent fine woody debris (% FWD)
3. percent litter cover
4. percent algal mat
5. percent tree canopy
6. percent shrub cover
7. percent herbaceous cover

The percent cover of all components was estimated occularly. Percent cover of coarse woody debris, fine woody debris litter cover, algal mat, shrub and herbaceous components was estimated by vertically projecting the cover of each onto the ground surface. Due to the multilayered nature of vegetation total vegetative cover can exceed 100 percent. An example of this is the occurrence of herbaceous species under shrub canopies. Tree canopy cover was estimated by viewing the tree canopy upwards through a sighting tube. The sighting tube was divided into quarters by a cross-hair. The percent of the sky obscured by tree canopy as viewed through the sighting tube was determined and recorded. At the center of each 1m X 1m quadrat, a 9.5 meter pole graduated in meters and decimeters was placed vertically within the foliage. The number of decimeter hits within each meter interval were recorded. A hit was defined as any vegetation within a 10 cm radius of the rod per vertical decimeter. Estimates of volume above 10-m in height are recorded as either three (3) or seven (7) hits per interval. Such estimates can be based on comparison with lower intervals where hits can be directly measured.

Performing Data Management and Statistical Analysis

Some limits to the assessment's data should be acknowledged. In some instances, notes on field sheets were difficult to interpret, so corrections were made when possible, and the results were discussed with Team members. In some instances, data on field sheets was disregarded. When data management problems arose, ERDC-EL consulted with the Team prior to data handling, and solutions were devised with their knowledge and consent.

Calculating Baseline Conditions

Conducting an HGM analysis requires that a baseline inventory be conducted, variable means and/or modes calculated, and cover type acreages quantified. The next step is to describe the baseline conditions in terms of FCUs. The value of each variable expressed as a mean or mode are applied to the Variable Subindex graphs as dictated by the model documentation. For example, if the percent of ground cover in the PWAAs at Site X were 50 percent on average, the value "20" was entered into the "X-axis" on the Variable Subindex curve below, and the resultant VSI score (Y-axis) was recorded (VSI = 1.0).

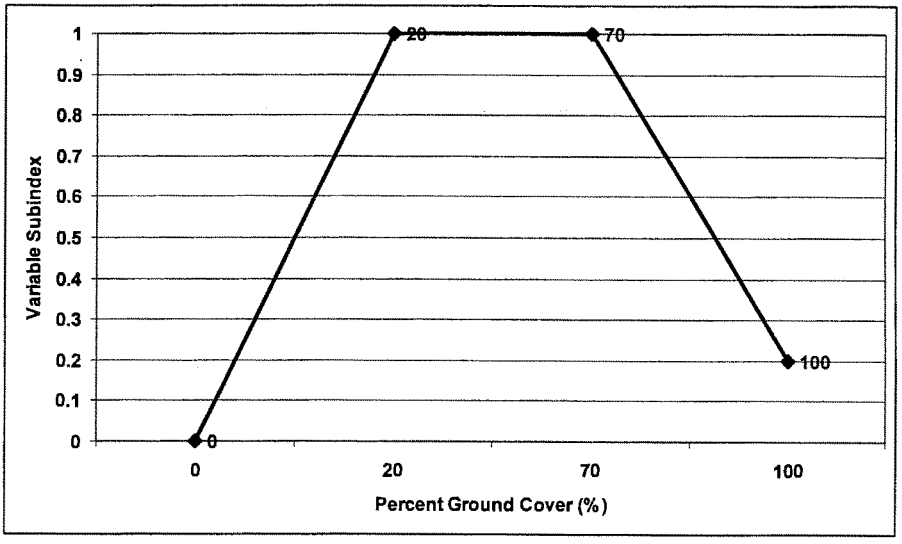


Figure 2 – 3
Example variable subindex (VSI) curve.

The process is repeated for every associated variable and PWAA per model. The individual VSI scores are then entered into the FCI formula on a PWAA specific basis and individual PWAA FCIs are generated. Each result, referred to as the PWAA FCI is then weighted by the relative area (RA) of the PWAA. In HGM, the RA is a mathematical process used to "weight" the various applicable cover types on the basis of quantity. To derive the relative area of a model's cover type, the following equation can be utilized:

Relative Area (RA) = Cover Type Area / Total Area

where:

Cover Type Area = only those acres assigned to the cover type (or PWAA) of interest
Total Area = the sum of the acres utilized in the model.

Results from the remaining associated PWASS are combined in an additive manner. Mathematically, this can be expressed using the following relationship:

$FCI_{Subclass\ Model} = \sum (PWAA\ FCI \times RA)_X$

where:

PWAA FCI = Results of the PWAA FCI calculation,
X = Number of PWAAs associated with the model, and
RA = Relative area of each PWAA

The final step involves multiplying the FCI result by the habitat acres (PWAA acreage associated with the model). The final results, referred to as FCUs, quantify the quality and quantity of the wetlands at the site for the baseline conditions (TY0).

Generating Without Project Conditions and Calculating the Outputs

Predicting both the short-term and long-term condition of the environment is a necessity when developing ecosystem restoration plans for a community or region (USACE 2000). Forecasting, the process of developing predictions for future conditions, is undertaken to identify patterns in natural systems and human behavior, and to discover relationships among variables and systems, so that timing, nature, and magnitude of change can be estimated over time. In HGM, a judgment-based method, supported by the scientific and professional expertise of the evaluation team, is often relied upon to forecast the effectiveness of ecosystem restoration alternatives, assess project performance, and determine many other aspects of both the Without Project and With Project scenarios.

The Without project condition is regarded as an important element of the HGM evaluation (USACE 2000). A critical element in the planning process is the prediction of likely future conditions in the study area if no action taken. The No Action Alternative in NEPA is the Without Project condition of the study site should no action be taken. When formulating plans, NEPA regulations require that the No Action Alternative always be considered.

The Without Project descriptions should adequately describe the future conditions (USACE 2000). Significant variables, elements, trends, functions, and processes should be sufficiently described to support good decision-making. Without Project descriptions must be rational to be defensible. Forecasts are typically based on appropriate and acceptable methods, and must adhere to professional standards of the time. Accuracy is important and should take into account assumed rational behavior by future decision makers. Scenarios that rely on an unlikely series of event or irrational behavior do not support sensible predictions.

"Before and after" comparisons should not be confused with estimates of the Without Project conditions. "Before and after" comparisons can overlook the causality that is important to effective plan evaluation. Without Project conditions are a "look" into the future. Forecasts that concentrate on causality of existing conditions, and focus too narrowly on how existing conditions might change, fail to be future-oriented. Without Project conditions should be oriented toward comparing alternative future scenarios, not just extensions of existing conditions. Information used to forecast scenarios should not be misleading or withheld. Both the strengths and weaknesses of future scenarios must be considered. Forecast scenarios should be based on empirical data. This complete analysis in needed to enable an interested stakeholder or a decision maker to make a qualitative assessment of the study. Scenarios should point out weaknesses in the analysis, and state the implications of such drawbacks. Significant differences in future scenarios should be accurately described. Finally, the Without Project condition is subjected to review and comment as part of the coordination and review process, as well as the public participation process.

Specific Without Project Trends

Forecasting of the without project condition relied upon forecasting the future water supply and changes to land use within the project boundary and contributing watershed. Considering such trends as a baseline condition allowed for the formulation of alternatives that would improve the wetland functions and values within the project area over time. An overriding consideration was water supply. In the absence of coordinated and timed discharges from the upstream reservoir system, it was assumed that the majority of the project area would be ephemeral in flow character. Further, it was assumed that in the future, only those features that were scaled to a dedicated and available water supply would be sustainable.

Several prominent land use categories are present in and immediately adjacent to the Va Shyl'ay Akimel project area and hence influenced the future without project trends. Several land use categories were considered in the formulation of without project trends. Sand and gravel operations past, present, and future, influence sediment, surface water and ground water regimes. This was taken into account by assuming a general degradation of existing habitat in extraction and processing areas. Agricultural and open space areas on the east side of the project will likely turn to urban or residential land use and as such restrict immediately adjacent restoration options.

In terms of variable projections over the life of the project, the without project scenario has several general assumptions. First, the wetland and riparian biotic communities will in general degrade over time with reduced water supply and the influx of invasive/exotic species. Urban encroachment will continue, resulting in loss of buffer and native vegetative communities. Continued commercial activities within and immediately adjacent to the channel disrupt hydrologic regimes and cause the degradation of existing and impact the recruitment of native riparian cover types.

Calculating Annualized Units for the Without Project Condition
Most federal agencies use annualize results as a means to display benefits and costs. Ecosystem restoration analyses should therefore provide data that can be directly compared to the traditional benefit: cost analyses typically portrayed in standard evaluations of this nature. Federal projects are evaluated over a period of time commonly referred to as the "life of the project", which is defined as that period of time between when the project becomes operational and the end of the project as dictated by construction effort or lead agency. However, in many cases, gains or losses in wildlife habitat may occur before the project becomes operational and these changes should be considered in the assessment. Examples of such changes include construction impacts, implementation and compensation plans, or other land use impacts. Ecosystem restoration analyses incorporate these changes into their evaluations by using a "period of analysis" that includes pre-start impacts. If the no pre-start changes are evident, then the "life of the project' and the "period of analysis" are equivalent.

In HGM, FCUs are annualized by the summing FCUs across all years in the period of analysis and dividing the total (cumu8lative FCU) by the number of years in the life of the project. In this manner, pre-start changes can be considered in the analysis. The results of this calculation are termed AAFCUs, and can be expressed by the following relationship:

$$AAFCUs = \sum (\text{Cumulative FCUs} / \text{Number of years in the life of project})$$

$$\text{Where: Cumulative FCUs} = \sum (T_1-T_2)[((A_1F_1+A_2F_2)/3) + ((A_2F_1+A_1F_2)/6)]$$

and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available habitat at beginning of T_1
A_2 = Area of available habitat at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

The equation presented above is a generalized formula and requires that the FCI and the area available for habitat be considered for each target year. The numbers "3" and "6" are constants derived from the integration of (FCI **x** area) for the interval between any two target years. This formula is applied to the time intervals between target years and was developed to precisely calculate cumulative FCUs when either the FCI or area or both change over a given time interval of interest. The rate of change of FCUs may be linear if either FCI or area change over the time interval. The FCU values for all years in the period of analysis are calculated by summing the products of the FCI and area of

available habitat for all years in the period of analysis. All HGM results developed for the Va Shly'ay Akimel ER-FS were calculated in this manner and are reported in terms of annualized units for the Without and With Project conditions.

Generating With Project Conditions and Calculating the Outputs

Several meetings were held over the course of the Va Shly'ay Akimel Environmental Restoration Study in which Team members were asked to estimate the future conditions of the project area under differing scenarios. In the early stages the source and amount of water to the project was in question. As such, the original alternatives focused upon maintaining and enhancing the existing vegetative character of the now ephemeral Salt River reach through the Va Shly'ay Akimel study area. With the exception of two perennially wet segments, this amounted to preserving and enhancing relatively xeric scrub-shrub communities along the majority of the reach. Because of the high percentage of suitable sand and gravel extraction areas, development of alternatives was further constrained. This resulted in an initial matrix of 13 initial alternatives that minimized water use and avoided existing and future sand and gravel extraction areas.

As the process continued and more information became available, two things came clear. First, the local sponsors did not care for alternatives that did not focus upon establishment of native riparian forests of cottonwood and willow. Second, the sponsors were able to secure larger amounts of water for the project. As such, two additional alternatives were added both of which focused upon providing maximal amounts of cottonwood and willow habitat. This resulted in a list of 15 alternatives. These 15 alternatives were further expanded by considering two means of irrigating project features, rill and drip irrigation. It was these resultant 30 alternatives for which HGM scores were developed and the CEA and ICA costs calculated.

Developing RVIs and Performing Tradeoffs

In order to select one alternative as the "preferred," or most effective alternative, it is necessary to compare it to other alternatives. Comparing the alternatives is a way to distinguish the benefits and drawbacks of each plan, as well as, the strengths and weaknesses. The purpose of the comparison step is to identify the important criteria for evaluation and compare the alternatives across those criteria. Ideally, the comparison of alternatives results in a ranking of alternatives, or some determination of the best course of action for the decision-makers. The comparison can be simplified by measuring the alternative designs in the same units, such as ecological units, acres, dollars, or others.

Typically, alternative designs are measured in a combination of dollars, ecological units, acres, water quality changes, noise levels, changed erosion rates, or a host of other tangible or intangible units. Sometimes these comparisons lead to trade-offs. Trade-offs

are made throughout the planning process and screening activities, but they may play a more prominent role as the study team, decision-makers, and other stakeholders move toward selecting the "preferred" alternative. These trade-offs are made regarding both the measures and alternatives under evaluation. Measures and alternative designs can be dropped from further analysis for a variety of reasons including cost ineffectiveness, design inconsistencies, hydrologic issues, and biological unproductiveness.

Trade-offs are considered across and among, all the alternatives. Trade-offs are considered when contrasting outputs are encountered. For example, Alternative 1 may be less costly, but restores fewer wetlands than Alternative 2, a more costly design that restores significantly more wetland acres. Trade-off analysis is a multi-criteria evaluation method commonly used by USACE when it may not be possible (or not desirable) to express all alternative effects in a single metric evaluation. In some cases, more than one evaluation metric can be considered (i.e., HEP, HGM, and costs together) in a trade-offs analysis (Edmunds and Letey 1973). Trade-offs enable planners to account for the entire spectrum of differing (but relevant) criteria when comparing alternatives. Trade-offs can be as simple, or as complex, as necessary to afford the greatest suite of comparisons. In a simple application, trade-offs can frequently rely on professional knowledge and judgment. Planners "trade-off" alternative contributions to objectives based on their own accumulated technical expertise, general experience, and specific knowledge of the study area (including stakeholder views and values). In essence, planners sit down and develop an alternative with "a little more of this" and "a little more of that," where the trade-offs made tend to be of a subjective nature. However, more quantifiable approaches exist to conduct trade-off analyses in a controlled environment.

Simple weighting is an approach to trade-offs that can be used when there are no apparent prominent alternatives among those compared. In HGM, FCI models are selected on the basis of their representation of ongoing critical ecosystem processes, and can be "traded-off" by incorporating a weighting scheme into the calculation of final FCIs. By applying Relative Value Indices (RVIs) to the resultant outputs, wetland function priorities can be characterized, and mathematical "weights" can be applied to the HGM analysis. RVIs can be applied to emphasize, or even decrease, the overall effect of individual FCIs. Using RVIs, mathematical "weights" can be used to prioritize functions. For example, the 11 functions in the HGM model generally fall into three functional groups, water, biogeochemical, or habitat. Recognizing that many of the same variables are used to calculate these functions, there is an obvious link between the functions. For example, it is reasonable to assume that an improvement in function 2, surface water storage, would lead in an improvement in function 8, plant communities, since more water means that plants would grow and improve the vegetation community. RVIs provide an opportunity to acknowledge the limited buffer areas, yet downplay their affect on the analysis so the value of the restoration project is not overshadowed. While the prioritization of functions, and whether or not to weight them with RVIs, is somewhat subjective, the process allows for the flexibility to emphasize particular components of a restoration project when warranted, as long as the choices are documented. Therefore, RVIs can be used in HGM to perform trade-offs among functions.

Reporting the Results of the Analyses

Successful evaluation lies in the planner's ability to discuss the assessment strategies and findings to the public. Reporting simply refers to communicating the methodologies and results of the habitat assessment in a clear and concise manner to the reader. Underlying the HGM process is the concept of "repeatability". To assure that the assessment is reasonable and reliable, the reader should be able to follow the descriptions of approach and applications presented and repeat the analyses just as the planner did. To assure the repeatability aspects of the assessments, the planner should document the evaluation. Usually this is done through an assessment report. Reports typically include five plus chapters: Introduction, Methods, Results, Trade-offs, and Summary/Conclusions. In addition, the report should have a Literature Cited section and an appendix documenting the models used in the assessment. Further reporting of the assessment results can include, but is not limited to, graphics (maps, graphs, tables, etc.) that visually depict the conditions of both Without and With Project, of the study area under evaluation. In HGM, it is important to document the results in terms of functional capacity units (FCU), quality (FCIs), and quantity (acres). In addition, any factors that significantly affected the outcome of the study (e.g., minutes of team meetings, data extrapolations, etc.) should be documented, either in the report itself, or in the appendix to the report.

Software Used In The Va Shly'ay Akimel Ecosystem Restoration Project

EXHGM is a Microsoft Access© 2000 software package developed by ERDC-EL to automate standard HGM calculations. EXHGM's programming architecture is similar to that of the EXHEP package. The EXHGM program should be viewed as a tool that can provide a rational, supportable, focused, and traceable evaluation of wetland functionality, and its application to the decision-making process is unquestionable. However, the user must understand the basic HGM tenets as defined in supporting literature (Brinson 1993; Smith et al. 1995) prior to attempting application of the software. In other words, the user should not expect the EXHGM software to provide the only predictive environmental response to project development scenarios, and should understand the limitations of the methodology's response to predictive evaluations prior to its application.

The EXHGM program was designed to process large amounts of data quickly and efficiently, handling a large number of FCI models simultaneously. Each model can incorporate any number of cover types and partial wetland assessment areas. Each cover type can include a large number of variables, and the user can incorporate as many functions within each model as necessary. These capabilities support the examination of complex studies with large numbers of permutations. The number of permutations, processing speed, and program performances are limited only by the capacity of the user's hardware, where data storage becomes the limiting factor.

The EXHGM program allows the user to evaluate a large number of projected changes (future factors) across numerous years for each alternative design. Each package allows the user to assign future factors to each model for each year considered within the life of the project (i.e., each TY). This capability allows the user to manage forecasts across the long-term planning horizon, in an attempt to better reflect reality through the life of the project. Again, the number of permutations is limited only by the user's computer storage capacity. EXHGM evaluates any FCI-based model. In most instances, a wetland cannot be described using a single PWAA. A standard HGM tool must complete these computations, regardless of whether the model uses a single PWAA or multiple PWAAs. EXHGM can be used to calculate suitability for any single or multiple PWAA model whether the wetlands functionality is based on one or more multi-faceted functions. The two tools are capable of reevaluating HSI and FCI models as the user adapts previously created alternative designs to fit new situations. It is not necessary to reinvent FCI models once a standard evaluation configuration has been created. The software package allows the user to open a previously created configuration and introduce change (e.g., adding field data, future factors, TYs, cover types, acreage quantities, variables, etc.). This capability supports the software's utilization in a wide range of agency activities over the long term. For example, an alternative design developed to evaluate project impacts for a stream restoration study in the past can be adapted to evaluate stream restoration projects throughout the region in the future. By simply altering the cover type composition of a previously developed EXHGM data file, the software can account for regional variations and quickly define functionality impacts. Thus, as projects are funded or evolve, EXHGM can be easily implemented with little effort devoted to modeling "setup."

Introduction to the Cost Analysis Process

Between 1986 and 1987, the Headquarters' Office of the U.S. Army Corps of Engineers provided policy directing USACE Districts to perform a type of cost analysis referred to as Incremental Cost Analysis (ICA) for all feasibility-level studies. The required ICA is, in effect, a combination of both a Cost Effectiveness Analysis (CEA) and Incremental Effectiveness Analysis. Together, the CEA/ICA evaluations combine the environmental outputs of various alternative designs with their associated costs, and systematically compare each alternative on the basis of productivity. Cost effectiveness analyses focus on the identification of the least cost alternatives and the elimination of the economically irrational alternatives (e.g., alternative designs which are inefficient and ineffective). By definition, inefficient alternative designs produce similar environmental returns at greater expense. Ineffective alternative designs result in reduced levels of output for the same or greater costs. The incremental cost analysis is employed to reveal and interpret changes in costs for increasing levels of environmental outputs.

In 1990, USACE issued Engineer Regulation 1105-2-100 (U.S. Army Corps of Engineers 1990) directing planners, economists, and resource managers to conduct CEA/ICA for all

recommended mitigation plans. Later, in 1991, USACE produced Policy Guidance Letter Number 24 that extended the use of cost analysis to projects that restored fish and wildlife habitat resources (U.S. Army Corps of Engineers 1991). In the USACE Engineering Circular 1105-2-210, the incorporation of cost analysis was declared "fundamental" to project formulation and evaluation (U.S. Army Corps of Engineers 1995).

To facilitate the inclusion of these basic economic concepts into the decision making process, USACE published two reports detailing the procedures to complete both incremental and cost-effective analysis (Orth 1994; Robinson et al. 1995). Based on these reports, there were nine steps that should be completed to evaluate alternative designs based on CEA/ICA. These were as follows:

A. Formulate all possible combinations of alternative designs by:
   1. Displaying all outputs and costs.
   2. Identifying filters, which restrict the combination of alternative designs.
   3. Calculating outputs and costs of combinations.
   4. Complete a cost effective analysis by:
   5. Eliminating economically inefficient alternative designs.
   6. Eliminating economically ineffective alternative designs.

B. Develop an incremental cost curve by:
   7. Calculating the average costs.
   8. Recalculating average costs for additional outputs.

C. Complete an incremental cost analysis by:
   9. Calculating incremental costs.
   10. Comparing successive outputs and incremental costs.

In the ICA terminology, an alternative design is considered the With Project condition (i.e., "Build A Dam," "Develop a Wetland," "Restore the Riparian Zone," "Management Plan A," etc.). Under an alternative design, a series of scales (i.e., variations) can be defined which are modifications or derivations of the initial With Project conditions (i.e., "Develop 10 acres of Low Quality Wetlands," "Develop 1,000 acres of High Quality Wetlands," etc.). Often, these scales are based on differences in intensity of similar treatments and can, therefore, can be "lumped" under an alternative design class or category. During the first steps of CEA/ICA, all possible combinations of alternative designs and their scales are formed. As a general rule, intra-scale combinations (i.e., combinations of variations within a single alternative design) are not allowed. These activities would occupy the same space and time.

In most instances, CEA/ICA results are displayed in tables, scatter plots, and/or bar charts. These illustrative products assist decision-makers in the progressive comparisons of alternative design costs, and the increasing levels of environmental outputs. Before a user makes a decision based upon the outputs generated by the CEA/ICA, they must

determine whether cost thresholds exist that limit production of the next level of environmental output (i.e., cost affordability). In addition, factors such as curve anomalies (i.e., abrupt changes in the incremental curve), output targets, and output thresholds can influence the selection of alternative designs.

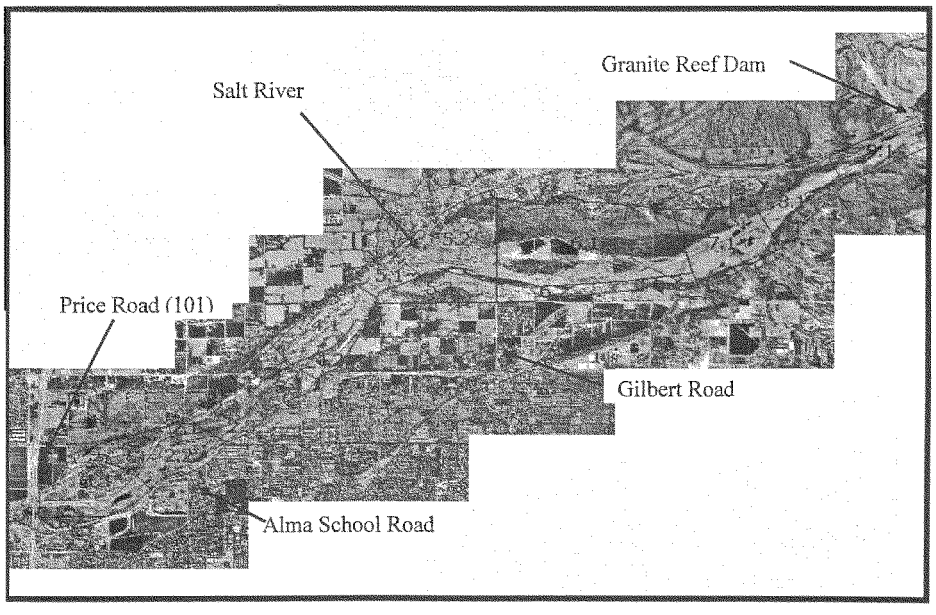
CHAPTER 3 - Va Shly'ay Akimel Project Results

Va Shly'ay Akimel (Salt River)

Project Description

Location
The Va Shly'ay Akimel study area is located in south central Arizona, in the eastern portion of Maricopa County. The project study area is located entirely within the Lower Salt watershed (USGS Cataloging Unit: 15060106). The Va Shly'ay Akimel Ecosystem Restoration project boundary follows the Salt River from Granite Reef Dam to Price Road (US 101), Figure 3-1. Thirteen project alternatives were developed in the Feasibility Study, F4 Phase.

Purpose
The objective of the study was to develop alternatives that increased native riparian vegetation, increased vegetation connectivity, and stabilized bank sections, where necessary. Figure 3-1 shows the project location identifying key features and sub-area locations used in this report.



Measures Under Consideration
In order to complete ecosystem restoration on the Va Shly'ay Akimel project, multiple measures will likely need to be implemented. In all, ten measures were considered that when implemented will influence the cover type within a given reach of the project. Alternatives were then formulated using various measures in combination. Not all measures were used in all alternatives. The following provides a brief summary of the measures considered.

Water Sources
Six water sources are available to supply the project facilities: 1) Surface water available for use by the Pima Maricopa Indian Community via existing water sources, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water, and 5) irrigation tailwater. Alternatives rely primarily on surface water and groundwater from the Salt River Pima Maricopa Indian Community (SRPMIC) and effluent from the City of Mesa Wastewater Treatment Facility. According to the Pima Maricopa Indian Community staff, 30,000 acre-ft/yr of water can be allocated to the project. Groundwater is considered a secondary source of water.

Water Distribution System(s)
Infrastructure is needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, well, or effluent line) to areas where vegetation will be restored. The distribution system does not take into account the irrigation system.

Irrigation Techniques
Surface water from the storm water sources, irrigation canals and ditches will be diverted to various vegetated areas by a network of lined irrigation channels and buried pipes. The size of the channel and pipe will be dependent on site specific conditions such as flow requirements and terrain. Pumps may be needed to distribute water.

Reshaping
Many of the alternatives require surface reshaping. Three types of reshaping categories are proposed for use in this project: 1) Channelization, 2) Surface Reshaping, and 3) Vegetation/Irrigation Reshaping. Channelization is defined as the material moved in the process of constructing the 200 ft wide low flow channel. Surface Reshaping is defined as the material moved to alter significant features such as large mounds, filling quarry pits and reducing the side slopes of the quarry walls. Vegetation Reshaping is defined as minor reshaping required for planting purposes and to ensure that gravity irrigation systems will be feasible. It is assumed that for Vegetation Reshaping, 2 ft of material will be moved per acre of vegetated area. And Irrigation Reshaping is defined as the construction of irrigation ditches needed in the flood irrigation and SBIN irrigation methods (2-3 ft wide and 6 inches deep) and the construction of the drainage ditches (15 ft wide and 3 ft deep).

Vegetation
Five vegetation types were evaluated: 1) Cottonwood/Willow, 2) Mesquite, 3) Wetlands, 4) Sonoran Desert, and 5) River Bottom. In addition to the planting of the vegetation, some reshaping may be necessary to provide the proper landscape to maintain and encourage the future propagation of the vegetation.

River Channelization
Some alternatives require segments of the Salt River to be channelized, off setting the reduction in water conveyance, due to planting of vegetation within the main channel. The river bottom will be excavated to form a low flow channel with a bottom width of 200 ft, 1V:3H side slopes and 4 to 8 ft in depth. The channel will be free to migrate. The excavated material can be used to create benches along the channel, to fill quarry pits and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. A two hundred foot buffer on both sides of the low flow channel will be incorporated to allow for the migration of the low flow channel. Portions of the low flow channel will be designed with a semi impervious soil substrate to support wetland areas. In some alternatives requiring channelization activities, Sonoran desert vegetation will be planted along the low flow channel to increase stability of the overbank area.

Grade Control Structure
A grade control structure may be needed to protect the Gilbert Road Bridge due to the extensive mining that has occurred downstream of the bridge. Mining operations have altered the channel system, creating a nickpoint, or area where an abrupt change in elevation and slope occurs.

Buried Guide Dikes
The buried guide dikes are used to control lateral migration of the low flow channel and have been included in only Alternative I (CHNL). These structures will be constructed with soil cement and buried perpendicular to the low flow channel alignment.

Bank Stabilization
Several areas require bank stabilization to stabilize the river, reducing erosion, and provide protection for newly established vegetation. Four general bank stabilization measures have been evaluated: 1) riprap, 2) buried groins, 3) endways weirs (wingdams, groins), and 4) soil cement. Application of each stabilization measure depends upon the local hydraulic, and scour and deposition conditions and the proximity to significant areas.

Levee
Although considered by the design team, a levee measure is not recommended near Gilbert Road, to protect the Lehi area, because it already appears to be out of the100 year flood plain. To protect from the 500 Year event, the levee needs to be 15,000 ft long, extending from Reach 6 to Reach 5 (Figure 1) and 6 ft high. If built to Army Corps of Engineer's standards, the levee would require armoring. A levee is not recommended

because there appears to be very little damage for the 100 Year event and only slightly more for the 500 Year event.

Cultural Center
A Cultural Center, intended to provide Community members and visitors with information regarding the historic way of Pima Maricopa Indian Community life, is planned as part of the greater river restoration project. The exact location of the Center has yet to be determined, however, it will be placed relatively close to the river, so that the river and its associated vegetation can be visually highlighted in the area surrounding the Center itself. Materials historically and culturally important to the Indian Community may be planted in the area surrounding the Center, as well as highlighting the native river vegetation. It can be expected that greater infrastructure and resources will be necessary to achieve the expected level of vegetation establishment.

Alternatives Under Evaluation
The thirteen alternatives developed vary with respect to vegetation layout, amount of river channelization, reshaping and method(s) for distributing water. Levees, bank stabilization and water sources (groundwater and/or surface water) were examined. These measures were combined into alternatives that result in varying amounts of a given PWAA being represented within the project reach. Table 3-1 provides a list of all alternatives considered for the Va Shly'ay Akimel ER and is followed by a brief description of each.. An in-depth description of each alternative is available in the F4 document.

Table 3-1
Va Shly'ay Akimel ER-FS alternative list.

Alternative Name	Alternative Letter
LOAD	A
MEAD	B
HIAD	C
MINE	D
VHAD	E
MAX	F
CWAD	G
MSAD	H
CHNL	I
BRAD	J
NODL	K
POCK	L
WET	M
MAX	N
MAX	O

A - LOAD: Xero-Riparian dominated with minimal vegetation establishment.

B - MEAD: Xero-Riparian dominated with moderate vegetation establishment.

C - HIAD: Xero-Riparian dominated with extensive vegetation establishment.

D - MINE: Meso-Riparian dominated with moderate vegetation establishment. Stream channelization, but avoiding sand and gravel mines.

E - VHAD: Meso-Riparian dominated (cottonwood-willow, mesquite and xero-riparian species) with extensive vegetation establishment.

F - MAX: Meso-Riparian dominated with maximum vegetation establishment. Reshaping and channelization activities are also included.

G - CWAD: Cottonwood dominated with a braided channel network.

H - MSAD: Mesquite bosque dominated with a braided channel network.

I - CHNL: Cottonwood dominated with moderate vegetation establishment. Stream channelization is also included.

J - BRAD: Cottonwood dominated with extensive vegetation establishment. Also includes reshaping of selected sand and gravel impacted areas.

K - NODL: Cottonwood dominated with extensive vegetation establishment. No reshaping of sand and gravel mining areas.

L - POCK: Cottonwood and mesquite co-dominated with moderate vegetation establishment. Restoration activities located to provide maximum visibility from surrounding roadways.

M - WET: Hydro-riparian dominated with extensive vegetation establishment.

N – MAX: Meso-Riparain dominated modification of alternative F-MAX.

O – MAX: Meso-Riparian dominated modification of alternative F-MAX.

Baseline Conditions

Baseline Acres and Cover Types
Thirteen existing cover types were identified in the Va Shly'ay Akimel project area, the majority of which could be considered degraded because of a lack of water or because of

anthropogenic activities. Of the 5,870.6 total project acres, Scrub-shrub lands occupy the majority of the project area at 2,057.1 acres. The second most prevalent existing cover type supports sand and gravel mining activities (1,651.6 acres), while the third is considered Desert (961.9 acres). Wetland and hydroriparian cover types do occur but these are, in general, located at the upstream and downstream most reaches of the project area where subflow from Granite Reef Dam or surface discharges from agriculture, wastewater treatment, or urban dry-weather flows enters the system respectively. Existing cottonwood-willow forests only represents 69.5 acres of the project, while riverbottom (largely unvegetated but including emergent marshes) accounts for 334.6 acres. A complete listing of baseline cover types (PWAAS) and their respective acreages is presented in Chapter 2, Table 2-9.

Baseline Variable Values for Each Cover Type
The HGM model was used to assess the baseline conditions for the Va Shly'ay Akimel ER study site. Baseline field data were collected in the spring of 2002 to determine existing conditions for the site. Data for each variable per cover type was recorded, and the means/modes were calculated to generate baseline Functional Capacity Index (FCIs). For detailed information regarding the field data collected by the Biological Team, please refer to the discussion on the collection of variables in Chapter 2 of this document.

Baseline Evaluation
Ten (10) HGM functional formulae from the Arizona Riverine model were used to evaluate the ecosystem benefits in the Va Shly'ay Akimel project area under baseline conditions, as well as for the different alternatives. These functional indices included:

FXN 01: Maintenance of Characteristic dynamics
FXN 02: Dynamic Surface Water Storage/Energy Dissipation
FXN 03: Long Term Surface Water Storage
FXN 04: Dynamic subsurface Water Storage
FXN 05: Nutrient Cycling
FXN 06: Detention of Imported Elements and Compounds
FXN 07: Detention of Particles
FXN 08: Maintain Characteristic Plant Communities
FXN 09: Maintain Spatial Structure of Habitat
FXN 10: Maintain Interspersion and Connectivity

Plots showing the baseline FCI and FCU results are provided in Appendix A, while these data are provided in tabular form in Table 3-2 below.

Table 3-2
Baseline HGM Functional Capacity Indices (FCI) and Functional Capacity Units (FCU) for the Va Shly'ay Akimel ER project.

Function Name	Weighted FCI	FCU
FXN 01: Maintenance of Characteristic dynamics	0.333	821.8
FXN 02: Dynamic Surface Water Storage/Energy Dissipation	0.423	1044.0
FXN 03: Long Term Surface Water Storage	0.048	119.1
FXN 04: Dynamic subsurface Water Storage	0.083	204.1
FXN 05: Nutrient Cycling	0.384	947.3
FXN 06: Detention of Imported Elements and Compounds	0.333	820.8
FXN 07: Detention of Particles	0.311	767.5
FXN 08: Maintain Characteristic Plant Communities	0.602	1484.5
FXN 09: Maintain Spatial Structure of Habitat	0.399	983.4
FXN 10: Maintain Interspersion and Connectivity	0.377	929.7
Total	N/A	8122.2

Inspection of Table 3-2 shows only one weighted FCI value falling within the moderately functional range ($0.5<FCI\leq0.75$) indicating the potential for restoration does exist within the Va Shly'ay Akimel project reach of the Salt River. The lowest overall baseline FCI's are related to long term surface water and dynamic subsurface water storage which reflect the current lack of water resources entering the project area(s). The far right column of Table 3-2 provides the baseline FCU's based upon the FCI scores multiplied by the associated existing partial wetland assessment area acreages (PWAAs).

Future Conditions

Without Project Conditions
Based in the general Without Project trends described earlier in Chapter 2, the Biological Team developed a series of incremental projections to describe future conditions at the study site. Important factors in the projects were the continuing degradation of the river by incision, sand and gravel mining activities, as well as urban development. The team forecast the impacts in terms of acreage losses, as well as capturing the impacts in terms of degrading water quality and vegetation composition and structure scores.

In terms of acres, it was assumed that 5-years after construction (TY 6) 288 acres of existing PWAA would be lost and converted to residential, industrial, and transportation cover types. This includes 50% of the 69.50 acres of the cottonwood willow forest PWAA. Cover type acreage does not vary, except for the remnants of the existing cottonwood-willow forest, until the end of the project (TY 51). Between TY 26 and TY 51, it was assumed that the remaining 30.6 acres of cottonwood-willow forest would become newly developed river bottom areas within the active channel.

Without project FCI results for all 10 functions are presented graphically in Figure 3-2.

As can be seen all functional capacity indices decrease over time for the without project conditions. With the exception of function 01 which does not vary until between TY 6 and TY 26 (Maintenance of Characteristic Dynamics), all other FCI's experience a reduction in value that occurs between TY 1 and TY 6.

Resulting Without Project changes in Average Annual Functional Capacity Units (AAFCUs) are provided graphically in Figure 3-3. In general, the AAFCUs remain constant for the first year, but degrade significantly (-92 AAFCUs) between TY 1 and TY 6. The decline in AAFCUs is then more gradual with a reduction of 11 AAFCUs occurring over the next 18 years (TY 20). By the end of the project's life (TY 51) an additional 4 AAFCUs are lost.

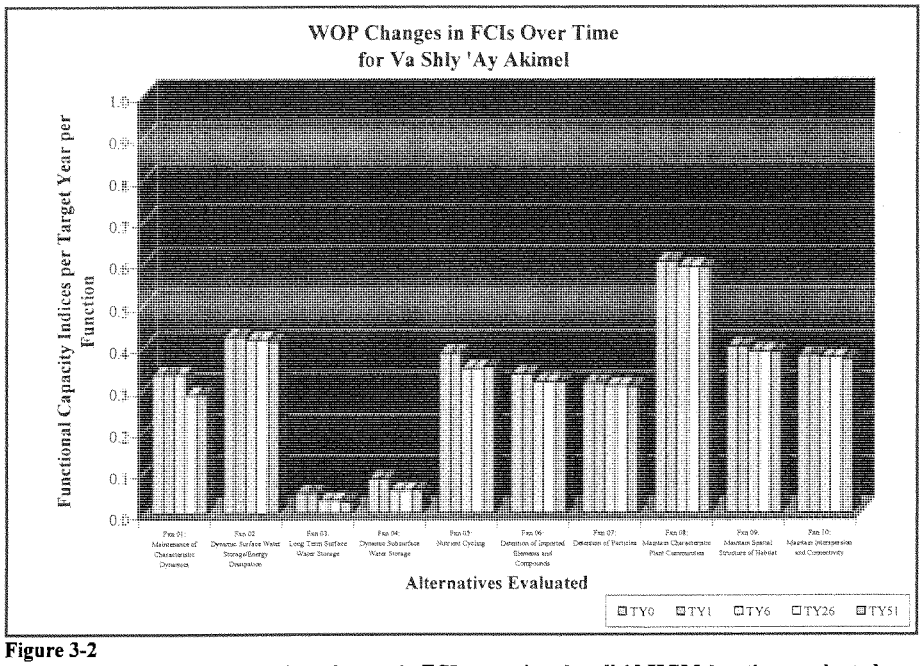


Figure 3-2
Va Shly'ay Akimel without project changes in FCIs over time for all 10 HGM functions evaluated.

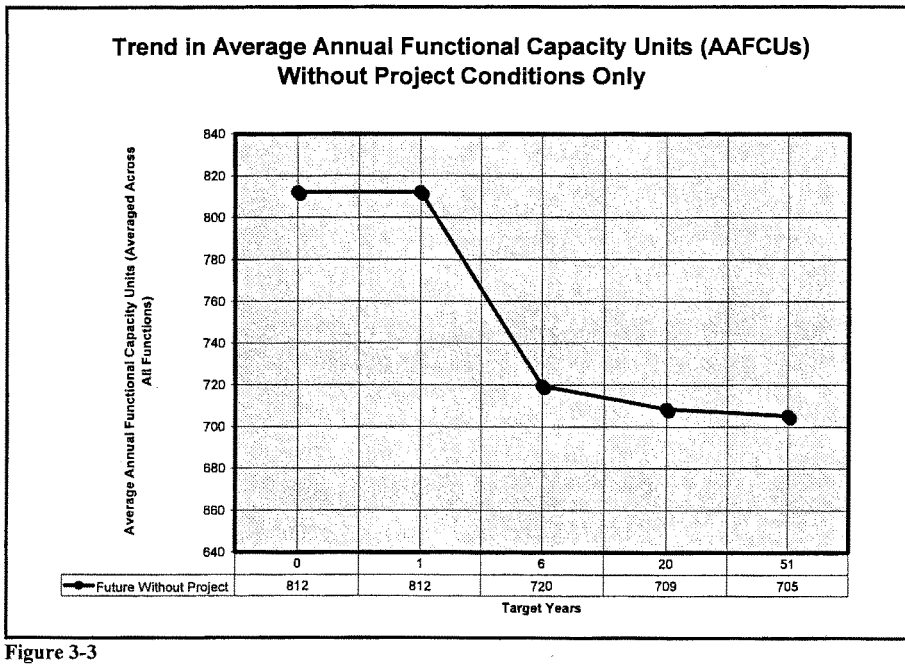


Figure 3-3
Without project Annual Average Functional Capacity Units (AAFCU) summary plot.

With Project Conditions
With the general trends of the Without Project condition in mind, the E-Team developed acreage and variable projections for the 15 alternatives presented above. Further these alternatives, when possible, were formulated with the intent of meeting as many of the goals and objectives developed and discussed earlier. As a general rule, the E-Team developed alternatives that varied with respect to the character and level of vegetation restoration, and either did or did not require specific engineering issues to be addressed (Table 3-3).

Vegetation character included Xeric-, Meso-, and Hydro-riparian communities in addition to those in which either Cottonwood or mesquite dominate. The level of vegetation restoration was defined by a range that includes minimal, moderate and extreme. The alternative MAX (F, N, & O) involves the maximum level of vegetation restoration, while LOAD (A) requires a minimal level. The remaining 11 alternatives require a moderate level of vegetation restoration.

Engineering considerations were necessary for 8 of the thirteen alternatives. Such considerations include the creation of channelized streams segments, reshaping of the channel invert, construction of braided channel networks, and sight/visibility corridors adjacent to surrounding roadways.

Table 3-3
Va Shly'ay Akimel ER-FS with project alternative conditions.

Vegetation Proposed	Level of Vegetation Restoration	Specific Engineering Issues	Alternative Code
Xero-Riparian Dominate	Minimal	None	A-LOAD
	Moderate	None	B-MEAD
	Extensive	None	C-HIAD
Meso-Riparian Dominate (Cottonwood, Mesquite & Xero-Riparian)	Moderate	Channelized Stream (Avoiding Mine)	D-MINE
	Extensive	None	E-VHAD
	Maximum	Reshaping and Channelized Stream	F-MAX
Cottonwood Dominate	Extensive	Braided Channel Network	G-CWAD
Mesquite Dominate	Extensive	Braided Channel Network	H-MSAD
Cottonwood Dominate	Moderate	Channelized Stream	I-CHNL
	Extensive	Reshaping of Sand & Gravel	J-BRAD
	Extensive	NO Reshaping of Sand & Gravel	K-NODL
Cottonwood & Mesquite Dominate	Moderate	High Visibility from Roads	L-POCK
Hydro-Riparian Dominate	Extensive	None	M-WET
Meso-Riparian Dominant	Maximum	Reshaping and Channelized Stream	N-MAX
Meso-Riparian Dominant	Maximum	Reshaping and Channelized Stream	O-MAX

Evaluation of Alternatives

Overall Review of the HGM Results

The overall HGM gains and losses in AAFCUs per alternative are summarized in Table 3-4. Inspection indicates only three alternatives exceed the performance target of 915.

Table 3-4
Net AAFCUs for each HGM model per alternative for the Va Shly'ay Akimel ER-FS.

Va Shly Ay Alternatives					NET AAFCUs									
					WATER				BIOGEOCHEM			HABITAT		
Vegetation Proposed	Level of Vegetation Restoration	Specific Engineering Issues	Alternative Code	Average Net AAFCUs	FXN 1: CHANNELDYN	FXN 2: WATSTORENR	FXN 3: WATSTORLNG	FXN 4: WATSTORSUB	FXN 5: NUTRIENT	FXN 6: ELEMENTS	FXN 7: DETPARTICL	FXN 8: PLANTS	FXN 9: HABSTRUCT	FXN 10: INTERSPERS
Xero-Riparian Dominate	Minimal	None	A-LOAD	373	400	407	311	72	324	275	385	569	534	454
	Moderate	None	B-MEAD	594	561	623	564	240	422	370	621	808	840	887
	Extensive	None	C-HIAD	771	628	817	792	300	591	466	812	1015	1065	1226
Meso-Riparian Dominate (Cottonwood, Mesquite & Xero-Riparian)	Moderate	Channelized Stream (Avoiding Mine)	D-MINE	598	425	634	611	383	520	355	622	727	755	950
	Extensive	None	E-VHAD	926	763	987	883	396	690	567	953	1225	1267	1525
	Maximum	Reshaping and Channelized Stream	F-MAX	1035	680	1129	1155	694	852	587	1102	1248	1377	1521
Cottonwood Dominate	Extensive	Braided Channel Network	G-CWAD	943	682	1020	979	552	750	554	991	1177	1257	1466
Mesquite Dominate	Extensive	Braided Channel Network	H-MSAD	850	674	905	939	535	592	462	957	1040	1147	1249
Cottonwood Dominate	Moderate	Channelized Stream	I-CHNL	675	420	816	732	589	601	409	663	752	766	1006
	Extensive	Reshaping of Sand & Gravel	J-BRAD	872	591	948	902	640	717	508	901	1044	1131	1343
	Extensive	NO Reshaping of Sand & Gravel	K-NODL	627	486	755	761	619	572	405	715	527	619	814
Cottonwood & Mesquite Dominate	Moderate	High Visibility from Roads	L-FOCK	758	516	884	744	693	671	477	751	920	947	977
Hydro-Riparian Dominate	Extensive	None	M-WET	829	547	944	862	777	667	477	830	953	1024	1211
Meso-Riparian Dominate	Maximum	Modification of MAX (Alternative F)	N-MAX	913	599	1023	891	652	812	565	912	1127	1178	1370
Meso-Riparian Dominate	Maximum	Modification of N-MAX (Alternative N)	O-MAX	963	627	1084	951	657	851	590	976	1192	1242	1455
			Performance Targets	915	689	1324	234	194	1152	821	1157	1617	1040	926

In general, the alternative requiring moderate or minimum levels of vegetation restoration resulted in the least amount of Net AAFCUs, while those requiring maximum or extensive levels resulted in the highest amount. Interestingly, the need to address specific engineering issues did not appear to correlate well with the amount of AAFCUs produced by a given alternative.

When considered by functional group, e.g. Water-related, Biogeochemically-related, or Habitat-related, Performance Target Net AAFCUs are met or exceeded by four of the 10 functions. All 15 alternatives exceed the performance target value for FXN 3: WATSTORLNG, while 14 alternatives satisfy target values for FXN 4: WATSTORSUB. None of the alternatives exceeded the performance target value for FXN 1: CHANNELDYN, FXN 2: WATSTORENR, nor were they by any of the biogeochemical functions, (NUTRIENTS, FXN 5, ELEMENTS, FXN 6, and DETPARTICL, FXN 7). Two of the habitat related functions, 9 (HABSTRUCT) and 10 (INTERSPERS), met performance targets in 9 and 12 of the alternatives respectively. Detailed information regarding these results can be found in the Appendix to this report.

Top Four Biological Winners Using HGM

As previously mentioned inspection of Table 3-4 above indicates that only three alternatives E - VHAD, F - MAX, and G - CWAD exceed the targeted net AAFCUs. F - MAX was subsequently reformulated into three alternatives F-MAX, N-MAX and O-MAX. O-MAX turned out to be the sponsors preferred alternative. These winners are briefly described below:

#1	O - MAX	Meso-Riparian dominated with maximum vegetation establishment. Minimal reshaping and channelization activities are also included. Net AAFCUs produced = 963
#2	F - MAX	Meso-Riparian dominated with maximum vegetation establishment. Reshaping and channelization activities are also included. Net AAFCUs produced = 1035
#3	G - CWAD	Cottonwood dominated with a braided channel network. Net AAFCUs produced = 943
#4	E - VHAD	Meso-Riparian dominated (cottonwood-willow, mesquite and xero-riparian species) with extensive vegetation establishment. Net AAFCUs produced = 926
		Performance Target = 915 AAFCUs

Individual HGM Model Results

Creating wetland and riverine riparian habitat under these winning scenarios, even though the quality of these areas were less than optimal for the HGM functions (i.e., $0 < FCIs \leq 1.0$

by TY51), nevertheless resulted in favorable returns on an AAFCU basis for all four of the proposed winning alternatives. With respect to the FCI scores at TY51, the flowing summations can be made on a model-by-model basis.

Function 1: Maintenance of Characteristic dynamics
Less than optimum (FCI = 1.0), the FCI values for the four top finishers ranged from 0.37 (E - VHAD) to 0.38 (O-MAX, F-MAX, and G-CWAD). The baseline results indicated the FCI for TY 51 was 0.28, hence improvement in this model is seen over baseline conditions for all three alternatives. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 689
AAFCU O-MAX = 627
AAFCU F-MAX = 680
AAFCU G-CWAD = 682
AAFCU E-VHAD = 763

Function 2: Dynamic Surface Water Storage/Energy Dissipation
FCI values for the four top finishers ranged from 0.50 in E-VHAD to a high of 0.59 for alternatives O-MAX and F-MAX. G-CWAD had an intermediate value of 0.55. Only O-MAX and F-MAX resulted in an improved FCI score when compared to the baseline condition at TY 51 for Function 2 (0.57). A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 1324
AAFCU O-MAX = 1084
AAFCU F-MAX = 1129
AAFCU G-CWAD = 1020
AAFCU E-VHAD = 987

Function 3: Long Term Surface Water Storage
The performance target FCI, (0.09) for Function 3 was exceeded by the top four biological alternatives. At TY 51 the FCI for long term surface water storage was 0.29 and 0.35 for O-MAX and F-MAX respectively, 0.29 for G-CWAD, and 0.25 for E-VHAD. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 234
AAFCU O-MAX = 951
AAFCU F-MAX = 1155
AAFCU G-CWAD = 979
AAFCU E-VHAD = 883

Function 4: Dynamic Subsurface Water Storage
The final FCI target value for Function 4 (0.08) was exceeded by all four top biological winners. O-MAX and F-MAX were almost three times the target value at 0.22 and 0.23 respectively, while G-CWAD was 0.19. E-VHAD had the lowest TY51 FCI value at 0.14. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top three biological winners:

AAFCU Performance Target = 194
AAFCU O-MAX = 657
AAFCU F-MAX = 694
AAFCU G-CWAD = 552
AAFCU E-VHAD = 396

Function 5: Nutrient Cycling
The performance target FCI value at TY 51 was exceeded by O-MAX, F-MAX, and CWAD. In such cases these improvements were slight, 0.07 increases for O-MAX and F-MAX, and 0.01 increase for G-CWAD over the target FCI for this function which was 0.50. The fourth top biological alternative E-VHAD does not achieve the performance target value at 0.44. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners:

AAFCU Performance Target = 1152
AAFCU O-MAX = 851
AAFCU F-MAX = 852
AAFCU G-CWAD = 750
AAFCU E-VHAD = 690

Function 6: Detention of Imported Elements and Compounds
All four top biological winners meet or exceed the performance target FCI value (0.33) for Function 6. The Alternatives O-MAX and F-MAX are highest at 0.39, while G-CWAD and E-VHAD were 0.37 and 0.34 respectively. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners:

AAFCU Performance Target = 821
AAFCU O-MAX = 590
AAFCU F-MAX = 587
AAFCU G-CWAD = 554
AAFCU E-VHAD = 567

Function 7: Detention of Particles
Only one of the top four biologically winning alternatives, F-MAX (0.52), meets the performance target established for the Function 7 of 0.50 at TY 51. O-MAX had a value of 0.49, while G-CWAD had a value of 0.47, and E-VHAD had a value of 0.43. A summary of the TY 51 performance target AAFCU and the AAFCU values for the top four biological winners are provided below:

AAFCU Performance Target = 1157
AAFCU O-MAX = 976
AAFCU F-MAX = 1102
AAFCU G-CWAD = 991
AAFCU E-VHAD = 953

Function 8: Maintain Characteristic Plant Communities
The performance FCI target value at TY 51 for Function 8 was achieved by three of the four top winning biological alternatives, O-MAX (0.76), F-MAX (0.79) and G-CWAD (0.74), while the fourth best biological winner E-VHAD equaled it at 0.70. All of these alternatives fall within the moderately functioning range of FCI values. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners are now provided:

AAFCU Performance Target = 1617
AAFCU O-MAX = 1192
AAFCU F-MAX = 1248
AAFCU G-CWAD = 1177
AAFCU E-VHAD = 1225

Function 9: Maintain Spatial Structure of Habitat
The top four biologically winning alternatives exceed the target FCI TY 51 value for Function 9 (Target TY 51 FCI = 0.45) and all fall within the moderately functioning range. The final FCI TY 51 values for the alternatives were 0.64, 0.69, 0.63, and 0.60 for the alternatives O-MAX, F-MAX, G-CWAD, and E-VHAD respectively. A summary of the TY 51 performance target AAFCU and the AAFCU values for the top four biological winners are shown below:

AAFCU Performance Target = 1040
AAFCU O-MAX = 1242
AAFCU F-MAX = 1377
AAFCU G-CWAD = 1257
AAFCU E-VHAD = 1267

Function 10: Maintain Interspersion and Connectivity
The final performance target value for Function 10 was 0.40. This was exceeded by all three of the top biological winners. O-MAX and F-MAX produced final TY 51 FCI values of 0.68 and 0.70 respectively. G-CWAD had a final TY 51 FCI score of 0.67 for Function 10, while E-VHAD was 0.64. A summary of the TY 51 performance target AAFCU and the AAFCUs values for the top four biological winners are now provided:

AAFCU Performance Target = 926
AAFCU O-MAX = 1455
AAFCU F-MAX = 1521

AAFCU G-CWAD = 1466
AAFCU E -VHAD = 1525

Cost Analysis

Project Costs
Two techniques were used to determine the most cost effective alternatives. The first method compared alternatives with respect to their cost effectiveness and is termed the Cost Effectiveness Analysis or CEA. Using this method, alternatives that produced increased levels of output, measured as AAFCUs, for the same or lesser costs were considered "effective" solutions and were retained. Those alternatives that provided lesser return for higher associated cost were dropped from consideration. The "effective" solutions were then assessed on the basis of efficiency in which "efficient" alternatives where those that produced similar levels of AAFCUs at the least expense. In order to establish a common point in time for alternative comparisons, the AAFCUs developed from the HGM analysis were modified. The reader is encouraged to refer to Section 5.7 of the Alternative Formulation Briefing Report for a full explanation.

The second technique involved conducting an Incremental Cost Analysis (ICA) using those alternatives that were deemed "efficient". In short, the ICA explores the costs associated with a given incremental increase in output of a given alternative. The results of this two-part analysis identified alternatives that are both cost and incrementally effective. Annualized costs and outputs for all alternatives, as well as the results of the CEA and ICA evaluations are discussed in the Cost Appendix to the main F4 Report.

Top Three Cost Effective Solutions Based On HGM Results

The cost analysis indicates that the top three Cost Effective Solutions include alternatives A2 - LOAD, B2 - MEAD, and L2 - POCK (Table 3-5). Alternative A2 - LOAD produces 389 AAFCUs with an average annual cost of $1,621,000. Alternative B2 - MEAD was the next most cost effective solution producing 619 AAFCUs for an average annual cost of $5,355,000. Alternative L2 - POCK was the third most cost effective solution providing 792 AAFCUs for an average annual cost of $7,570,000. The average annual cost per average annual functional capacity unit for the top three most cost effective solutions are provided in Table 3-5 below. Three of the top four biological winners are included in Table 3-5 for comparison; the least costly being two-times the cost of the least expensive alternative.

Table 3-5. The top three cost effective solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s.

Alternative	AAFCU*	AAC/AAFCU
1) A2 (LOAD)	389	$4.20
2) B2 (MEAD)	619	$8.60
3) L2 (POCK)	792	$9.60

*Note: AAFCU's adjusted for cost analysis time-frame.

Top Three Incrementally Effective Solutions Based On HGM Results

Results of the ICA indicate that the top three incrementally cost effective solutions include alternatives A2 - LOAD, O2 - MAX, and F2 - MAX (Table 3-6). Alternative A2 - LOAD is again included as an ICA alternative although the AAFCU is well below the project goals. The second place ICA alternative, O2 - MAX does however meet the project biological goals with an AAFCU of 1,006. The average annual cost for alternative O2 is $9,158,000. The third most incrementally cost effective alternative was F2 which produced 1,084 AAFCUs for an average annual cost of $15,409,000. Table 3-8 provides a summary of the top three ICA alternatives including their respective AAFCUs, incremental AA Cost, and incremental AAC/AAFCU.

Table 3-6. The top three ICA solutions for the Va Shly'ay Akimel restoration study. Note: in $1,000s.

Alternative	AAFCU*	Incremental AA Cost	Incremental AAC/AAFCU
1) A2 (LOAD)	389	$1,621	$4.20
2) O2 (MAX)	1006	$7,537	$12.20
3) F2 (MAX)	1084	$15,409	$80.50

*Note: AAFCU's adjusted for cost analysis time-frame.

CHAPTER 4 - Tradeoffs

During the HGM process alternatives are compared based upon the model outcomes with respect to wetland functions achieved, plant communities present, and the overall species mixture of the proposed system. The model itself is based upon functional groups within which many variables can be measured. Other variables and hence functions can not and must be estimated. Using these data as a basis, the alternatives are formulated, and the resulting output collected, ranked, and compared. Often times, such comparisons rely upon expert opinion and documentation to make the final selection.

The Va Shly'ay Akimel Environmental Restoration Trade-offs Process

During the Va Shyl'ay Akimel environmental restoration HGM process, FCI models were chosen to emphasize the importance of critical wetland processes and functions. In all only four "priority" functions were selected and of those two focused upon the "water" functional group and two focused upon the "habitat" functional groups. No biogeochemical functions were considered as a "priority" because the Team felt that these functions could not be restored without restoring the overall hydrology to the contributing watershed. Conversely, those functions that were considered as "priority" functions were those that the Team felt, at least on an appropriate scale, could realistically be achieved. Those priority functions included: Maintenance of Characteristic Dynamics, e.g. appropriate energy can be supplied to sustain the project feature over the long-term; Long-Term Subsurface Water Storage, e.g. creation and maintenance of perched groundwater area(s) or long-term surface irrigation will be provided; Maintain Characteristic Plant Communities, e.g.. sufficient energy will be input over the long-term in the form of operation and maintenance to reduce invasive/exotic plants and to promote native plant communities; and Maintenance of Spatial Structure, e.g. there would be an operation and maintenance commitment to ensure the original habitat and ecosystem mosaic is sustained for the life of the project. Although the above listed functions were considered as a priority, the HGM analysis considered all eleven.

If desirable, the influence of one function over that of another in an HGM model can be altered through the use of a relative value index or RVI. For example, the Team felt that Function 4, Detention of Imported Elements and Compounds would not be improved because of a lack of incoming materials due to the ephemeral nature of the project reach. To downplay the importance of Function 4, an RVI score could be assigned to weight the outcome of Function 4 to be of less importance than the other functions. Along the same lines, the priority functions could be assigned RVI values that weight their outcomes to be more important.

Although the Team considered the use of the RVI Trade-Offs process, it was not implemented. The Team instead acknowledged that there were assumptions made about all functions and that many functions were interdependent. The interdependency was such that increasing the importance of one, similarly increased the importance of others that were related, e.g. increasing the importance of water in the root-zone, likely resulted in increased plant community fitness and spatial structure.

As stated, the Va Shly'ay Akimel project did not utilize a formal tradeoff process with RVIs. Instead, it relied upon the weighting done by prioritizing the functions which were constructed using weighted variables. Table 4-1 provides the reader with a summary of the top three Cost Effective Analysis, Incremental Cost Analysis, and HGM rankings.

Table 4-1. The Va Shly'ay Akimel Environmental Restoration Study top three Alternatives based upon the CEA, ICA, and HGM analyses.

Rank*	CEA	ICA	HGM
1st	A2 LOAD	A2 LOAD	F1 MAX
2nd	B2 MEAD	O2 MAX	O1 MAX
3rd	L2 POCK	F2 MAX	G1 CWAD

* The ranking of alternatives for the Va Shyl'ay Akimel Environmental RS does not consider RVIs, due to the decision not to conduct trade-offs.

CHAPTER 5 - Summary and Conclusions

Overall Results Summarized

Based on the HGM assessment, the District can expect the proposed ecosystem restoration efforts to increase in ecosystem productivity and associated returns to riparian communities. The primary goal of this study is ecosystem restoration. The ecosystem restoration goal consists of hydraulic, vegetation, then eventually species restoration. Given the results documented in the previous chapters of this report, the District can reasonably assume that this goal will be met, since ecosystem function and restored communities are expected to increase in both quality and quantity over the life of the project.

Summary of Plans Under Consideration

The Biological Plan

This section provides a short summary of each of the top three biological plans based on the HGM analysis. Note that sub-alternatives 1 and 2 (denoting irrigation methods) do not differ with regard to biological outcome and therefore are not discussed separately. The top three alternatives from first to third were: alternative F, alternative O, and alternative G. These alternatives produce net AAFCU gains of 1035, 963, and 943 respectively (Table 5-1). Final FCI gains and habitat acres gained are shown in Table 5-1.

Table 5-1. Net AAFCU gains, final FCI scores, and gains in habitat acres for the top three biological alternatives Va Shly'ay Akimel restoration study.

	Alternative		
	F	O	G
Net AAFCU	1035	963	943
Final FCI score	0.52	0.52	0.48
Habitat Gain (acres)	447	442	457

Figures 5-1 and 5-2 show net AAFCU gains per function and final FCI's per function for the top three biological alternatives and performance targets. The red line across the graph represents the average net AAFCU (Fig. 5-1) and FCI (Fig. 5-2) for all 30 alternatives. From the red line on the graph it can be seen that the top three biological alternatives exceed the average net AAFCU and FCI for many of the functions except for CHANNNELDYN (channel dynamics) and those functions dependent upon channel

dynamics such as WATSTORLNG (water storage) WATSTORSUB (subsurface water storage) and ELEMENTS (elements).

Increases in the amount of restored and preserved vegetation communities are shown in Figure 5-3. Most existing acreage is in the scrub shrub vegetation community type, while all three alternatives create significant acreage of cottonwood vegetation community, a community type with the highest biological value.

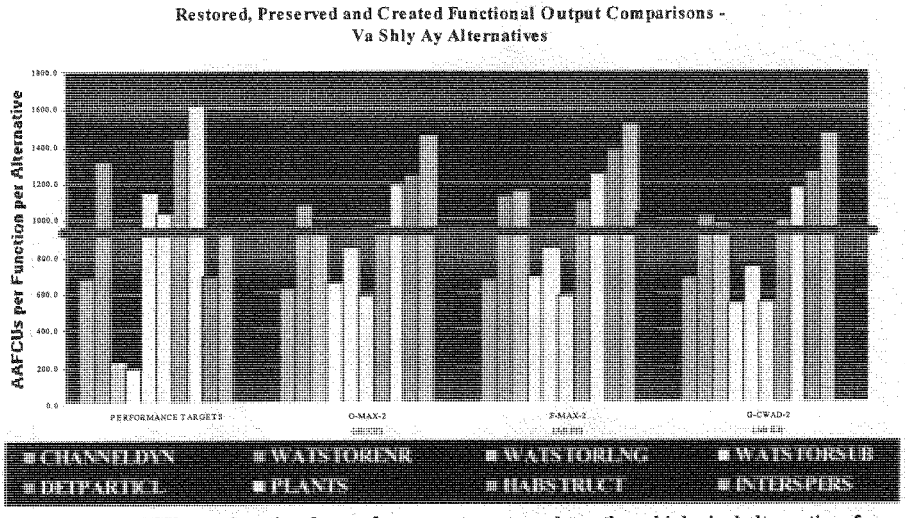


Figure 5-1. AAFCUs per function for performance targets and top three biological alternatives for the Va Shly'ay Akimel restoration study.

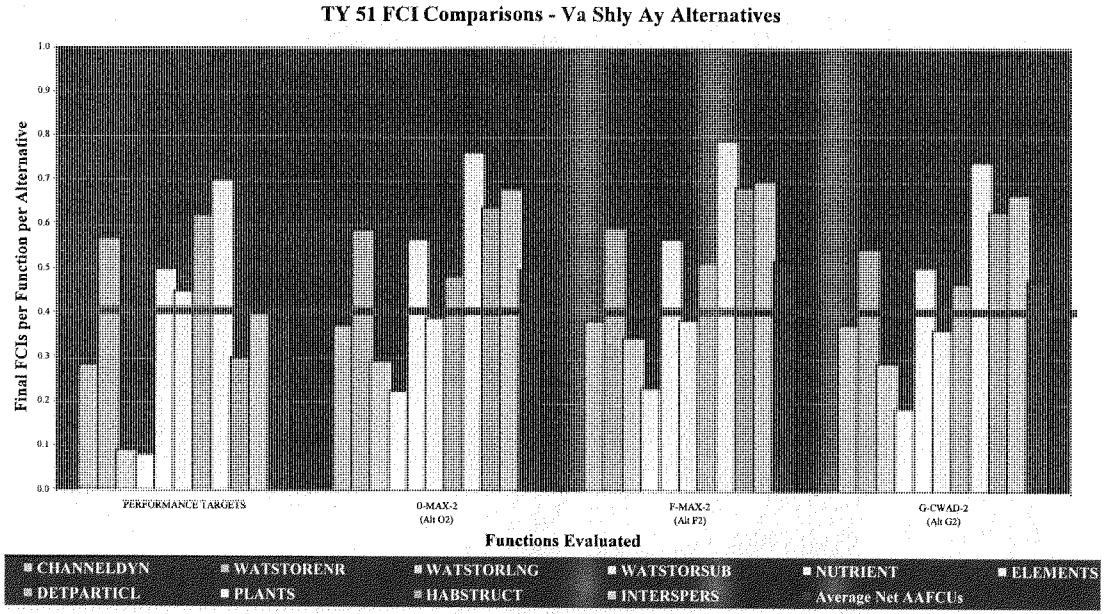


Figure 5-2. Final FCI's per function for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study.

1059

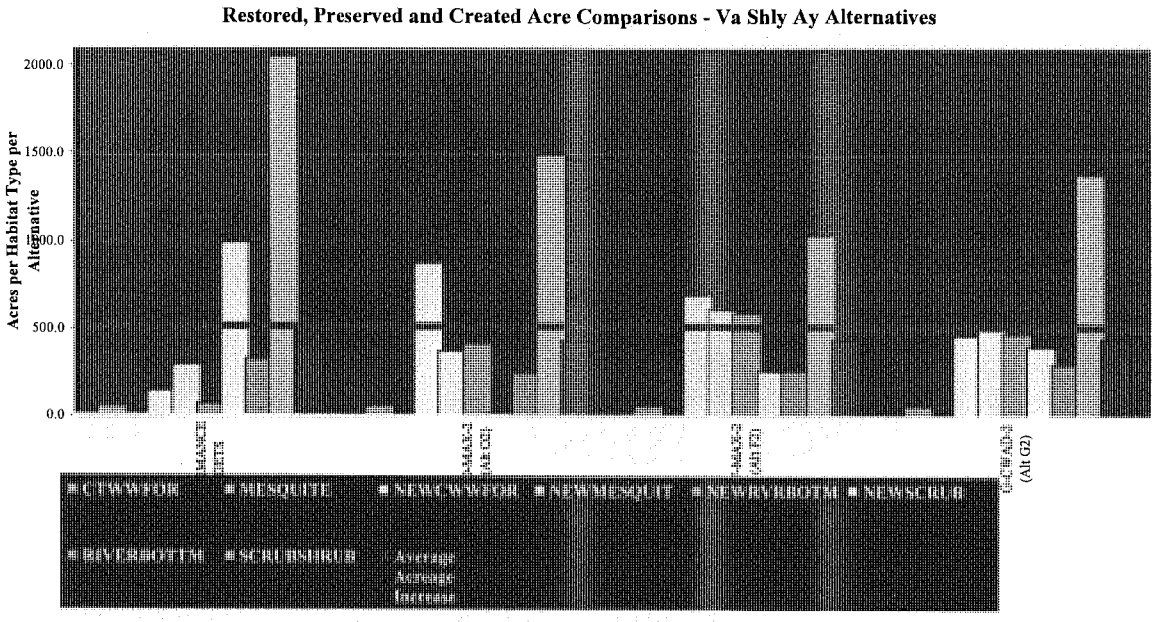


Figure 5-3. Acres per habitat type for performance targets and the top three biological alternatives for the Va Shly'ay Akimel restoration study.

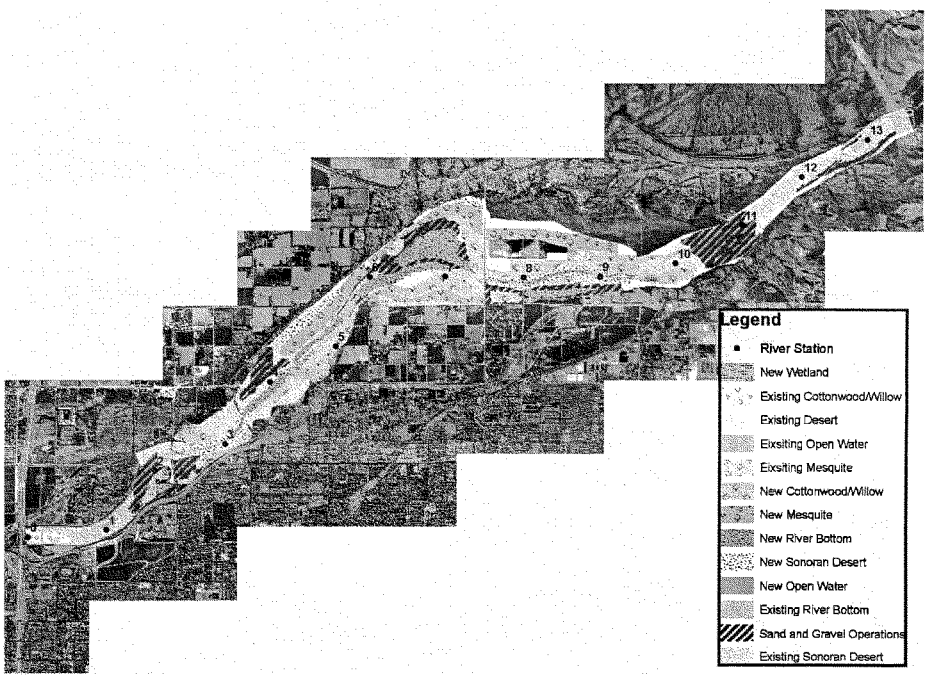


Figure 5-4. Diagram of alternative F, Va Shly'ay Akimel restoration study.

Alternative F

Alternative F creates a low flow channel from the Hennessey Drain to Gilbert Road and from Country Club Road downstream to Alma School Road. (Fig. 5-4) This channel would support Sonoran desert scrub shrub and wetlands. However, cottonwood/willow would be the dominant vegetation type with sufficient acreage of mesquite. Improvements by project reach including areas of bank stabilization are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

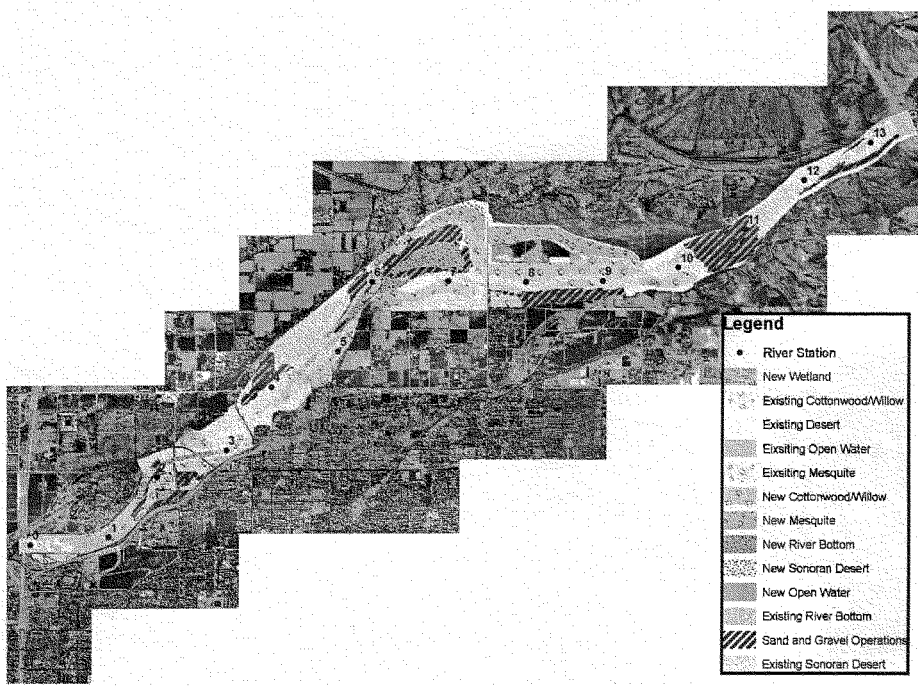


Figure 5-5. Diagram of alternative O, Va Shly'ay Akimel restoration study.

Alternative O

Alternative O creates a low flow channel from the Hennessey Drain to Gilbert Road and from Country Club Road downstream to Alma School Road. (Fig. 5-5) This channel would support Sonoran desert scrub shrub and wetlands. The major difference between Alternative O and Alternative F is the creation of additional cottonwood/willow habitat in the downstream reaches of the project. This alternative is a sponsor initiated alternative and did not appear in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

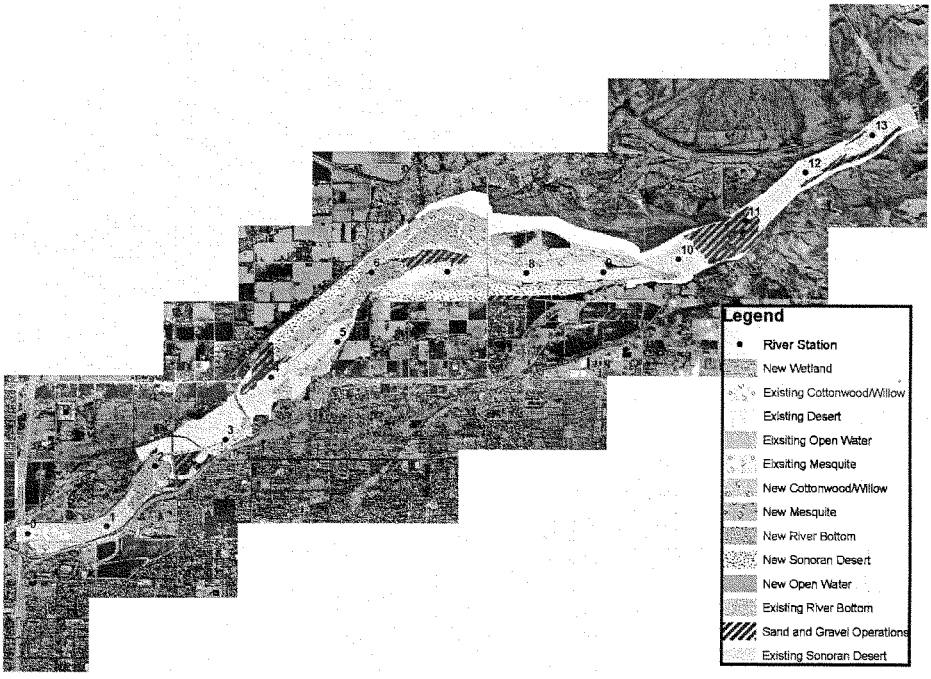


Figure 5-6. Diagram of alternative G, Va Shly'ay Akimel restoration study.

Alternative G

Alternative G is similar to alternative F. However, is does not have a low flow channel and some stands of cottonwood/willow are replaced with more xeric vegetation especially mesquite to reduce water demand (Fig. 5-6). Improvements by project reach including areas of bank stabilization are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, and gains in habitat area for this alternative and others are given in Table 5-1.

The Incremental Plan

This section provides a short summary of each of the top three plans based on an incremental cost analysis (ICA). Note that sub-alternatives 1 and 2 provide different ICA results due to differing installation and maintenance costs associated with the specific irrigation system. The top three alternatives from first to third were: alternative A2, alternative O2, and alternative F2. Cost per AAFCU ranges from $4.00 for alternative A2 to $15.00 for alternative F2. These alternatives produce net AAFCU gains ranging from 373 for alternative A2, to 1035 for alternative F2 (Table 5-2). Final FCI gains and habitat acres gained are shown in Table 5-2.

Table 5-2. Net AAFCU gains, final FCI scores, gains in habitat acres, average annual cost, and cost per AAFCU for the top three ICA alternatives for the Va Shly'ay Akimel restoration study.

	Alternative		
	A2	O2	F2
Net AAFCU	373	963	1035
Final FCI score	0.36	0.52	0.52
Habitat Gain (acres)	389	442	447
Average annual cost	$1621	$9158	$15409
Cost per AAFCU	$4.00	$10.00	$15.00

Figures 5-7 and 5-8 show net AAFCU gains per function and final FCI's per function for the top three ICA alternatives and performance targets. The red line across the graph represents the average net AAFCU (Fig. 5-4) and FCI (Fig. 5-5) for all 30 alternatives. From the red line on the graph it can be seen that of the top three ICA alternatives, alternative O2 and F2 exceed the average net AAFCU and FCI for many of the functions except for CHANNNELDYN (channel dynamics) and those functions dependent upon channel dynamics such as WATSTORLNG (water storage) WATSTORSUB (subsurface water storage) and ELEMENTS (elements). Alternative A2 which was the ICA winner had the lowest AAFCU and FCI gain. This alternative had below average AAFCU gain in all functions. This due to the only restoring scrub shrub habitat in this alternative.

Increases in the amount of restored and preserved vegetation communities are shown in Figure 5-9. Most existing acreage is in scrub shrub vegetation community type. Alternatives O2 and F2 create significant acreage of cottonwood vegetation community, a community type with the highest biological value. Habitat gain is lowest for alternative A2 because of minimal inputs in the restoration effort.

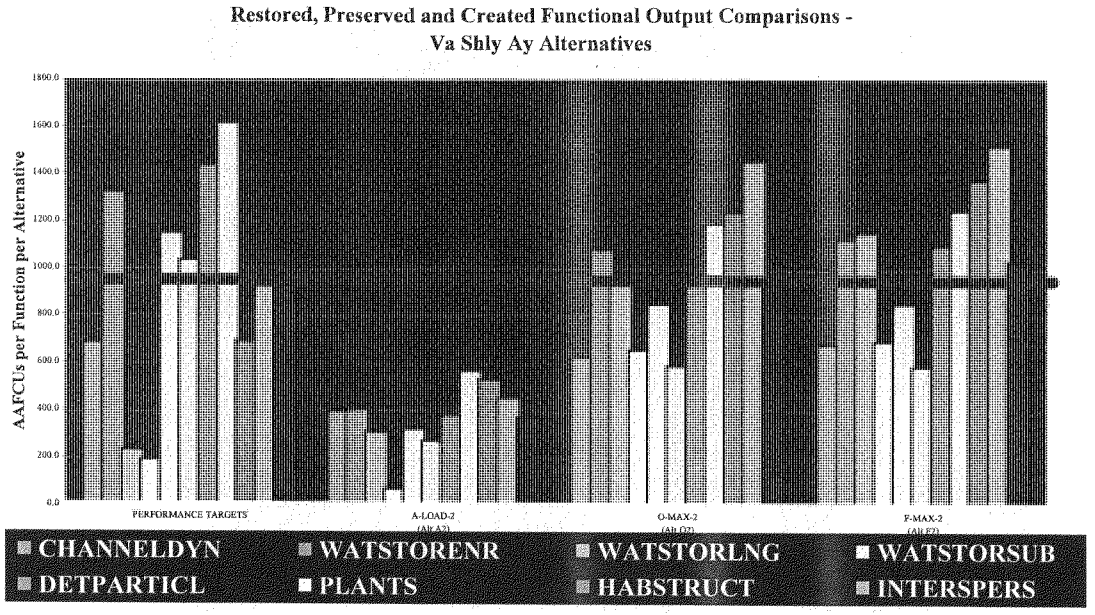


Figure 5-7. AAFCUs per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

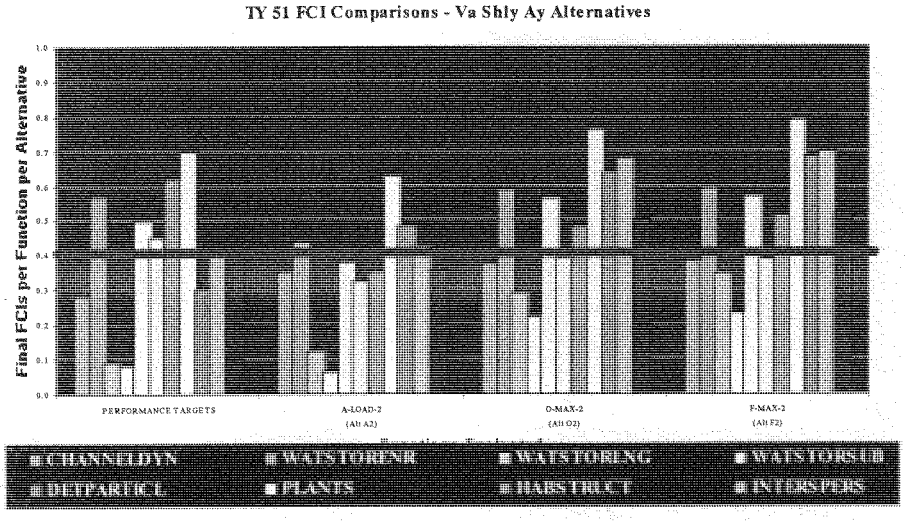


Figure 5-8. Final FCI's per function for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

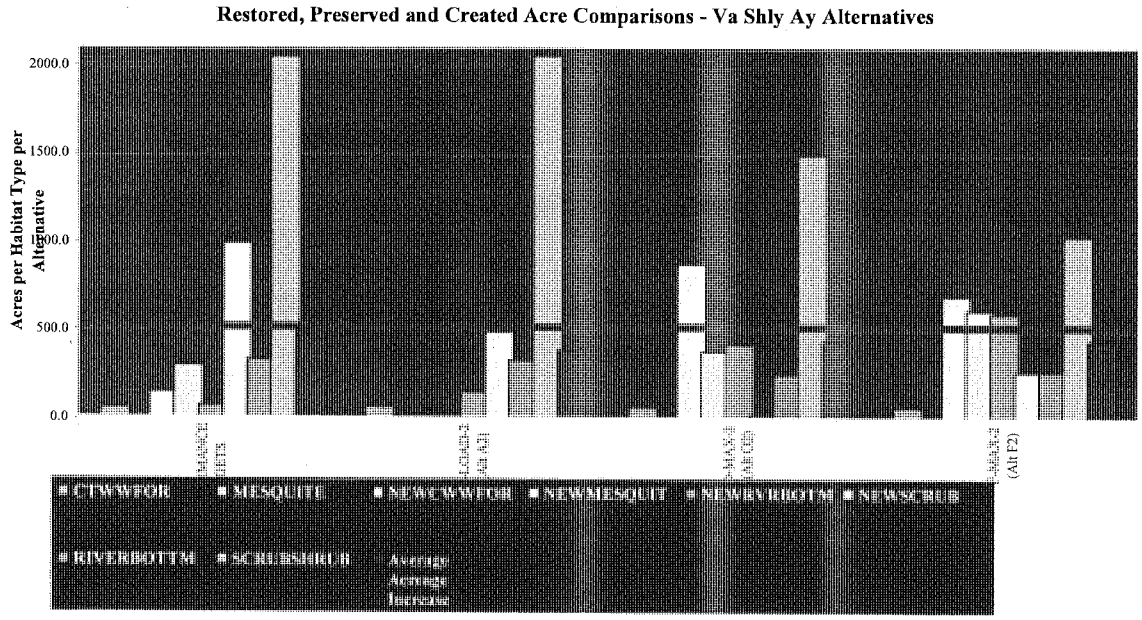


Figure 5-9. Acres per habitat type for performance targets and top three ICA alternatives for the Va Shly'ay Akimel restoration study.

Alternative A2

Alternative A provides a vegetative community that obligates the least amount of water. Sonoran desert scrub shrub, adapted to survive of relatively little rainfall, is the only vegetation type planned. No structural features are planned for this alternative. Improvements by project reach are detailed in the ITR Draft (F4) Feasibility Report. Net AAFCU gains, final FCI scores, gains in habitat area annual cost and cost per AAFCU for this alternative are given in Table 5-2.

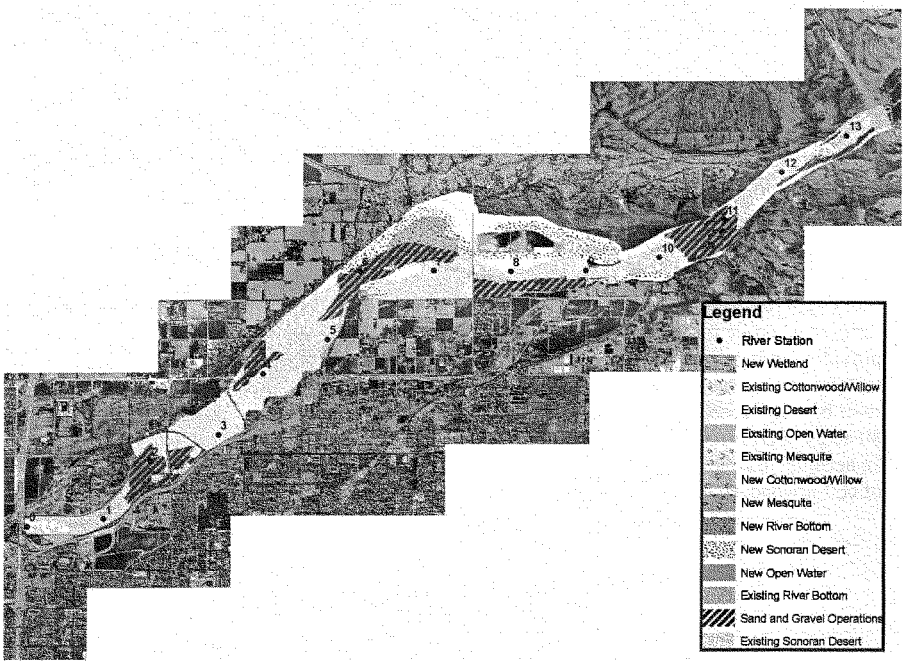


Figure 5-10. Diagram of alternative A, Va Shly'ay Akimel restoration study.

Alternative O2

A brief discussion and diagram (Fig. 5-5) of this alternative was presented in the previous section, The Biological Plan.

Alternative F2
A brief discussion and diagram (Fig. 5-4) of this alternative was presented in the previous section, The Biological Plan.

The Recommended Plan

Based on the HGM and ICA analyses, alternative O2 is the recommended plan. Alternative O2 is also the sponsor's preferred alternative. Alternative O2 ranked as the second biological alternative and the second ICA alternative. The sponsor's strong preferences for this alternative, combined with the high HGM and ICA rankings made O2 the recommended plan.

Net AAFCU gains, FCI scores, habitat gains, annual costs and costs per AAFCU compared to other leading alternatives have been discussed earlier (see The Biological Plan and The Incremental Plan).

Objectives Met

With respect to the goals of this restoration study, the alternative that meets the most objectives in a cost effective and efficient manner can be expected to achieve the ecosystem restoration goals, resulting in the most successful and desirable scenario of a restored ecosystem for a reasonable cost. The recommended plan (alternative O2) provides large gains in several biologically important habitat types. The amount of restored cottonwood vegetation type exceeds performance targets by 733 acres, restored river bottom exceeds targets by 350 acres and the amount of mesquite exceeds targets by 80 acres. Performance targets were not met for scrub shrub however this was considered an acceptable condition due to the low biological value of scrub shrub and the high value of cottonwood, river bottom, and mesquite.

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Glossary

Alternative
In HGM analyses, this is the "With Project" condition commonly used in restoration studies. An Alternative can be composed of numerous activities, measures, and/or options. Some examples of Alternatives include:

Alternative 1: Plant food plots, increase wetland acreage by 10 percent, install 10 goose nest boxes, and build a fence around the entire site.

Alternative 2: Build a dam, inundate 10 acres of riparian corridor, build 50 miles of supporting levee, and remove all wetlands in the levee zone.

Alternative 3: Reduce the grazing activities on the site by 50 percent, replant grasslands (10 acres), install a passive irrigation system, build 10 escape cover stands, use 5 miles of willow fascines along the stream bank for stabilization purposes.

Average Annual Functional Capacity Units (AAFCUs)
A quantitative result of annualizing Functional Capacity Unit (FCU) gains or losses across all years in the period of analysis.
AAFCUs = Cumulative FCUs ÷ Number of years in the life of the project, where:
Cumulative FCUs = Sum $(T_2 - T_1)[((A_1 F_1 + A_2 F_2) / 3) + ((A_2 F_1 + A_1 F_2) / 6)]$
and where:

T_1 = First Target Year time interval
T_2 = Second Target Year time interval
A_1 = Area of available wetland assessment area at beginning of T_1
A_2 = Area of available wetland assessment area at end of T_2
F_1 = FCI at beginning of T_1
F_2 = FCI at end of T_2

Baseline Condition
In the habitat assessment and planning analyses, baseline is the point in time before proposed changes, and is synonymous with Target Year (TY = 0).

Compensation
Also referred to as mitigation, in terms of wildlife habitat value loss, functional capacity loss, or environmental impacts, these are the methods or actions by which the inflicting agency or group offsets the unavoidable loss, of or damage to, these resources due to the proposed action.

Cost Effectiveness Analysis (CEA)
An economic analysis completed to determine the least-cost, economically rational, alternatives. Economically rational alternatives are, by definition, both the efficient and effective alternatives. The results of a cost effectiveness analysis are often displayed in tables, bar charts, and scatter plots.

Cover Type
A homogenous zone of similar vegetative species, geographic similarities, and physical conditions that make the area unique. In general, cover types are defined on the basis of species recognition and dependence.

Delimiting Situations
Occur when project manager's attempt to narrow the array of alternatives to a series of alternatives that meet certain restraining criteria. The project manager can eliminate the evaluation of costly alternatives and unproductive alternatives in cost analyses. For example, the project manager can declare an upper limit of costs—any alternative with a budget higher than this limit will be removed from further consideration. In this manner, project managers can limit the cost evaluation to alternatives that can be completed under the project's budget. Further, project managers can provide a minimum environmental productivity level. The cost analyses will "weed out" those alternatives that do not produce at least the minimal environmental output.

Dependent Alternatives
As a general rule, Dependent Alternatives cannot be implemented alone. Dependent Alternatives must be implemented in combination with their Independent Alternative to be successful. Dependent situations occur when the success of alternatives is contingent upon the presence of specific conditions (i.e., other alternatives) in the project. Often these situations arise when environmental, economic, and/or management factors reinforce one another to produce favorable outcomes. For example, the construction of a series of food plots on a high desert bench will require the installation of an irrigation system, or a channel/culvert system, connected to the nearest water source. The project manager will identify the food plot alternative as "dependent" upon either the irrigation system alternative, or the channel/culvert system alternative, on the basis of operation and management dependability.

Ecosystem
An ecosystem is a biotic community, together with its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole, unified through life processes. Ecosystems are hierarchical, and can be viewed as nested sets of open systems in which physical, chemical, and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multi states, more localized watersheds or a smaller complex of aquatic habitat.

Effective Alternatives
When comparing alternatives, these alternatives produce increased levels of outputs (AAHUs from HEP or AAFCUs from HGM) for the same or lesser costs.

Efficient Alternatives
When comparing alternatives, these alternatives produced similar levels of output (AAHUs from HEP or AAFCUs from HGM) at a lesser expense.

Existing Condition
Also referred to as the Baseline Condition, the Existing Condition is the point in time before proposed changes, and is designated as Target Year TY = 0 in the analysis.

Field Data
In HGM, this information is collected on various parameters (i.e., variables) in the field, and from aerial photos, following defined, well-documented methodology. An example is the measurement of percent herbaceous cover, over 10 quadrats, within a riparian forest cover type. The values recorded are each considered "field data." Means of variables are applied to derive functional capacity indices.

Functional Capacity Index Model (FCI)
In the HGM, an FCI Model is a quantitative estimate of functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects functional capacity at the site. The results of an FCI analysis can be quantified on the basis of a standard 0-1.0 scale, where 0.00 represents low functional capacity for the wetland, and 1.0 represents high functional capacity for the wetland. An FCI model can be defined in words, or mathematical equations, that clearly describe the rules and assumptions necessary to combine functional capacity indices in a meaningful manner for the wetland.
For example:

$$FCI = (VSI\ V_1 * VSI\ V_2) / 4,$$

where:

$VSI\ V_1$ is the Variable Subindex (VSI) for

variable 1;

$VSI\ V_2$ is the VSI for variable 2

Functional Capacity Units (FCUs)
A quantitative environmental assessment value considered the biological currency in HGM. Functional Capacity Units are calculated by multiplying the area of available wetland (quantity) by the quality of the wetland based on functionality. Quality is determined by measuring limiting factors describing wetland function, and is represented by values derived from Functional Capacity Indices (FCIs). FCU = AREA X FCI.

Changes in FCUs represent potential impacts or improvements of proposed actions.

Future Factor (FF)
A unit of quality change, used to define the anticipated changes in mean field data, by target year, on a variable-per cover type basis, rather than on a species-by-species basis. FF values are multiplicative factors (1.0, 1.5, 0.5, etc.), directly multiplied against the mean baseline condition, to allow project managers an opportunity to forecast changes over time on the site or project. For example, if the project manager anticipates a 50 percent increase in height of grass in the grassland cover type between TY_0 and TY_1, the baseline FF = 1.0, and the increase is an additional FF = 0.5, thus the overall FF = 1.0 + 0.5 = 1.5. In most instances, FFs less than 1.0 represent decreases in quality at the site, and FFs greater than 1.0 represent increases in quality at the site. Of course, this change is dependent upon the relationship between the species, the function, the cover type or PWAA, and the suitability index/functional capacity index for the model.

Guild A group of functionally similar species with comparable habitat requirements whose members interact strongly with one another, but weakly with the remainder of the community. Often a species HSI model is selected to represent changes (impacts) to a guild.

Increment
In cost analyses, this term represents the change in cost divided, by the change in outputs between those solutions that survive the cost effectiveness filtration of alternatives. An increment then, is used to answer the question: "Is it worth it to take the next leap in cost?" Increments are displayed in bar charts and tabular reports.

Incremental Cost Analysis (ICA)
An economic analysis is completed to reveal and interpret changes in costs for increasing levels of outputs (e.g., AAHUs from HEP or AAFCUs from HGM). The results of an incremental cost analysis are often displayed in bar charts and tables.

Independent Alternatives
These alternatives can be implemented alone or in concert with their dependent alternatives.

Ineffective Alternatives
When comparing alternatives, these alternatives produce **reduced** levels of output (AAFCUs from HGM) for the same or greater costs.

Inefficient Alternatives When comparing alternatives, these alternatives produced **similar** levels of output (AAFCUs from HGM) at a greater expense.

Limiting Factor
A variable whose presence/absence directly restrains the existence of a species or community in a habitat. A deficiency of the limiting factor can reduce the quality of the

habitat for the species or community, while an abundance of the limiting factor can indicate an optimum quality of habitat for the same species or community.

Limits
See "Delimiting Situations."

Measure
The act of physically sampling variables such as height, distance, and percent and the methodology followed to gather variable information (i.e., see "Method" below). In some economic terms, a "measure" is considered a hierarchy of alternatives that can be subdivided further into scales or increments.

Method
In HGM applications, this is the mode/protocol followed to collect and gather field data. It is important to document the relevant criteria limiting the collection methodology. For example, the time of data collection, the type of techniques used, and the details of gathering this data should be documented as much as possible. An example of a method would be:
Between March and April, run five random 50-m transects through the relevant cover types. Every 10-m along the transect, place a 10-m^2 quadrat on the right side of the transect tape and record the percent herbaceous cover within the quadrat. Average the results per transect.

Non-Additive Situations
These situations occur when the combination of alternatives results in non-cumulative outputs or costs. Often this condition arises when environmental, economic and/or management factors contradict summative outcomes. For example, if the implementation of two separate alternatives can save on mobilization and demobilization costs, the project manager can reduce the overall combined cost to reflect this savings. The solution is considered "non-additive." This information is included in the cost analyses.

Non-Combinable Situations
These situations occur when mutually exclusive alternatives exist in the project. Often this condition arises when environmental, economic and/or management factors contradict combinable outcomes. For example, the alternative "construction of a new highway through the Florida Everglades" will conflict with the alternative "preservation and enhancement of the existing wetlands, precluding any development." If the only alternatives are to provide protection to the wetlands, or build the highway, these two alternatives are deemed "non-combinable" on the basis of environmental incompatibility. This information is included in the cost analysis evaluations.

Partial Wetland Assessment Area (PWAA)
A homogenous zone of similar vegetative species, geographic similarities and physical conditions that make the area unique. In general, PWAAs are defined on the basis of species recognition and dependence, soils types and topography.

Plans of Interest
These situations occur when an outside qualitative factor directly influences the decision to implement an alternative, regardless of its environmental productivity or cost effectiveness. Several factors (i.e., political importance, aesthetic implications, environmental significance, community support, etc.) can compel decision-makers to evaluate alternatives that would have been eliminated under normal situations because of their ineffectiveness. For example, a "green belt" solution replacing a concrete channel through a business district might not be cost effective, or environmentally productive, but the co-sponsor (i.e., the local business association) can insist this alternative be evaluated as part of the project. This alternative is now considered a "Plan of Interest" alternative in cost analyses.

Project Manager
Any biologist, economist, hydrologist, engineer, decision maker, resource project manager, planner, environmental resource specialist, limnologist, etc., who is responsible for managing a study, program, or facility.

Relative Value Index Is a value that is used to adjust AAFCUs to accommodate social, economic, ecological, and political considerations? Judging criteria for relative values are defined by the decision-making team. Relative weights are calculated for each criterion, and then each evaluation model is rated against each criterion.
RVI = relative weight * value assigned to each evaluation model.

Relative Area
In HGM, the relative area is a mathematical process used to "weight" the various applicable cover types on the basis of quantity. To derive the relative area of a model's cover type, the following equation can be utilized:

Relative Area = Cover Type Area / Total Area

where:

Cover Type Area = only those acres assigned to the cover type (or PWAA) of interest
Total Area = the sum of the acres utilized in the model.

Scale (1)
In some geographical methodologies, the scale is the defined size of the image in terms of miles per inch, feet per inch, or pixels per acres; (2) scale can also refer to variations of the alternative in some cost analysis software packages.

Single Formula Model
Is an FCI model in HGM that is based on the existence of a single wetland function requirement and a single formula is used to depict the functional capacity.

Site

The location upon which the project manager will take action, evaluate alternatives and focus cost analysis.

Solutions
In cost analysis, this is the alternative (see definition above.)

Spreadsheet
A type of computer file or page that allows the organization of data (alpha-numeric information) in a tabular format. Spreadsheets are often used to complete accounting/economic exercises.

Target Year (TY)
A unit of time measurement used in HEP, that allows the project manager to anticipate and direct significant changes (in area or quality) within the project (or site). As a rule, the baseline TY is always TY = 0, where the baseline year is defined as a point in time before proposed changes would be implemented. As a second rule, there must always be a TY = 1, and a TY = X_2. TY_1 is the first year land- and water-use conditions are expected to deviate from baseline conditions. TY_{X2} designates the ending target year. A new target year must be assigned for each year the project manager intends to develop or evaluate change within the site or project. The habitat conditions (quality and quantity) described for each TY are the expected conditions at the end of that year. It is important to maintain the same target years in both the environmental and economic analyses.

Trade-offs
Are used to adjust the AAFCUs by considering human values. There are no right or proper answers, only acceptable ones. If trade-offs are used, outputs are no longer directly related to optimum habitat.

Variable
A measurable parameter that can be quantitatively described, with some degree of repeatability, using standard field sampling and mapping techniques. Often, the variable is a limiting factor for a species (or community), used in the development of SI curves and measured in the field (or from aerial photos) by personnel, to fulfill the requirements of field data collection in a HGM application. Some examples of variables include height of grass, percent canopy cover, distance to water, number of snags in 0.4 hectare, or average annual water temperature.

Variable Subindex (VSI)
In HGM, a VSI is a mathematical equation that reflects a wetland function's sensitivity to a change in a limiting factor (i.e., variable) within the PWAA. In HGM, VSIs are depicted using scatter plots and bar charts (i.e., functional capacity curves). The VSI value (Y-axis) ranges on a scale from 0.0 to 1.0, where a VSI = 0.0 represents a variable that is extremely limiting and a VSI = 1.0 represents a variable in abundance (not

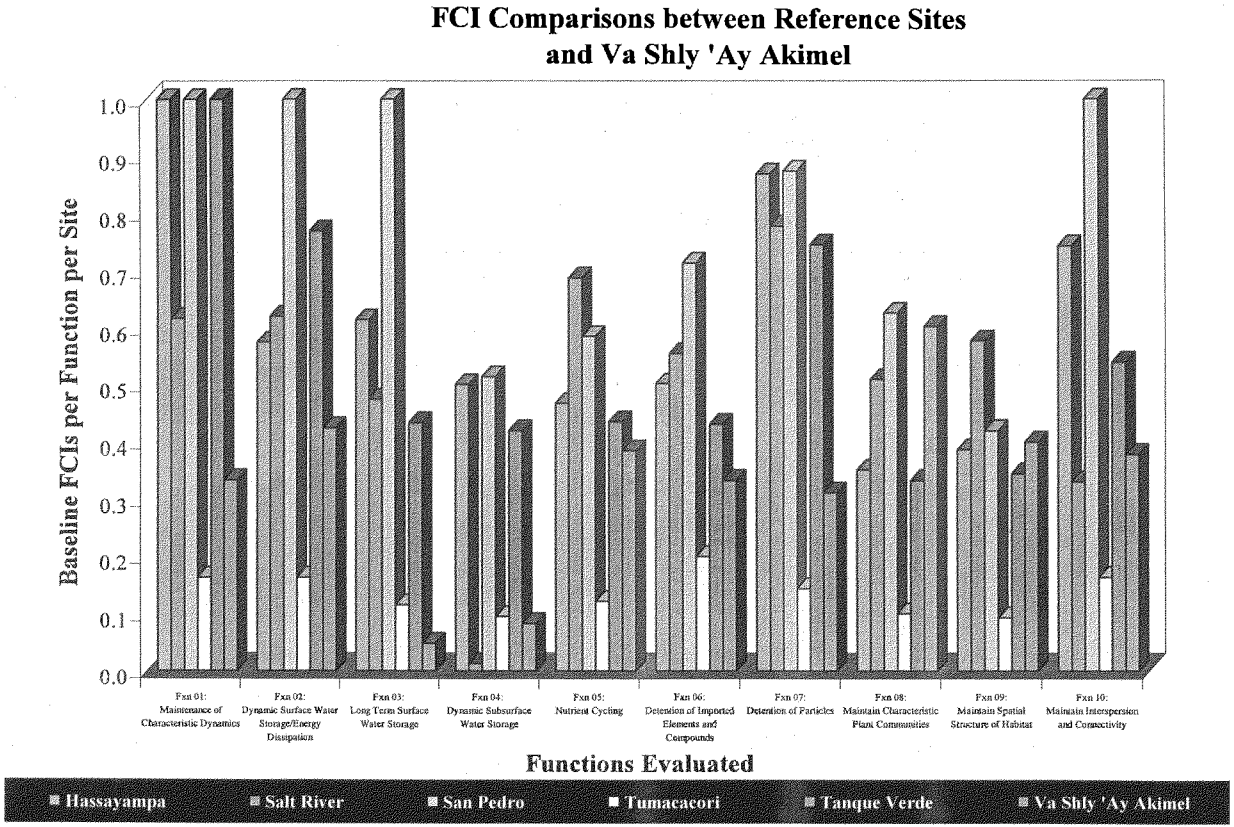
limiting) for the wetland.

With Project Condition
Also referred to as the alternative, this is the condition of the site after an alternative is implemented.

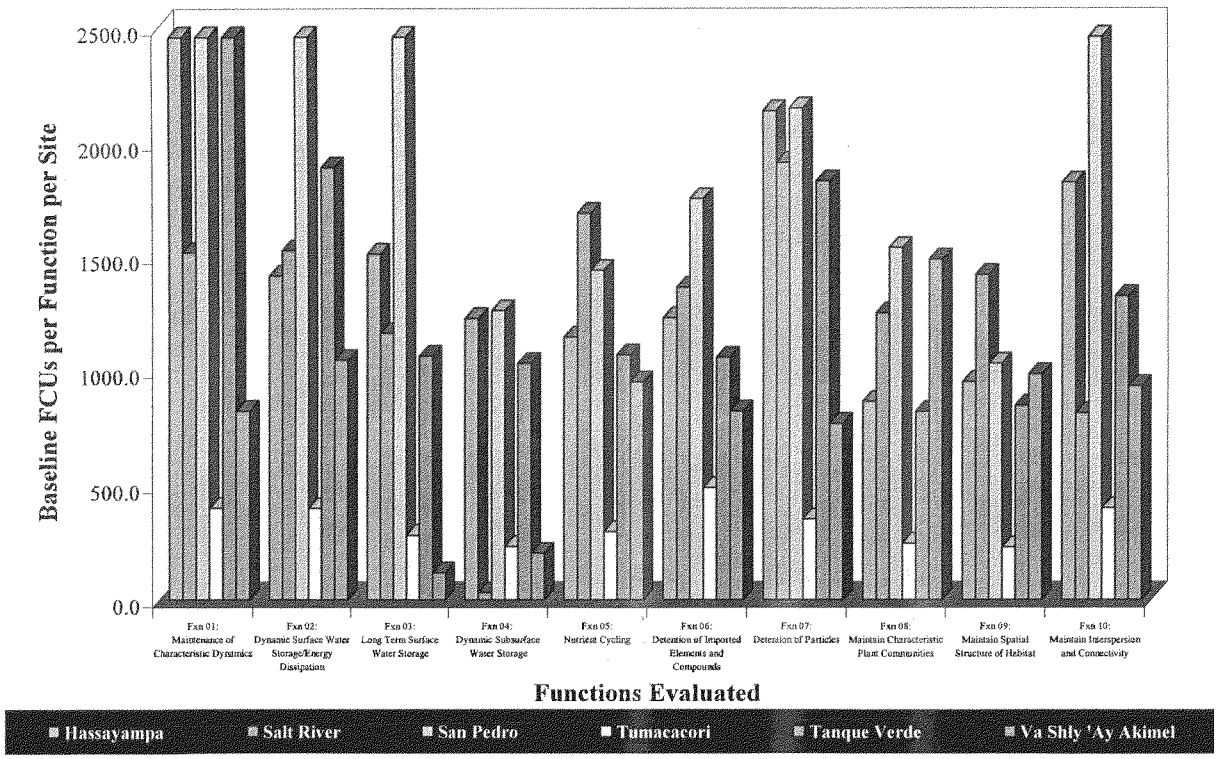
Without Project Condition
Sometimes referred to as the Baseline condition, or the Existing condition, this is the expected condition of the site without implementation of an alternative; referred to as the "No Action" condition in planning studies. The habitat conditions at TY 0 always refer to the pre-existing conditions.

Va Shly'ay Akimel HGM Appendices

Appendix A – Va Shly'ay Akimel Versus Reference Sites Baseline FCIs & TY 51 WOP FCUs & AAFCUs

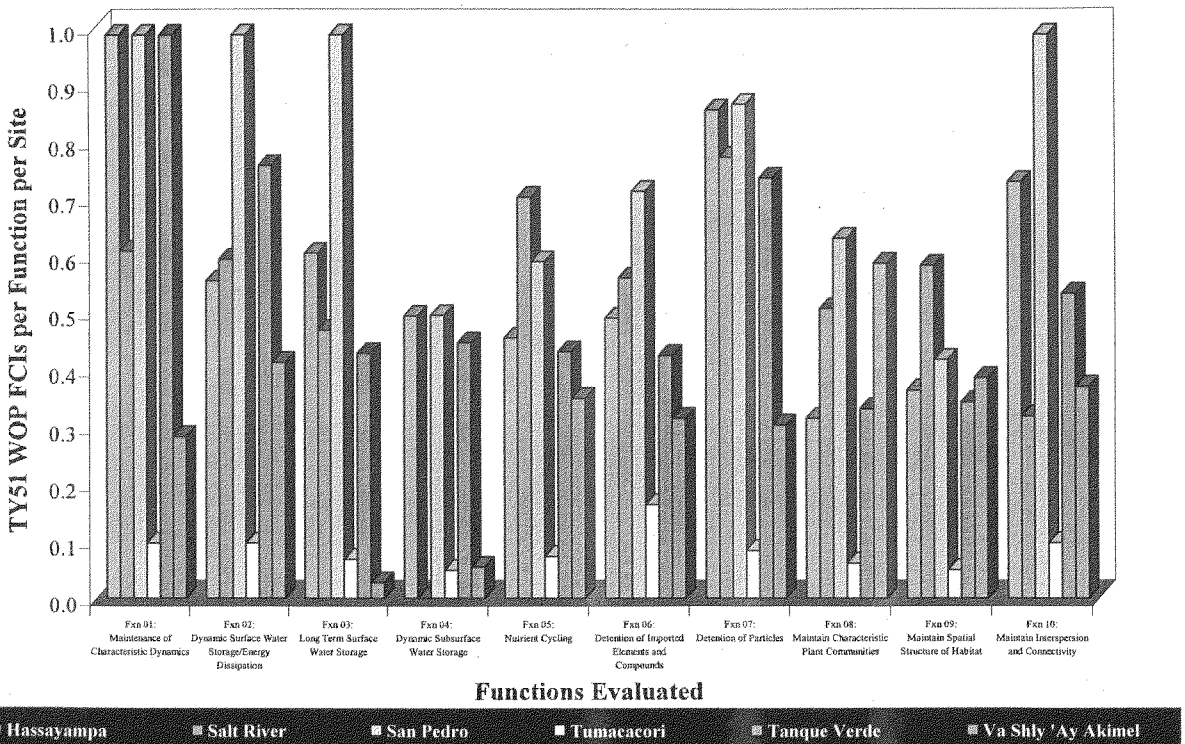

FCI Comparisons between Reference Sites and Va Shly 'Ay Akimel
Baseline FCIs per Function per Site
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functions Evaluated
Hassayampa
Salt River
San Pedro
Tumacacori
Tanque Verde
Va Shly 'Ay Akimel

FCU Comparisons between Reference Sites and Va Shly 'Ay Akimel



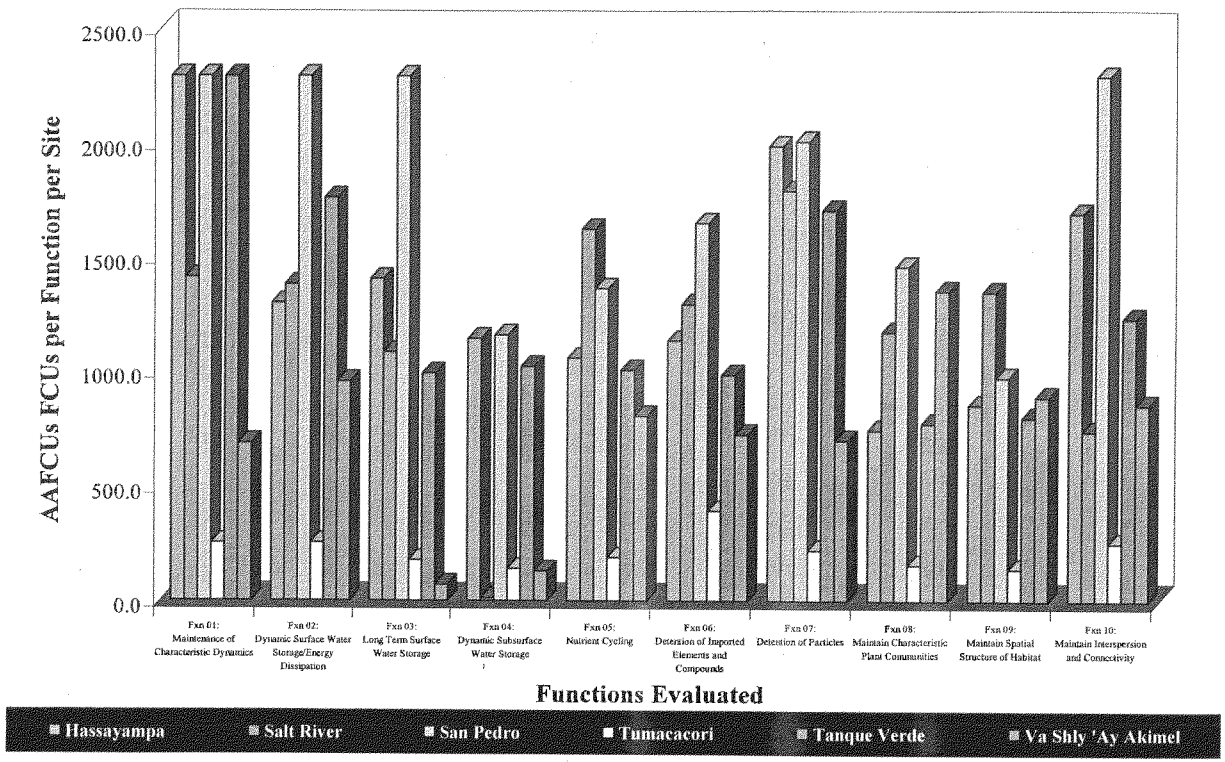
100% HGM
Appendix A – Va Shly'ay Akimel Versus Reference Sites
Page A3 of A5

TY51 WOP FCI Comparisons between Reference Sites and Va Shly 'Ay Akimel



100% HGM
Appendix A – Va Shly'ay Akimel Versus Reference Sites
Page A4 of A5

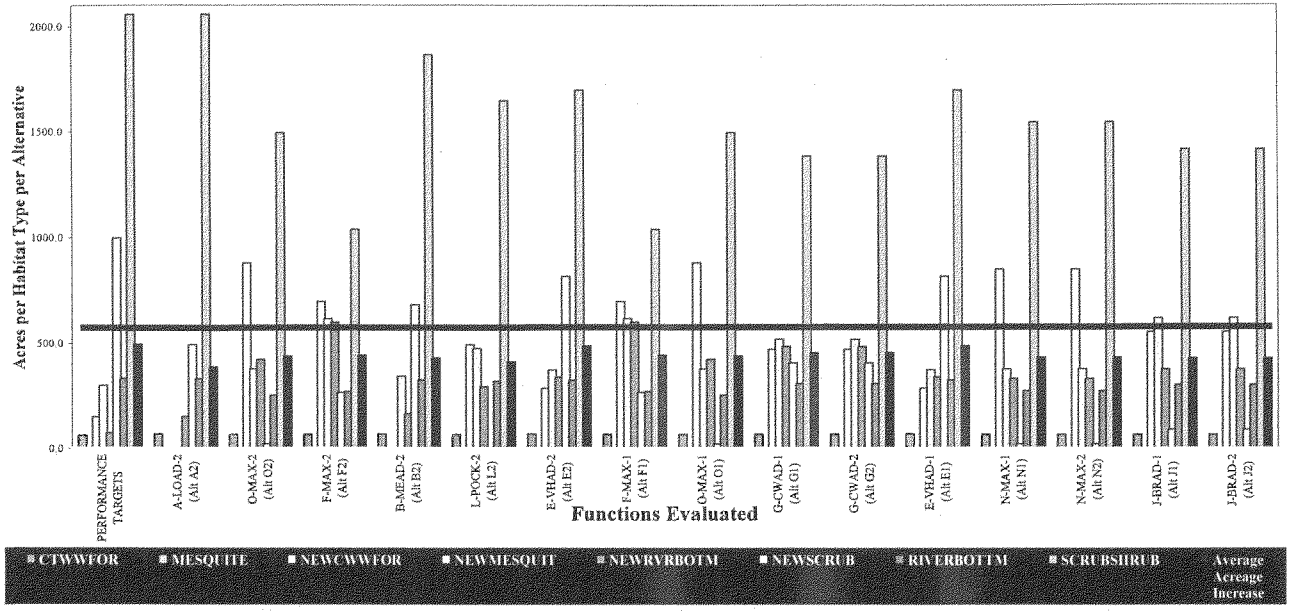
WOP AAFCU Comparisons between Reference Sites and Va Shly 'Ay Akimel



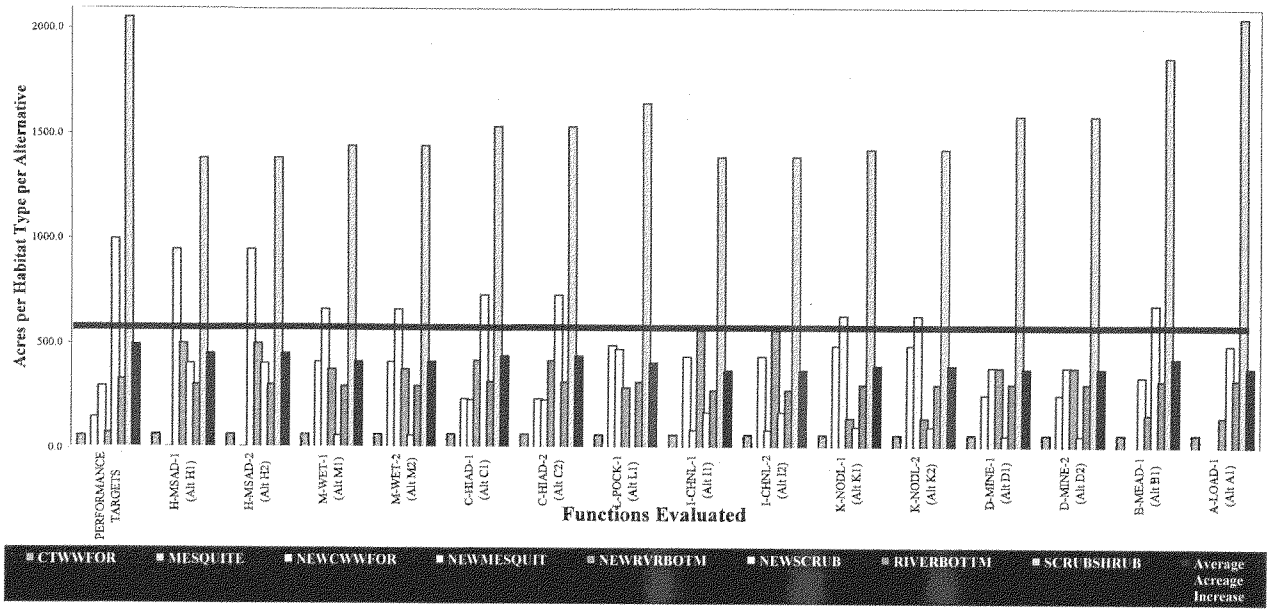
10086

Appendix B – Va Shly'ay Akimel Performance Targets

Restored, Preserved and Created Acre Comparisons - Va Shly Ay Alternatives

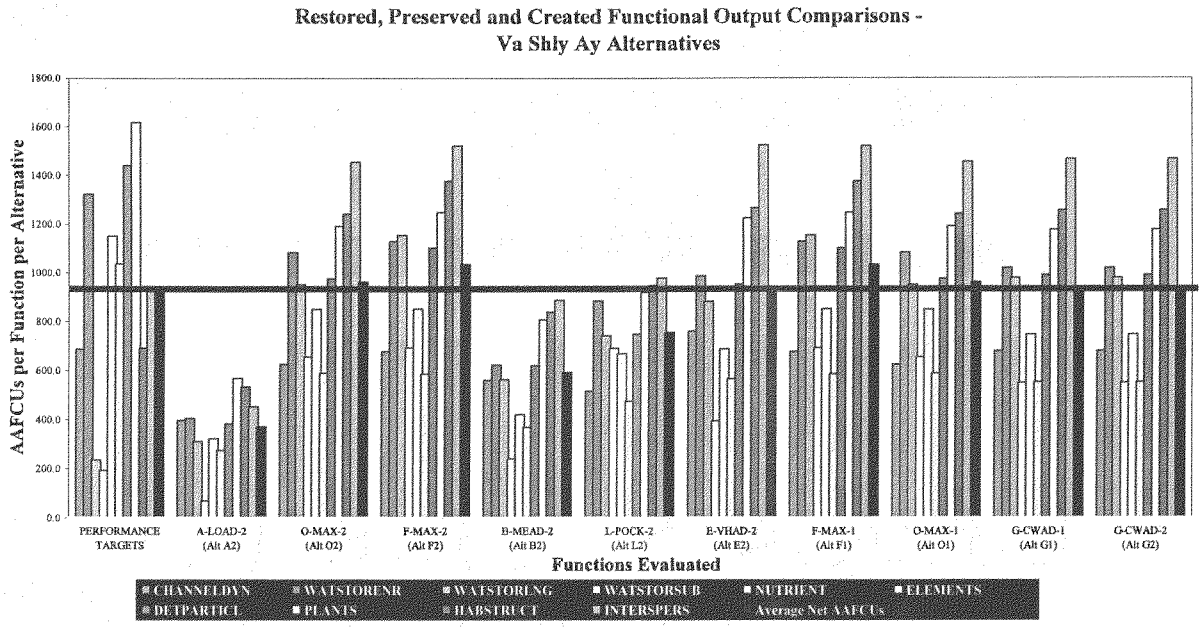


Restored, Preserved and Created Acre Comparisons - Va Shly Ay Alternatives

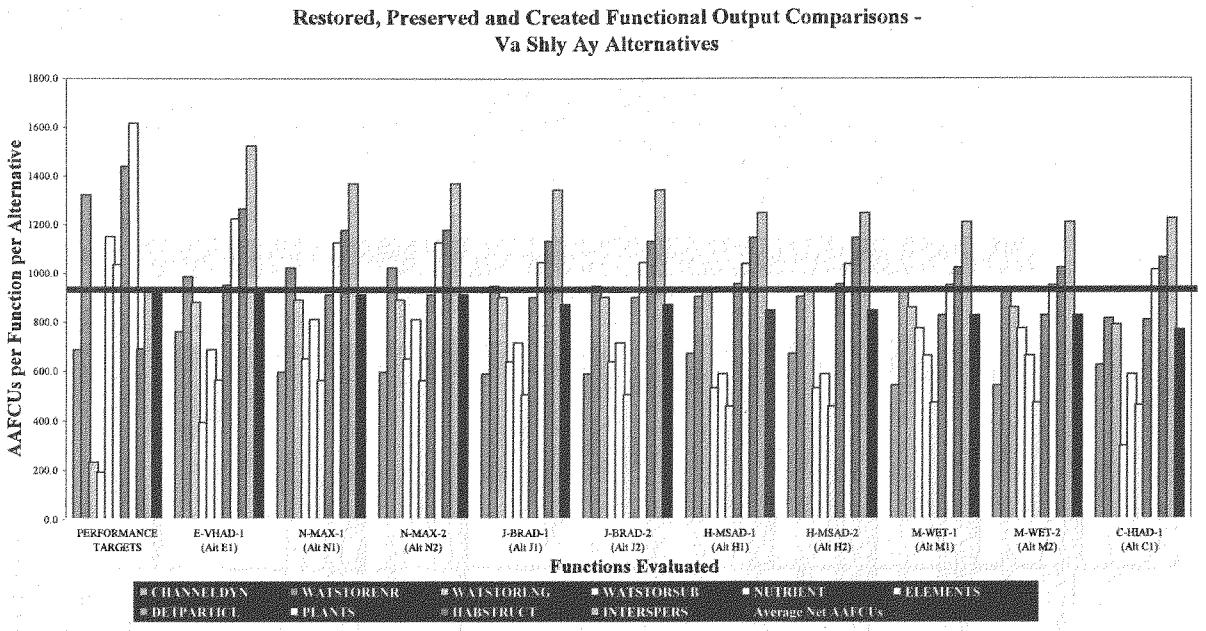


1089

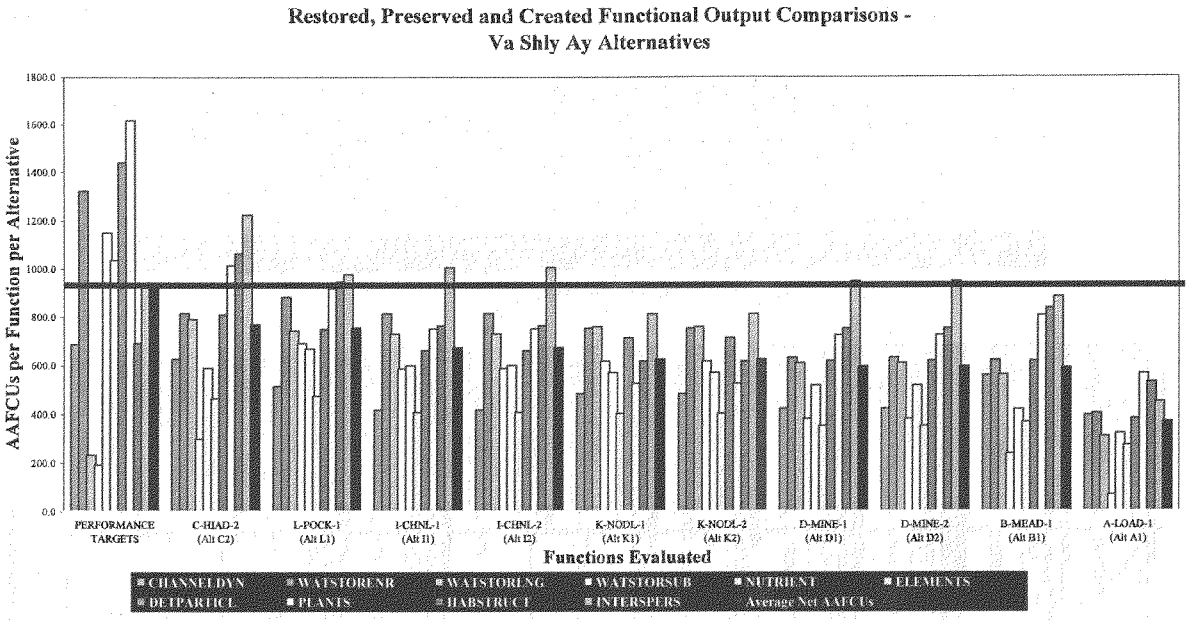
100% HGM
Appendix B – Va Shly'ay Akimel Performance Targets
Page B3 of B9

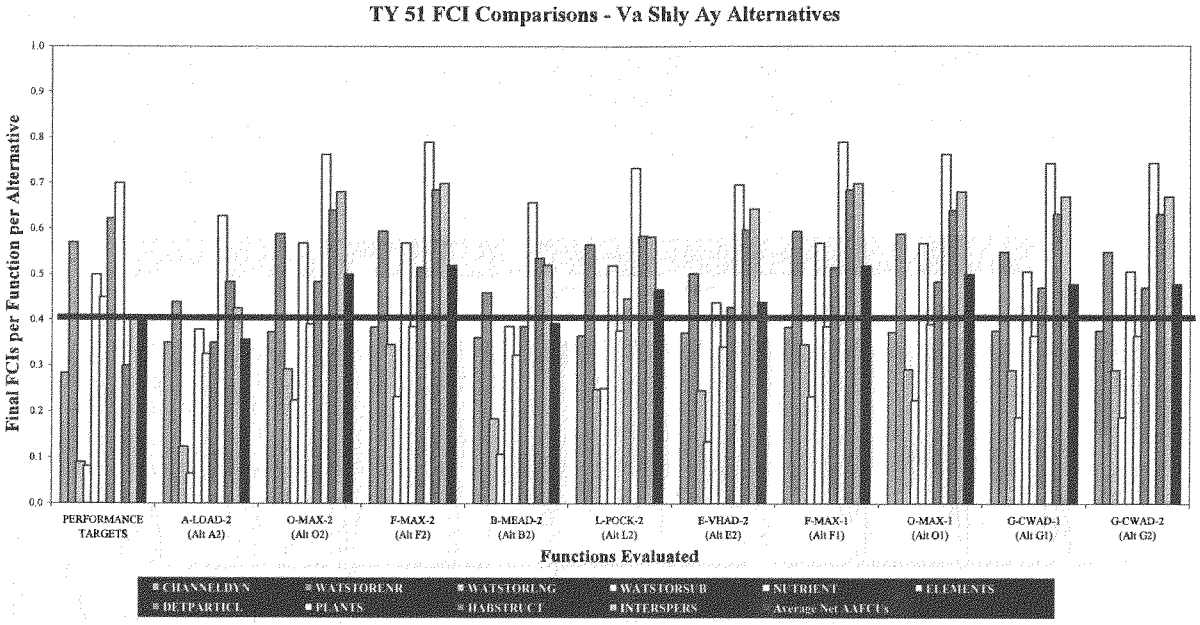

Restored, Preserved and Created Functional Output Comparisons -
Va Shly Ay Alternatives
AAFCUs per Function per Alternative
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
PERFORMANCE TARGETS
A-LOAD-2 (Alt A2)
O-MAX-2 (Alt O2)
F-MAX-2 (Alt F2)
B-MEAD-2 (Alt B2)
L-POCK-2 (Alt L2)
E-VHAD-2 (Alt E2)
F-MAX-1 (Alt F1)
O-MAX-1 (Alt O1)
G-CWAD-1 (Alt G1)
G-CWAD-2 (Alt G2)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

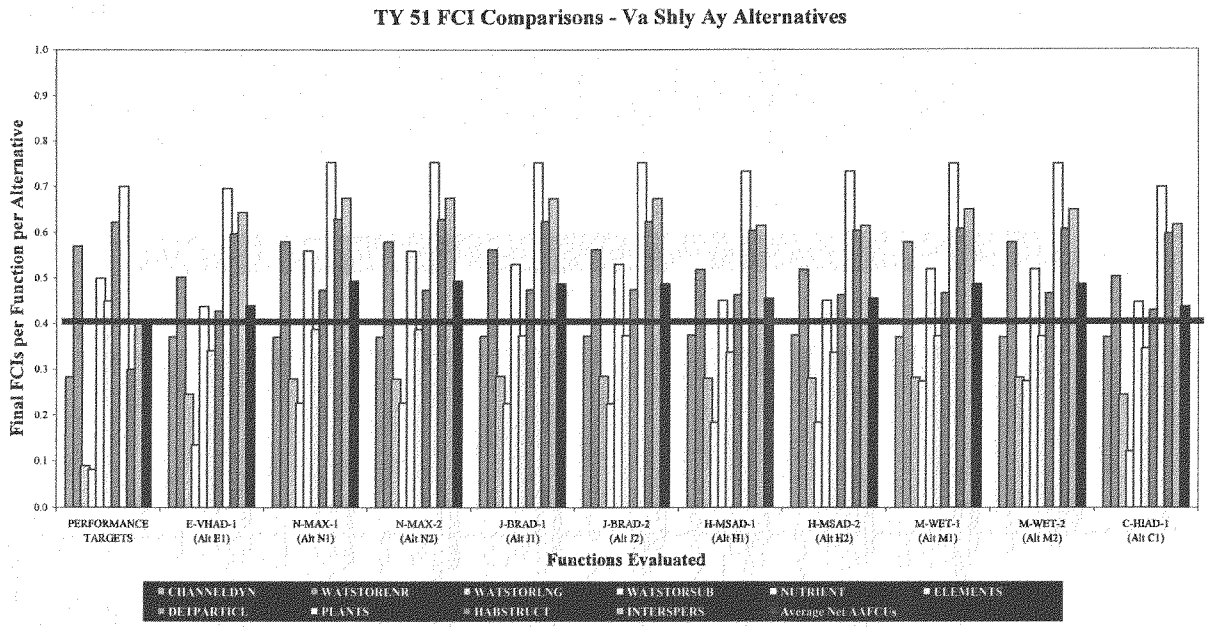
1090

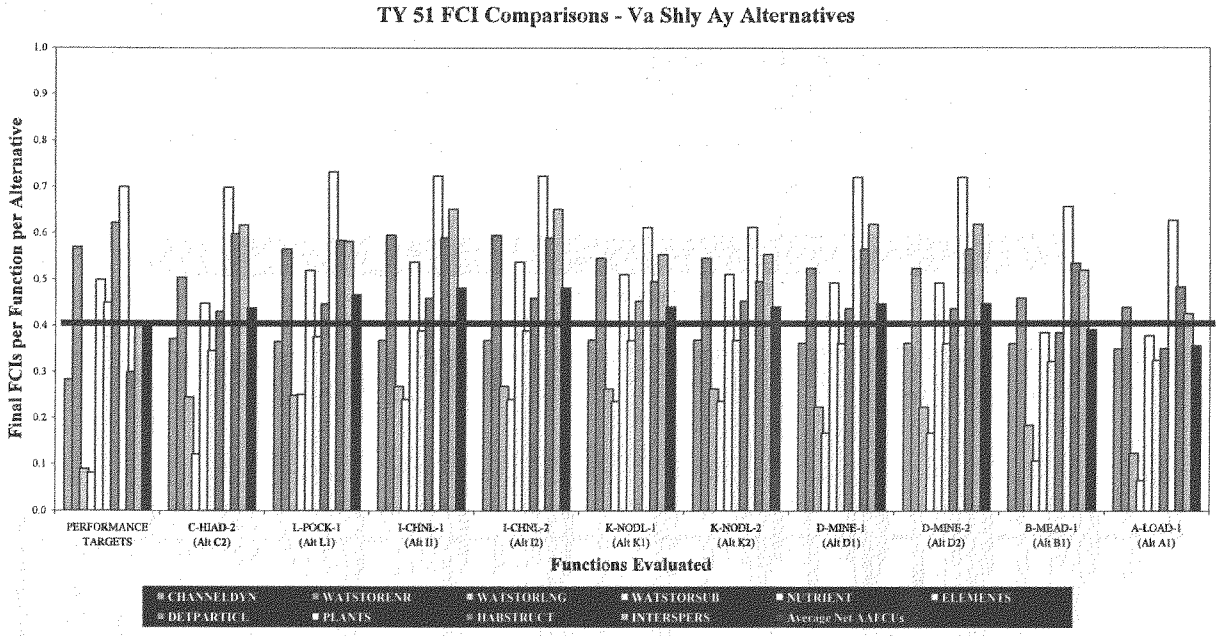


100% HGM
Appendix B – Va Shly'ay Akimel Performance Targets
Page B5 of B9

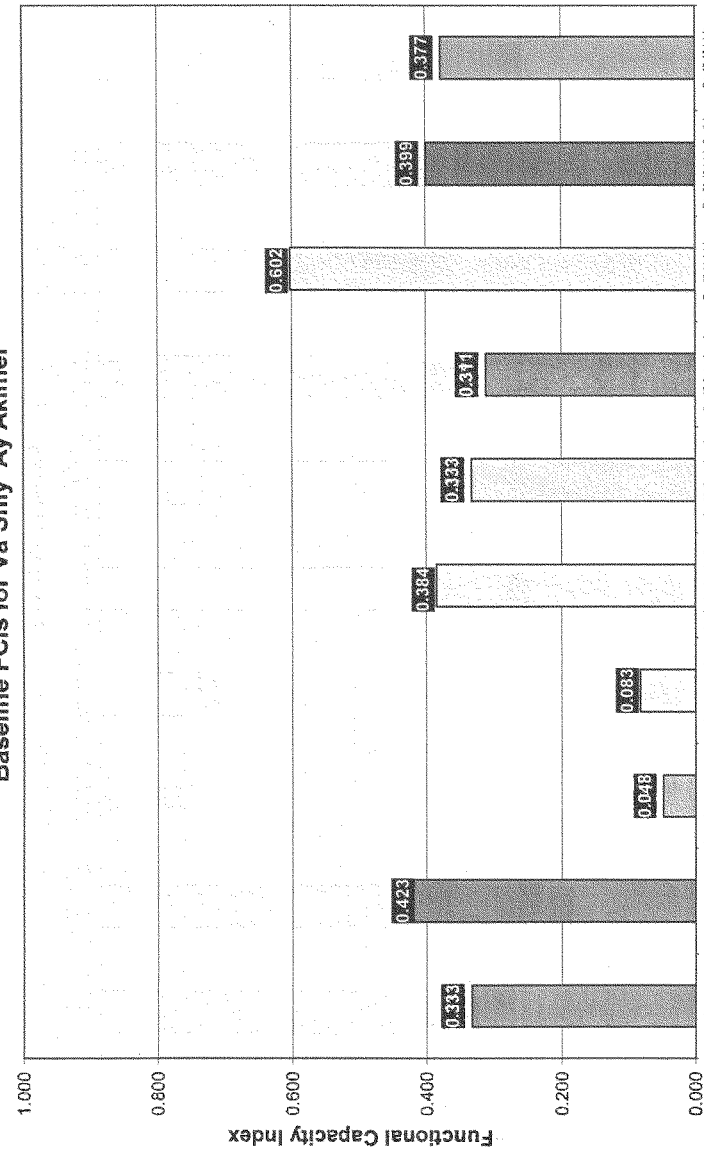

Restored, Preserved and Created Functional Output Comparisons -
Va Shly Ay Alternatives
AAFCUs per Function per Alternative
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
PERFORMANCE TARGETS
C-HIAD-2 (Alt C2)
L-POCK-1 (Alt L1)
I-CHNL-1 (Alt I1)
I-CHNL-2 (Alt I2)
K-NODL-1 (Alt K1)
K-NODL-2 (Alt K2)
D-MINE-1 (Alt D1)
D-MINE-2 (Alt D2)
B-MEAD-1 (Alt B1)
A-LOAD-1 (Alt A1)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

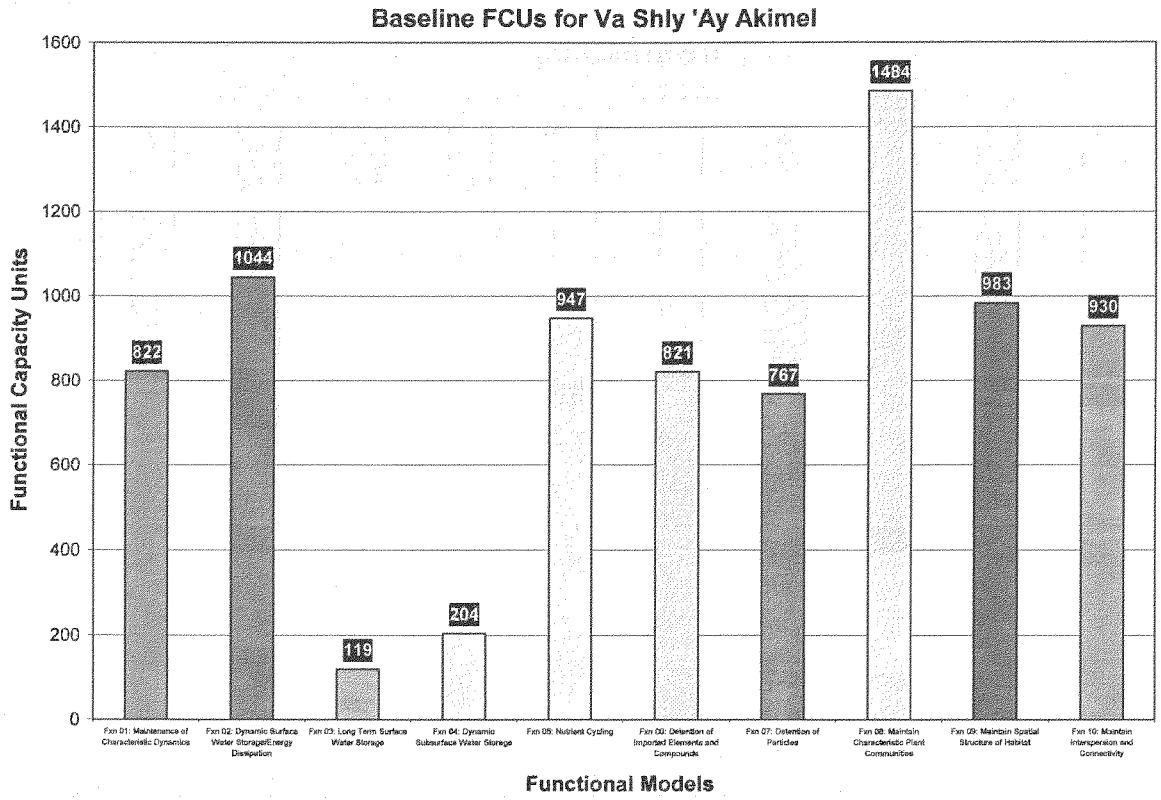

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
A-LOAD-2 (Alt A2)
O-MAX-2 (Alt O2)
F-MAX-2 (Alt F2)
B-MEAD-2 (Alt B2)
L-POCK-2 (Alt L2)
E-VHAD-2 (Alt E2)
F-MAX-1 (Alt F1)
O-MAX-1 (Alt O1)
G-CWAD-1 (Alt G1)
G-CWAD-2 (Alt G2)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORENG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

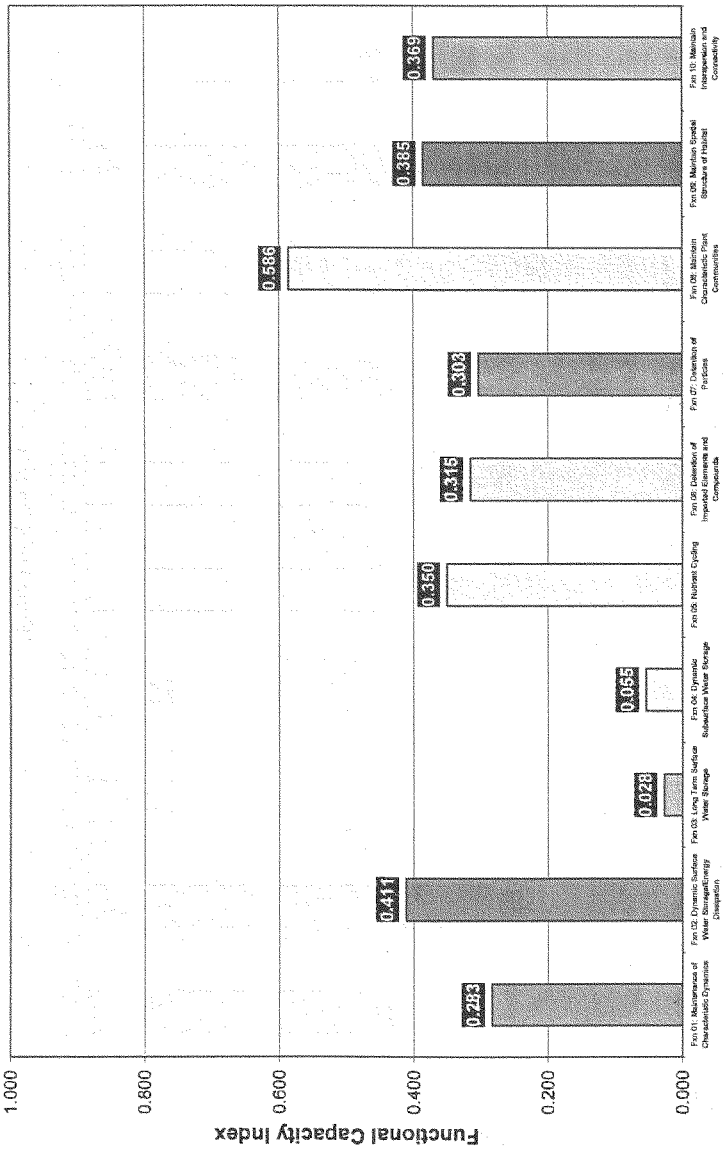

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
E-VHAD-1 (Alt E1)
N-MAX-1 (Alt N1)
N-MAX-2 (Alt N2)
J-BRAD-1 (Alt J1)
J-BRAD-2 (Alt J2)
H-MSAD-1 (Alt H1)
H-MSAD-2 (Alt H2)
M-WET-1 (Alt M1)
M-WET-2 (Alt M2)
C-HIAD-1 (Alt C1)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

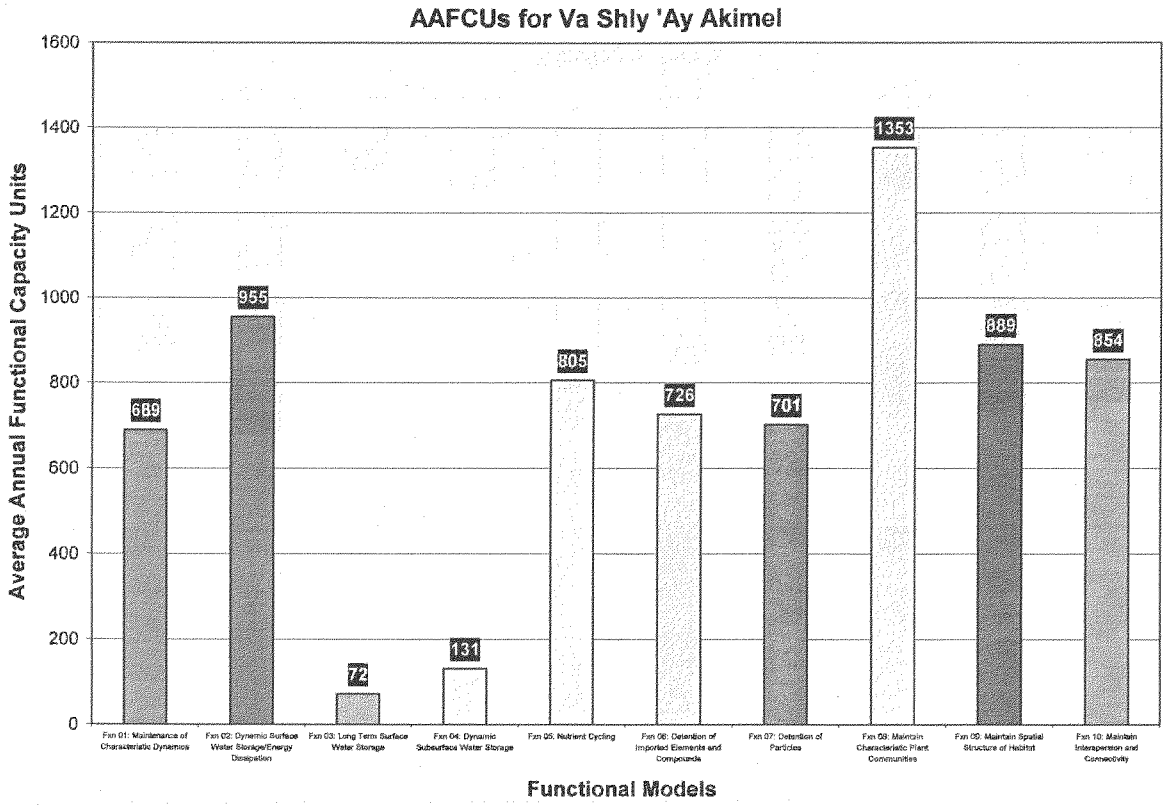

TY 51 FCI Comparisons - Va Shly Ay Alternatives
Final FCIs per Function per Alternative
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PERFORMANCE TARGETS
C-HIAD-2 (Alt C2)
L-POCK-1 (Alt L1)
I-CHNL-1 (Alt I1)
I-CHNL-2 (Alt I2)
K-NODL-1 (Alt K1)
K-NODL-2 (Alt K2)
D-MINE-1 (Alt D1)
D-MINE-2 (Alt D2)
B-MEAD-1 (Alt B1)
A-LOAD-1 (Alt A1)
Functions Evaluated
CHANNELDYN
WATSTORENR
WATSTORLNG
WATSTORSUB
NUTRIENT
ELEMENTS
DETPARTICL
PLANTS
HABSTRUCT
INTERSPERS
Average Net AAFCUs

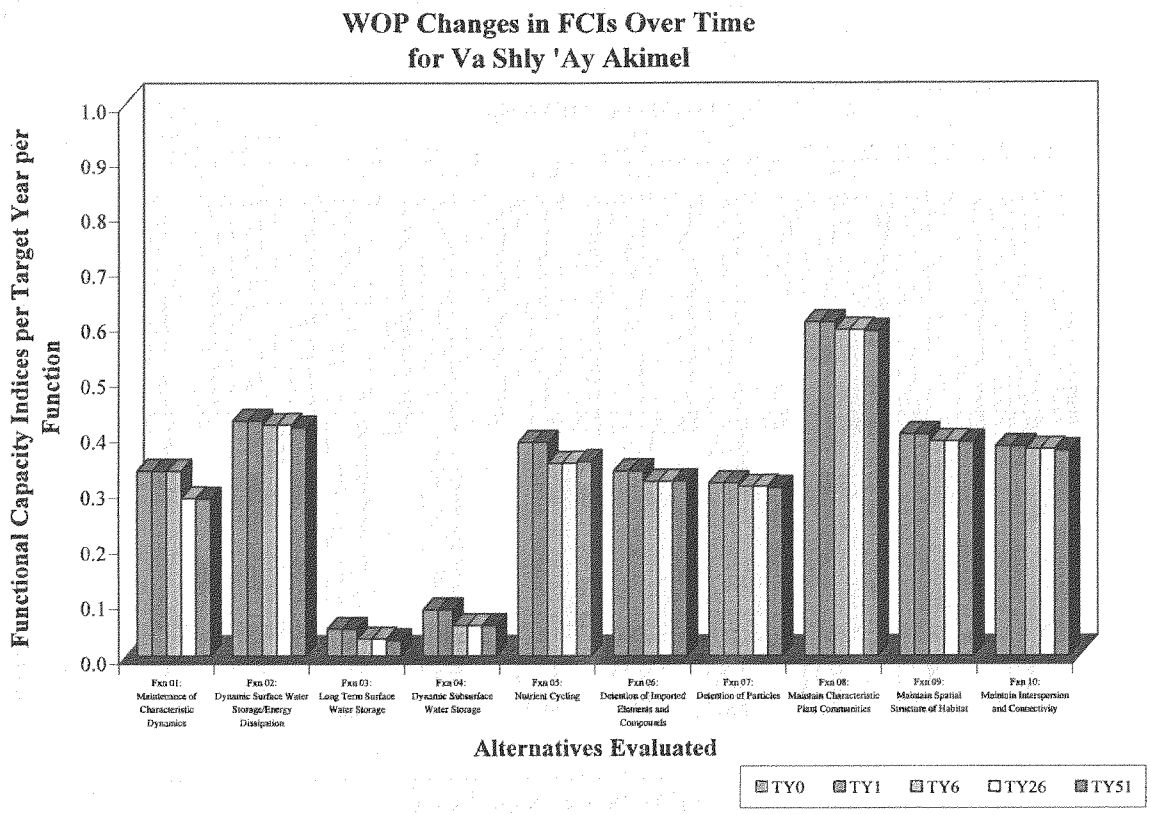
Appendix C – Va Shly'ay Akimel Without Project Results

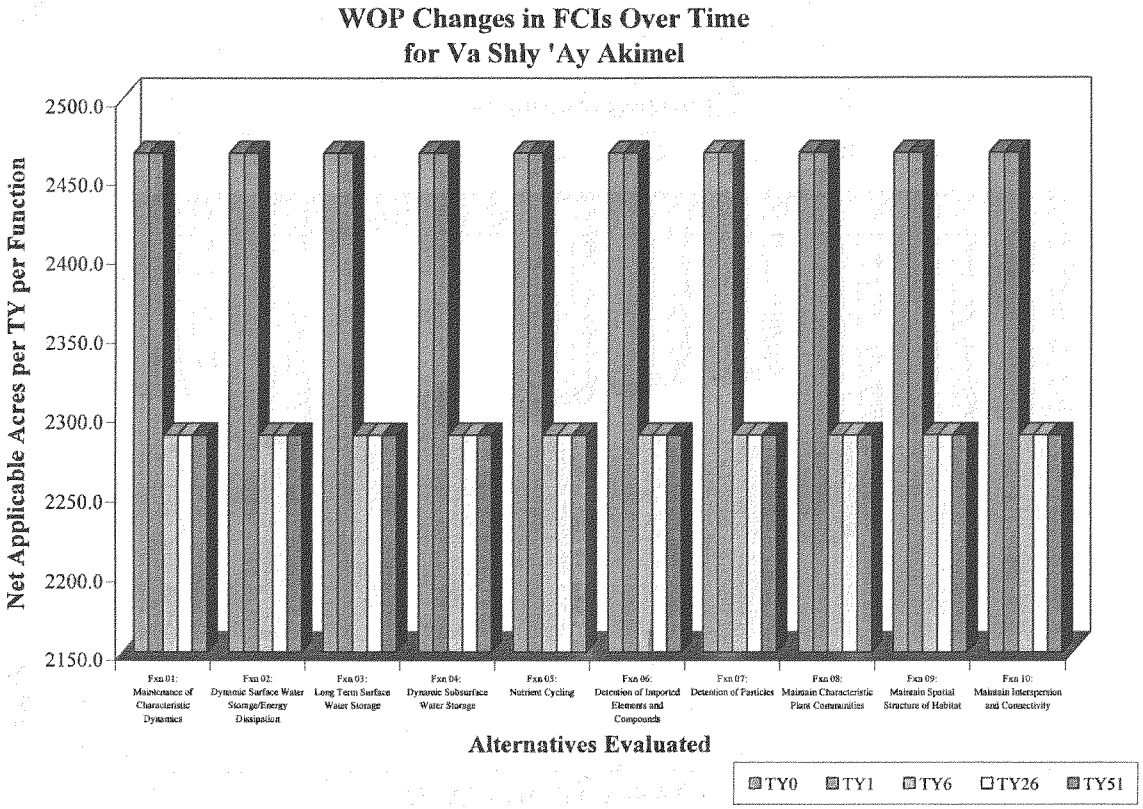

Baseline FCIs for Va Shly 'Ay Akimel
Functional Capacity Index
1.000
0.800
0.600
0.400
0.200
0.000
0.335
0.423
0.048
0.083
0.384
0.433
0.314
0.602
0.399
0.377
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 06: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models


Baseline FCUs for Va Shly 'Ay Akimel
Functional Capacity Units
1600
1400
1200
1000
800
600
400
200
0
822
1044
119
204
947
821
767
1484
983
930
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Retention of Imported Elements and Compounds
Fxn 07: Retention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models

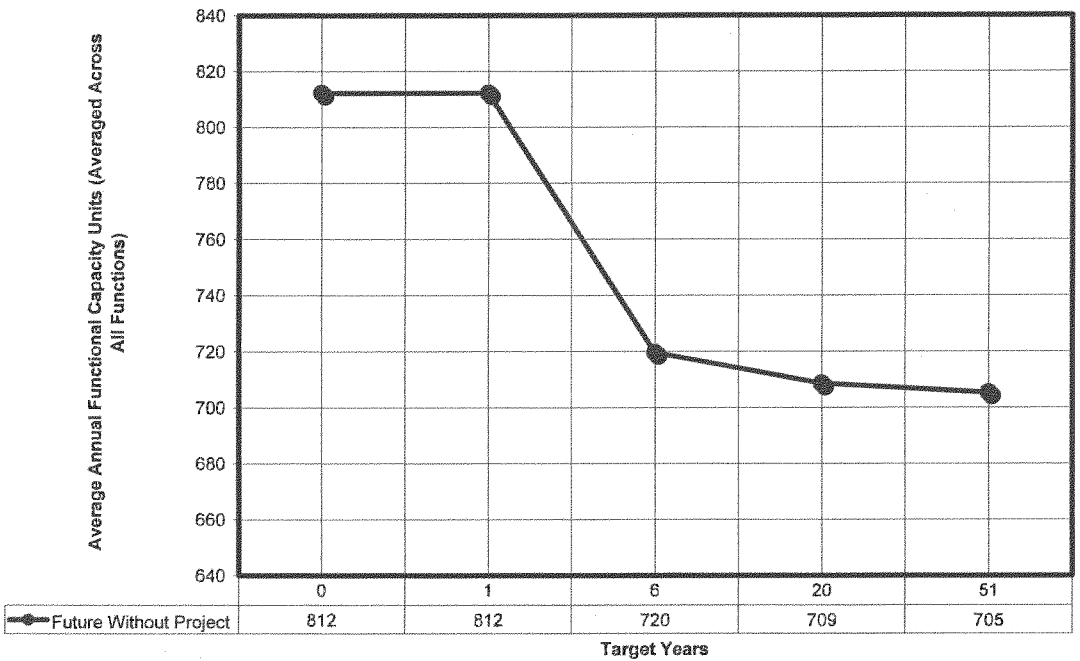

TY51 FCIs for Va Shly 'Ay Akimel
Functional Capacity Index
1.000
0.800
0.600
0.400
0.200
0.000
0.273
0.411
0.028
0.065
0.350
0.316
0.303
0.586
0.385
0.369
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long-Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models


AAFCUs for Va Shly 'Ay Akimel
Average Annual Functional Capacity Units
1600
1400
1200
1000
800
600
400
200
0
689
955
72
131
805
726
701
1353
889
854
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Functional Models

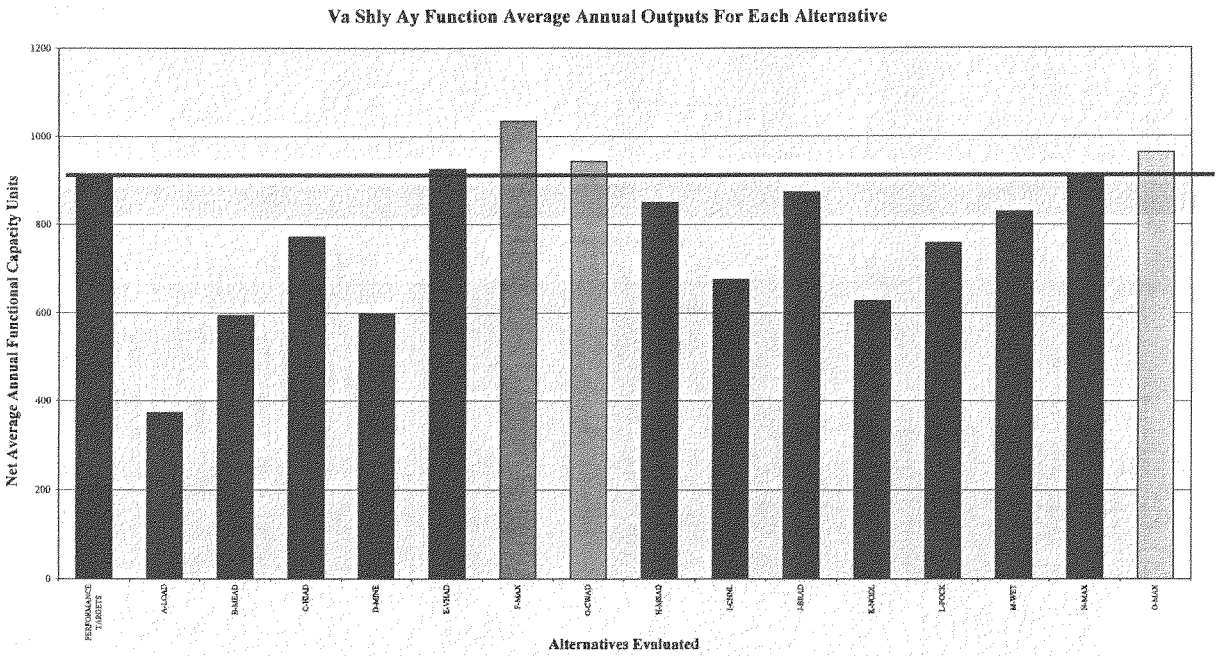

WOP Changes in FCIs Over Time
for Va Shly 'Ay Akimel
Functional Capacity Indices per Target Year per Function
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Retention of Imported Elements and Compounds
Fxn 07: Retention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Alternatives Evaluated
TY0
TY1
TY6
TY26
TY51

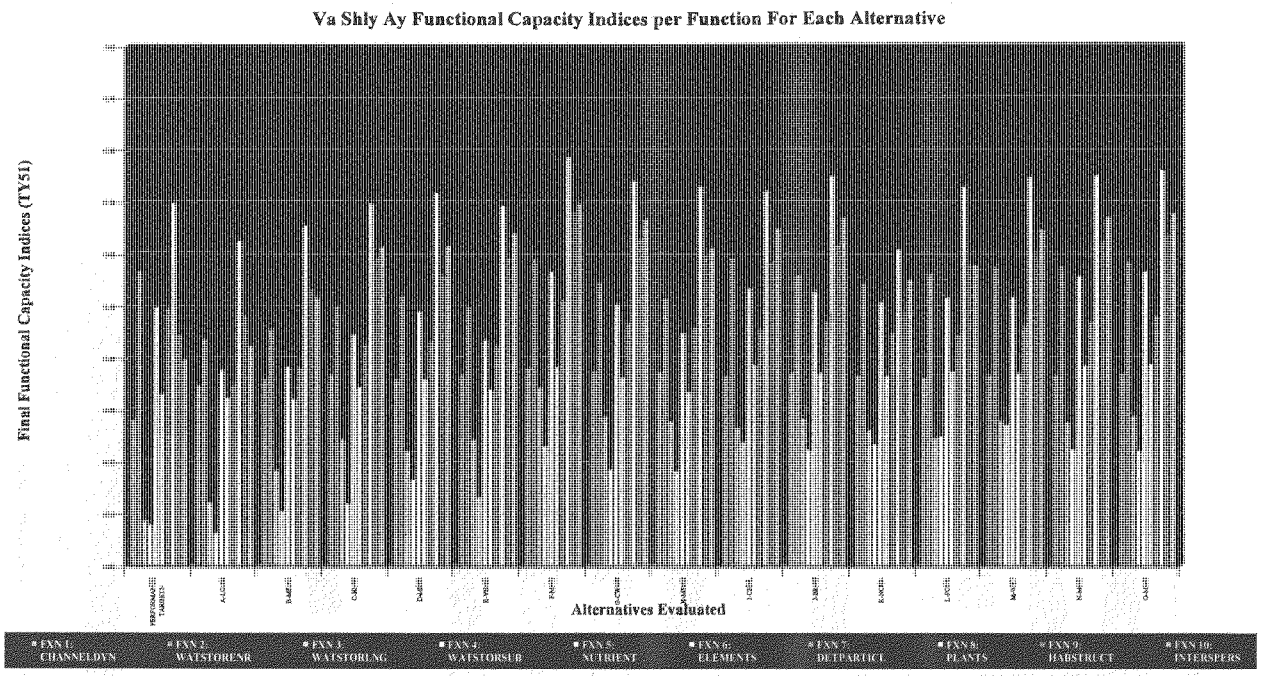

WOP Changes in FCIs Over Time
for Va Shly 'Ay Akimel
Net Applicable Acres per TY per Function
2500.0
2450.0
2400.0
2350.0
2300.0
2250.0
2200.0
2150.0
Fxn 01: Maintenance of Characteristic Dynamics
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation
Fxn 03: Long Term Surface Water Storage
Fxn 04: Dynamic Subsurface Water Storage
Fxn 05: Nutrient Cycling
Fxn 06: Detention of Imported Elements and Compounds
Fxn 07: Detention of Particles
Fxn 08: Maintain Characteristic Plant Communities
Fxn 09: Maintain Spatial Structure of Habitat
Fxn 10: Maintain Interspersion and Connectivity
Alternatives Evaluated
TY0
TY1
TY6
TY26
TY51

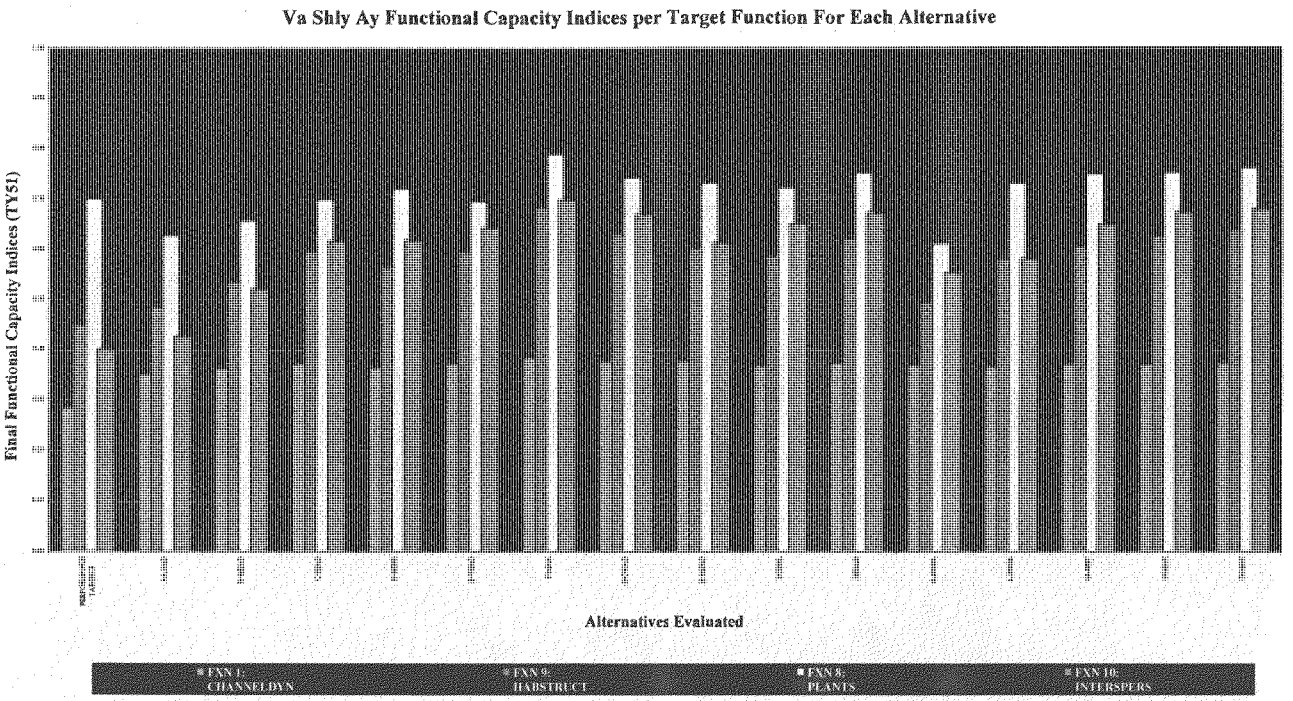
Trend in Average Annual Functional Capacity Units (AAFCUs) Without Project Conditions Only

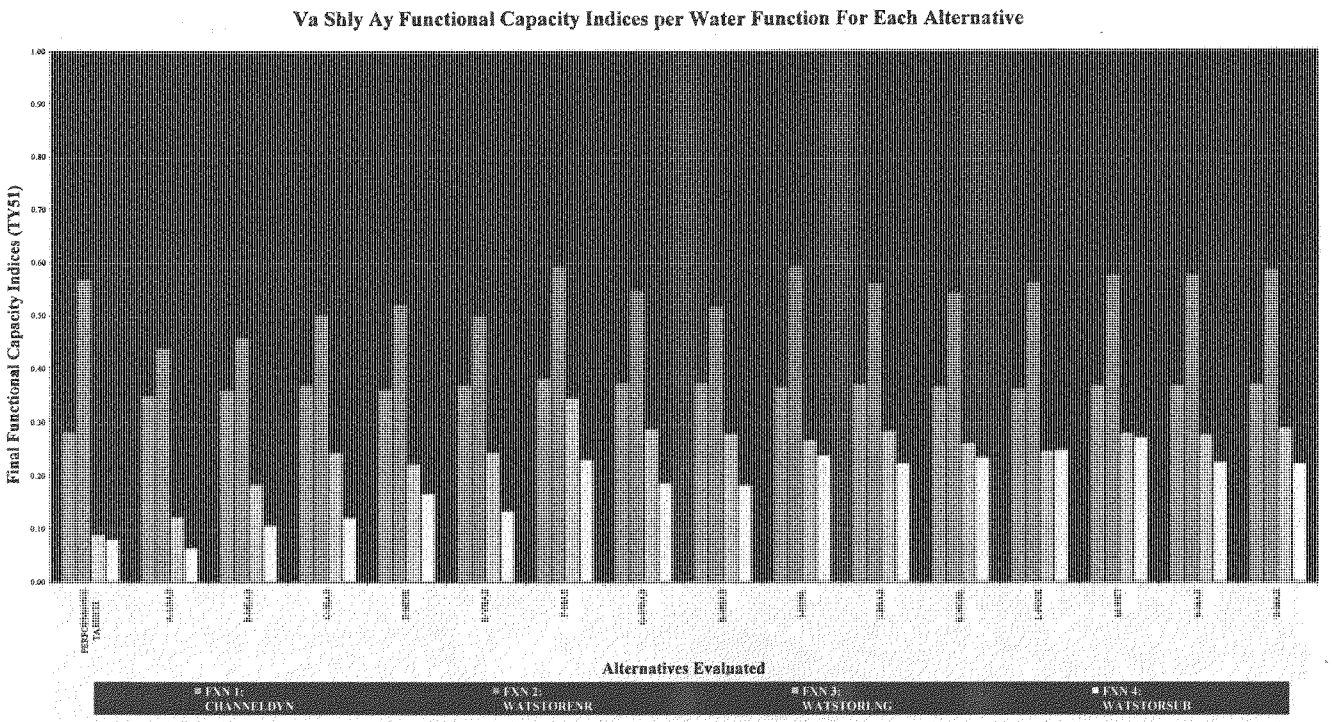


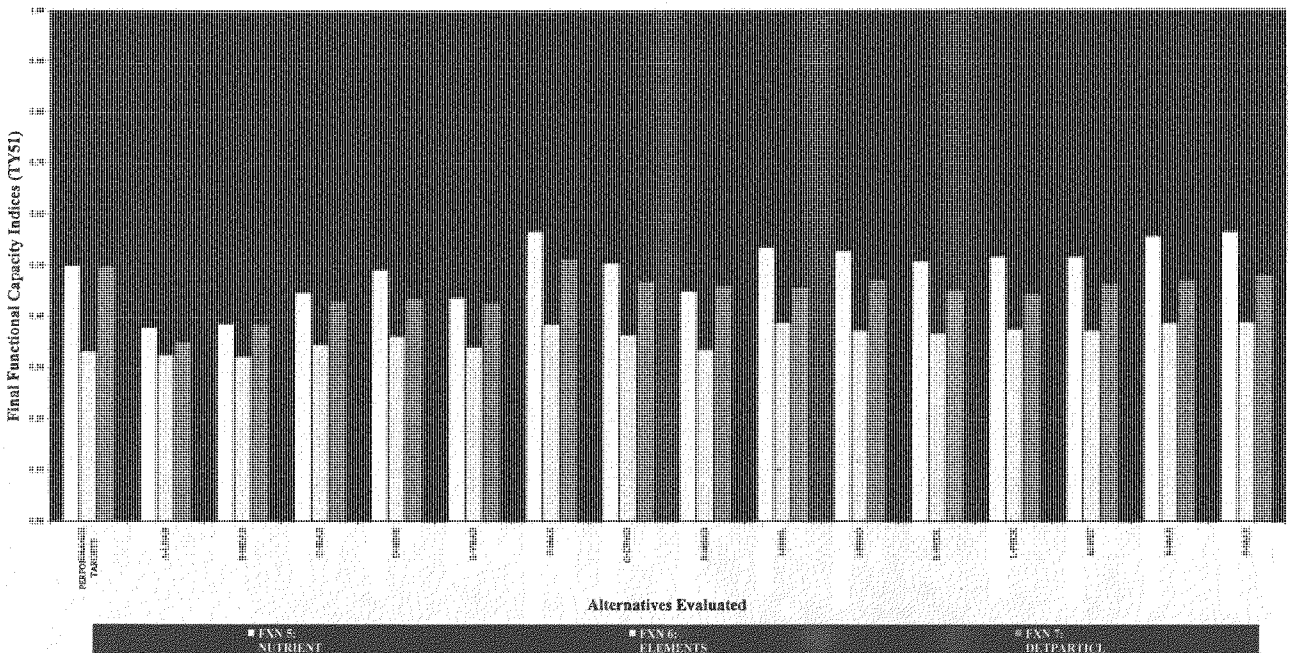
Appendix D – Va Shly'ay Akimel With Project Results

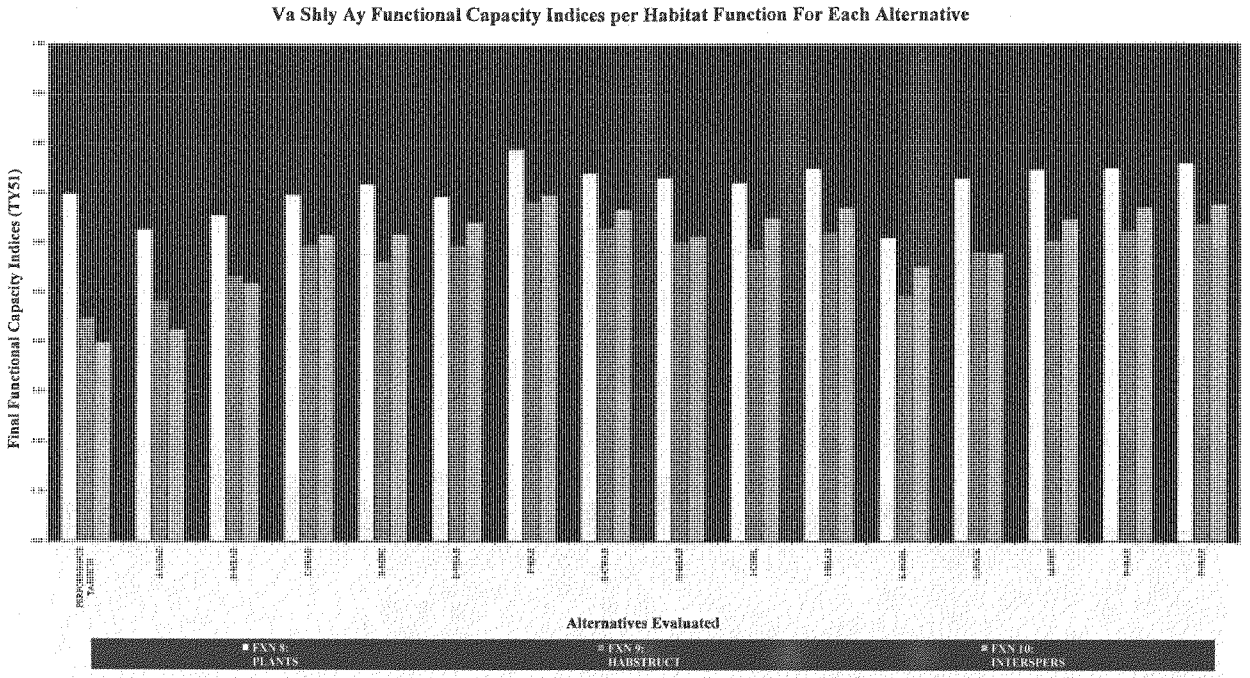

Va Shly Ay Function Average Annual Outputs For Each Alternative
Net Average Annual Functional Capacity Units
1200
1000
800
600
400
200
0
PERFORMANCE TARGETS
A-LOAD
B-MEAD
C-READ
D-MINE
E-VEAD
F-MAX
G-CHAD
H-MEAD
I-CINE
J-BEAD
K-NOOL
L-POCK
M-WET
N-MAX
O-MAX
Alternatives Evaluated

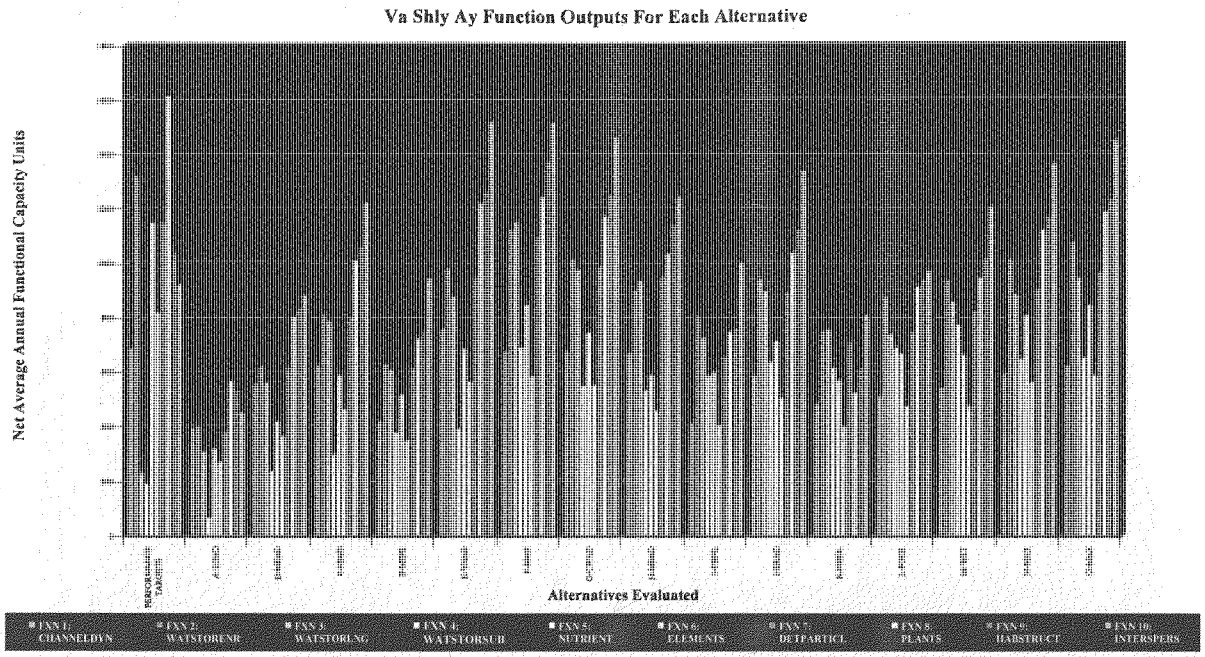

Va Shly Ay Functional Capacity Indices per Function For Each Alternative
Final Functional Capacity Indices (TY51)
Alternatives Evaluated
FXN 1: CHANNELDYN
FXN 2: WATSTORESR
FXN 3: WATSTORLNG
FXN 4: WATSTORSUB
FXN 5: NUTRIENT
FXN 6: ELEMENTS
FXN 7: DETPARTICL
FXN 8: PLANTS
FXN 9: HABSTRUCT
FXN 10: INTERSPERS

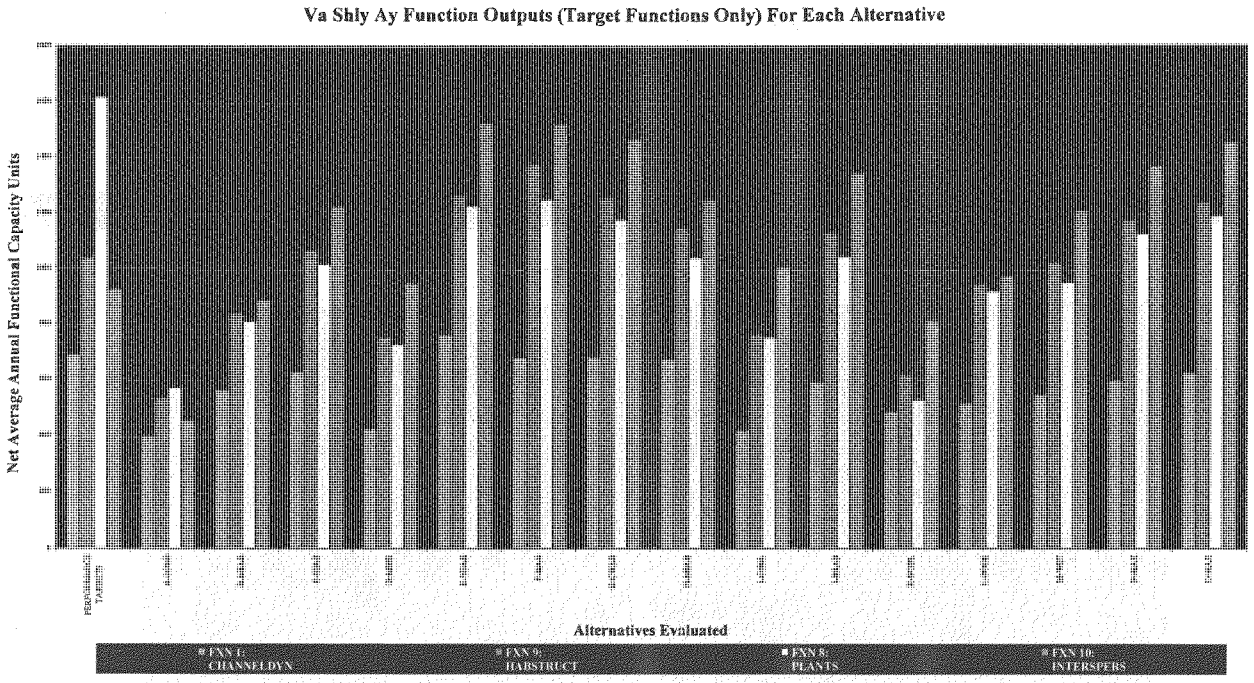

Va Shly Ay Functional Capacity Indices per Target Function For Each Alternative
Final Functional Capacity Indices (TY51)
Alternatives Evaluated
FXN 1: CHANNELDYN
FXN 9: HABSTRUCT
FXN 8: PLANTS
FXN 10: INTERSPERS

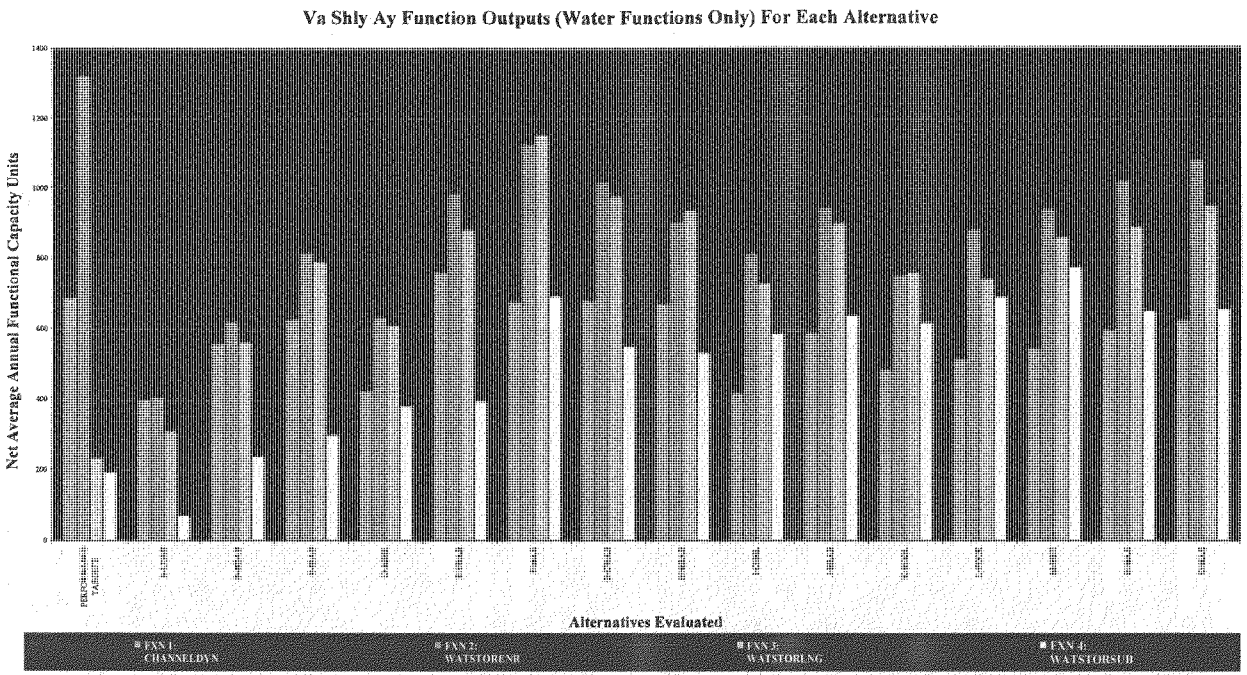

Va Shly Ay Functional Capacity Indices per Water Function For Each Alternative
Final Functional Capacity Indices (TY51)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Alternatives Evaluated
EXN 1: CHANNELDYN
EXN 2: WATSTORESR
EXN 3: WATSTORLNG
EXN 4: WATSTORSUB

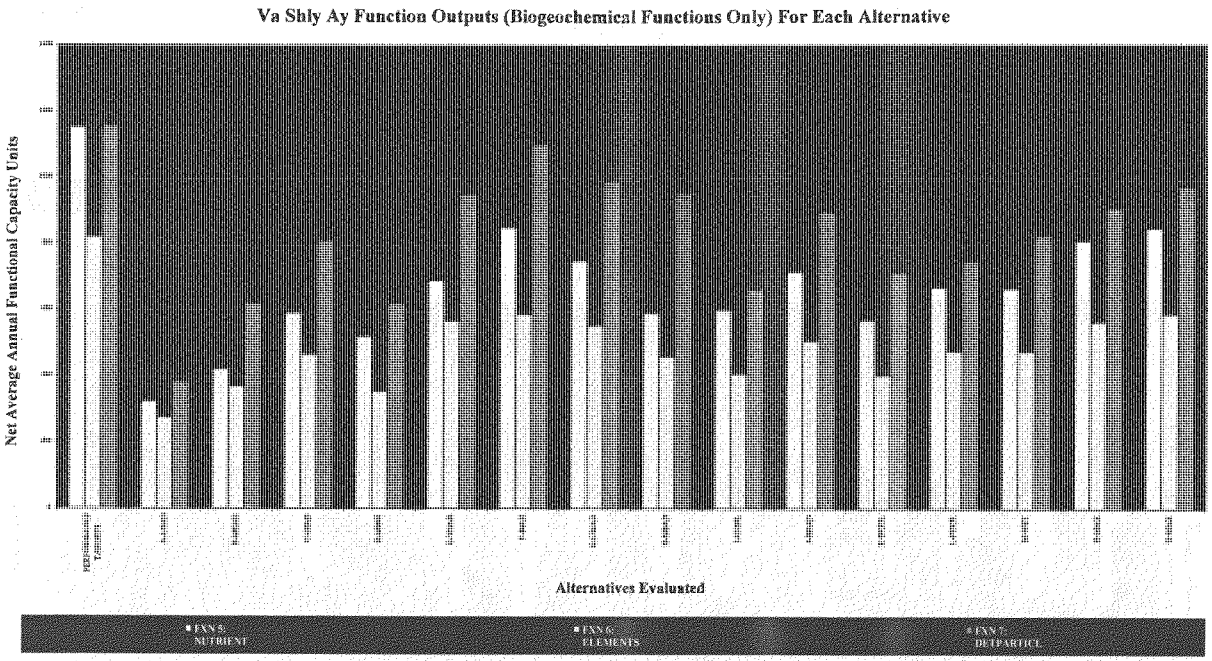

Va Shly Ay Functional Capacity Indices per Biogeochemical Function For Each Alternative
Final Functional Capacity Indices (TY51)
Alternatives Evaluated
FXN 5: NUTRIENT
FXN 6: ELEMENTS
FXN 7: DETPARTICL

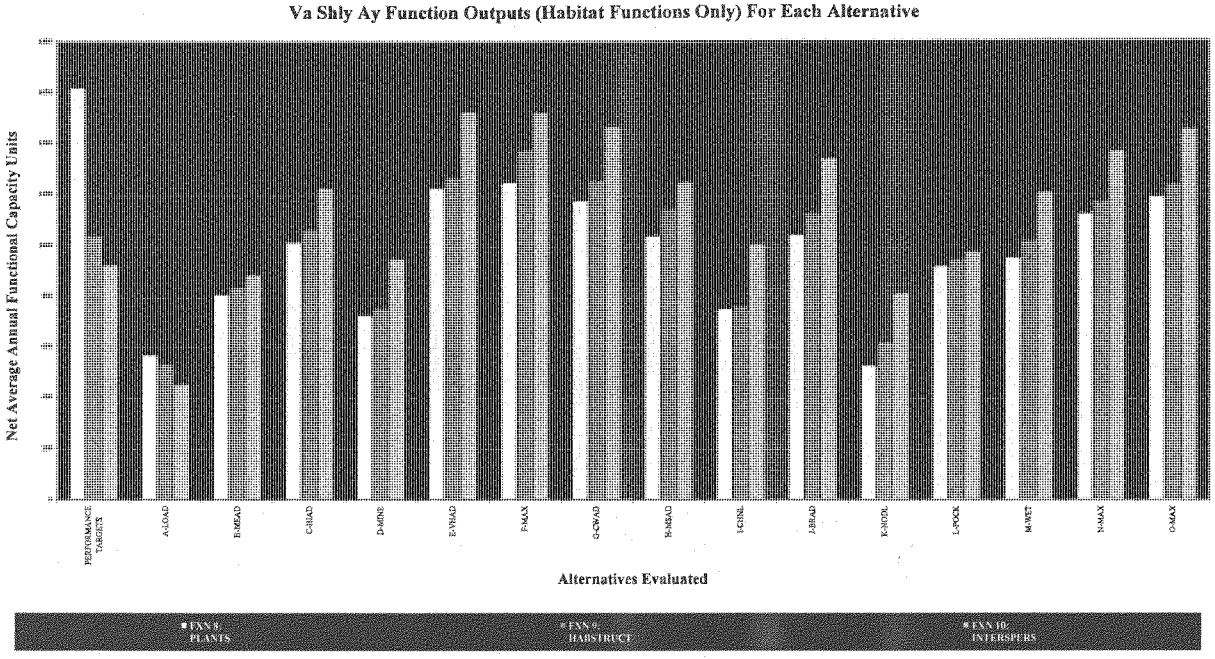

Va Shly Ay Functional Capacity Indices per Habitat Function For Each Alternative
Final Functional Capacity Indices (TY51)
Alternatives Evaluated
EXN 8: PLANTS
EXN 9: HABSTRUCT
EXN 10: INTERSPERS


Va Shly Ay Function Outputs For Each Alternative
Net Average Annual Functional Capacity Units
Alternatives Evaluated
FXN 1: CHANNELDYN
FXN 2: WATSTORENR
FXN 3: WATSTORLNG
FXN 4: WATSTORSUB
FXN 5: NUTRIENT
FXN 6: ELEMENTS
FXN 7: DETPARTICL
FXN 8: PLANTS
FXN 9: HABSTRUCT
FXN 10: INTERSPERS


Va Shly Ay Function Outputs (Target Functions Only) For Each Alternative
Net Average Annual Functional Capacity Units
Alternatives Evaluated
FXN 7: CHANNELDYN
FXN 9: HABSTRUCT
FXN 8: PLANTS
FXN 10: INTERSPERS


Va Shly Ay Function Outputs (Water Functions Only) For Each Alternative
Net Average Annual Functional Capacity Units
Alternatives Evaluated
FXN 1: CHANNELDYN
FXN 2: WATSTORENB
FXN 3: WATSTORENG
FXN 4: WATSTORSUB


Va Shly Ay Function Outputs (Biogeochemical Functions Only) For Each Alternative
Net Average Annual Functional Capacity Units
Alternatives Evaluated
FXN 5: NUTRIENT
FXN 6: ELEMENTS
FXN 7: DETPARTICL


Va Shly Ay Function Outputs (Habitat Functions Only) For Each Alternative
Net Average Annual Functional Capacity Units
PERFORMANCE TARGETS
A-LOAD
B-MEAD
C-HIAD
D-MINE
E-WIAD
F-MAX
G-CWAD
H-MEAD
I-GRNL
J-BEAD
K-WOOL
L-POOL
M-WET
N-MAY
O-XXX
Alternatives Evaluated
* EXN 9: PLANTS
* EXN 6: HABSTRUCT
* EXN 10: INTERSPERS

ECONOMICS

Va Shly' ay Akimel Feasibility Study
Economic Appendix

Table of Contents

PURPOSE....1
METHODOLOGY....1
STUDY AREA....1
Location....1
Problems & Opportunities....1
Environmental Resources....1
Flooding....3
Recreation....3
Population....3
Population Projections....4
Land Use....5
City of Mesa....5
SRP-MIC....5
Housing Unit Projections....6
Employment & Economy....6
WITHOUT PROJECT CONDITIONS....7
Environmental Resources....8
Hydrogeomorphic Model Description....8
HGM Results – Without Project Conditions....8
Flooding Problems....9
Historical Flood Damages....9
Floodplain Boundaries & Reach Definitions....10
Number of Structures....13
Value of Structures & Contents....13
Without Project Structure & Content Damages....14
Without Project Emergency & Cleanup Costs....21
Without Project Agricultural Damages....22
Without Project Flood Damage Analysis Summary....24
Recreation....25
Existing Recreation Resources in Market Area....25
Existing Recreation Resources in Study Area....27
Recreation Demand....28
WITH PROJECT CONDITIONS....33
Environmental Resources....33
General Management Measures....33
Description of Alternatives....35
Benefits of Alternatives....36
Cost Estimates....38
Cost Effectiveness & Incremental Cost Analysis....40
Recommended Ecosystem Restoration Plan....43
Erosion Analysis....46
Recreation....48
Proposed Recreation Alternatives....48
Benefit Analysis....49
Recreation Costs & Benefit/Cost Analysis....51

PURPOSE

The following presents an economic evaluation of the benefits and costs associated with riparian habitat restoration, flood control and recreation opportunities along the Salt River in the Salt River Pima-Maricopa Indian Community, adjacent to the City of Mesa in Maricopa County Arizona.

METHODOLOGY

Methodology employed for this economic analysis is in accordance with current principles and guidelines and standard economic practices, as contained in *Engineering Regulation 1105-2-100 – Planning Guidance Notebook (April 2000)*. Evaluation of environmental restoration alternatives has been completed in conformance with *IWR Report #95-R-1 -- Evaluation of Environmental Investments: Procedures Manual (May 1995)*. Benefits and costs are computed at October 2003 price levels utilizing the current Federal Discount rate of 5 5/8 percent. The period of analysis is 50 years. The Base Year for economic computations is 2011.

STUDY AREA

Location

The study area is located along the Salt River in the Salt River Pima-Maricopa Indian Community ("SRP-MIC"), adjacent to the City of Mesa in Maricopa County, Arizona. The Study Area is approximately 18 miles east of the City of Phoenix. The upstream limit of the study area is Granite Reef Dam, and the downstream limit is the Pima Freeway (US 101). **Figure 1** shows the location of the Va Shly' ay Akimel ("VSA") study area.

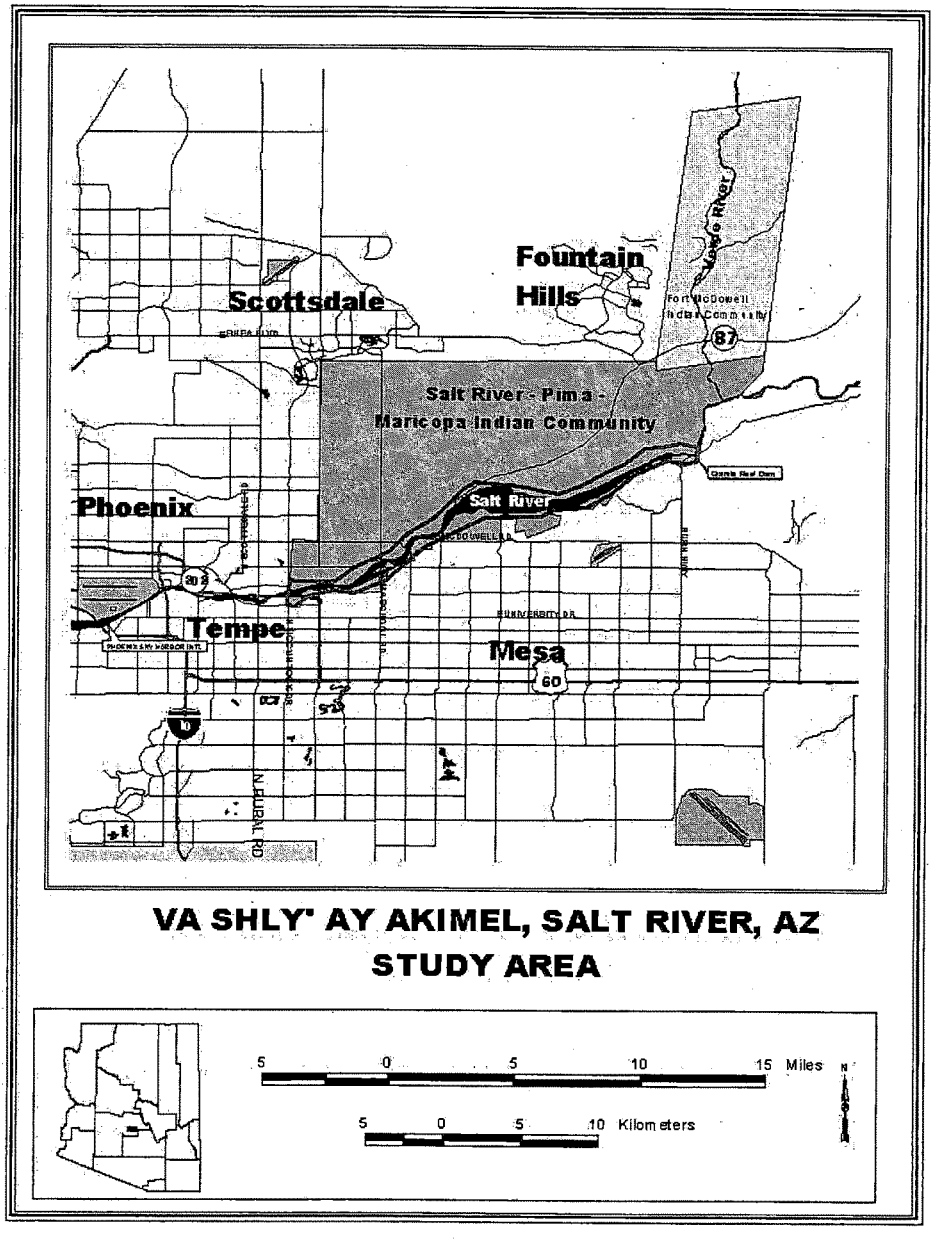
Problems & Opportunities

Environmental Resources

In pre-settlement times (prior to 1900) the Salt River was one of the few perennially-watered riparian areas of the Arizona Sonoran Desert, with highly productive cottonwood, willow, and mesquite habitats. These areas were rich in habitat diversity, supporting a wide variety of wildlife species. As the lower Salt River valley became developed, riparian habitat degraded significantly. The once perennial Salt River has now been transformed into a dry riverbed virtually devoid of habitat. Native plant species and wildlife habitat have been eliminated along the Salt River and adjacent overbank areas due to upstream water resources development, increased depths to groundwater beneath the river channel, changes in the natural flood regime, and land use changes, e.g., landfills and sand and gravel mining.

There is an opportunity to restore the environment through the creation of wetland, mesquite bosque, and cottonwood-willow habitat throughout the study area. Constructed wetlands could be created with water supplied from groundwater and surface water sources, including the Salt River Project, surface water from canals, reclaimed water, groundwater wells and storm drains. Potential locations include areas adjacent to storm drains and gravel mining pits. Mesquite trees could be established at higher elevations from the river bottom, including terraces and overbank areas. Cottonwood-Willow corridors could be created along the perimeters of open water areas, such as constructed wetlands and streams within the river bottom.

FIGURE 1
Va Shly' ay Akimel Study Area



Flooding

Based upon hydrologic and hydraulic analyses completed for this feasibility study, flooding problems in the study area are limited. There are primarily two developed areas subject to flooding during major storm events. The first overflow area extends south of the Salt River and is generally bounded by Lehi Road on the east, Harris Street on the west, and McDowell Road on the south. This area is rural and comprised primarily of residential properties east of Gilbert Road and agricultural properties west of Gilbert Road. The other area subject to potential flooding is also located on the south side of the Salt River, west of Mesa Drive and north of McKellips Road. This area includes more dense development, including mobile homes as well as some commercial and industrial properties. Even for most of these two areas, the probability of flooding in any given year is generally less than one percent.

Although expected annual flood damages for the Study Area appear to be minimal, it is possible that there could be opportunities for small-scale improvements to provide additional protection to these two reaches.

Recreation

Tremendous historical and projected population growth in the Phoenix metropolitan area has increased the demand for recreation facilities in the study area. As additional development occurs along the study area, including the conversion of vacant and agricultural lands to residential and commercial uses, development of new recreation facilities will also be essential. As part of a restoration project for VSA, there is an opportunity to provide complimentary passive recreation facilities, such as multiuse trails for hiking, biking and horseback riding, comfort stations, signage, and environmental education/interpretive centers. The study area location would be ideal for linking recreation facilities with existing and planned facilities downstream at Tempe Town Lake and Rio Salado. Additional linkages could be established with the Tonto National Forest and the Canal Trail System.

Population

The study area is located in Maricopa County and extends through the Salt River Pima-Maricopa Indian Community (SRP-MIC) and adjacent city of Mesa. As of the year 2000, Maricopa County had a population of 3.07 million. From 1995 to 2000, County population grew by over 543,000, representing an average annual growth rate of nearly four percent.

The city of Phoenix is by far the largest in the county in terms of population. Phoenix's population grew from about 1.15 million in 1995 to over 1.32 million in 2000, or by about 2.7 percent on an annual basis. About 43 percent of the County population resides within the City of Phoenix, although this ratio is declining, due to higher growth rates outside the city.

The City of Mesa was incorporated over 100 years ago. Between 1930 and 1960, the City's population and land area grew by about 30,000 and 12.7 square miles, respectively. By 1980, the City's boundaries expanded to over 66 square miles, and the population increased to over 152,000. The City now encompasses over 128 square miles and is Arizona's third largest in terms of population, behind Phoenix and Tempe. Mesa's population as of 2000 was 396,375. This value represents an average annual increase of about 3.2 percent over the 1995 population of 338,117.

The SRP-MIC is home to the Onk Akimel Au-Authm (Pima) and Xalchidom Pii-pash (Maricopa) Indians, descendants of the Hohokam Indians. The Community covers an area of nearly 84 square miles and shares

boundaries with the cities of Mesa, Tempe, Scottsdale, Fountain Hills and metropolitan Phoenix. The population of the SRP-MIC was 6,405 as of 2000, according to the US Census. From 1990 to 2000, population increased by 1,553, or an average annual rate of about 2.8 percent. Thus, the combined population of the communities adjacent to the study area (Mesa and SRP-MIC) exceeds 400,000.

Population Projections

The following table displays population estimates and growth projections for Maricopa County and the City of Mesa municipal planning area, obtained from the Maricopa County Association of Governments (MAG) and US Census websites. Strong growth is projected for the County through year 2050, although the rates of growth will be substantially lower than those experienced the past decade. The Arizona Department of Economic Security projects that population within the Phoenix metropolitan area will total over 7.26 million by the year 2050. Growth rates for the region are anticipated to be more than double the national average throughout the period of analysis.

Mesa's population is anticipated to grow significantly over the next decade. However, growth rates are anticipated to drop sharply after 2010.

Table 1
Projected Population & Annual Growth Rates (AGR)
Maricopa County and the City of Mesa Municipal Planning Area

Year	Maricopa County	AGR	Mesa MPA*	AGR
2000	3,072,000		425,000	
2010	3,710,000	2.0	541,000	2.4
2020	4,516,000	2.0	594,000	0.9
2050	7,265,000	1.6	665,000	0.4

Source: US Census and Arizona Department of Economic Security
** Mesa MPA includes some Maricopa County lands within the City's sphere of influence.*

SRP-MIC projects that population within the Community will increase by approximately 1,500 every decade, reaching nearly about 9,500 by 2020 and over 12,600 by 2040.

An examination of the census tracts within a cross section of about two to three miles south of the Salt River from Granite Reef Dam to the downstream limit of the study area indicates that the area is heavily populated with about 70,000 residents and over 28,000 dwelling units.

According to information furnished by the City, over ten square miles of the City's corporate limits lie within a one-mile distance of the Salt River. Within this area, there is a population of nearly 26,700 residents – up from about 23,900 in 1990. The rate of population growth in this area lagged that of the City as a whole over the past decade. The Maricopa County Association of Governments projects that the population of this area will reach about 32,400 by the year 2020 (representing an average annual growth rate of about one percent). Most of this growth is anticipated to take place in the area between Gilbert Road and Greenfield Road, north of McDowell Road.

The City of Mesa estimates that there are only about 350 residents of the SRP-MIC that reside within a one-

mile distance of the River along the Study area. The population in this area has remained fairly constant over the past couple of decades. Future population growth in this area may be impacted by the planned construction of the Red Mountain Freeway along the southern edge of the Community.

Land Use

City of Mesa

The City of Mesa's general plan shows various existing land uses on the south side of the Salt River. Agriculture and recreation/open space uses are present between Alma School Road and the downstream limit of the study area, as well as upstream between Val Vista Drive and Highly Road. There are some industrial land uses at the upstream end of the study area, east of Highly Road as well as surrounding the Falcon Field airport between Greenfield Road and Highly Road. Most of the remaining lands are rural and large lot residential north of University Drive. There are many commercial establishments and more high-density residential uses in the east/west corridor south of University Drive and north of Baseline Road.

The City's land use plan shows that much of the existing open space and rural lands south of the Salt River will be converted to industrial and residential uses.

The City has provided a detailed breakdown of City land uses within a one-mile radius of the Salt River throughout the Study Reach. According to this information, the largest categories represented are industrial (about 14 percent of the land area) and rural (about 20 percent of the land area). However, there are also large tracts of land that are currently vacant or agricultural (each representing about 12 percent of the land area).

The stretch of Study Area extending from Granite Reef Dam to Val Vista Drive is primarily vacant or in industrial uses. According to the City's 1996 General Plan, this area will develop with industrial land uses.

The area between Val Vista Drive and Mesa Drive is mostly agricultural and rural. This area is known as the Lehi area within the City of Mesa. According to the City, land uses are expected to remain the same within this area for the foreseeable future.

The downstream stretch from Mesa Drive through the Pima Freeway is mostly medium to medium-high density residential, with some industrial uses adjacent to the riverbed (e.g., rock and gravel operations). The area is primarily built out; so future development will be limited. There was a possibility that a multi-use sports facility for the Arizona Cardinals National Football League team would be built in this area, which would have resulted in substantial changes in existing land uses, particularly in the commercial category. However, Mesa residents rejected the proposal on a recent ballot measure.

SRP-MIC

Land north of the Salt River is primarily owned by SRP-MIC, although the reservation also includes some lands (about 900 acres) south of the river as well. Most of the Community's land area is comprised of open space and agricultural lands, including a variety of crops such as cotton, watermelon, and honeydew. There is a commercial corridor along the Community's border with the City of Scottsdale along Pima Road, which includes a 140-acre retail center.

Community zoning within a one-mile radius of the study reach shows that over 82 percent of the land is currently designated for agriculture, natural resources and open spaces. The remaining lands are designated primarily for industrial and commercial uses. Most of the planned commercial and industrial development will

take place west of Gilbert Road adjacent to the Salt River. East of Gilbert Road, land uses are planned to remain agricultural and rural in nature.

SRP-MIC property includes a large tract south of the Salt River from Gilbert Road to Mesa Drive. This property is currently being used for agricultural purposes. This area will remain primarily agricultural and rural, with the exception of some planned commercial development along Gilbert and McDowell Roads.

The SRP-MIC lands north of the Salt River downstream of Mesa Drive could see an increase in residential development as well as some commercial development along freeway corridors.

Housing Unit Projections

According to the US Census and MAG, the ratio of persons per housing unit in the City is about 2.7. Mesa's Draft General Plan (*Mesa 2025 – A Shared Vision*, October 2001) shows a similar ratio projected at buildout. Table 2 shows the number of additional housing units that would need to be built to accommodate the anticipated population increases.

Table 2
Projected Housing Unit Growth
City of Mesa

Period	Population Inc.	HU Inc.
2000-2010	116,000	43,000
2010-2020	53,000	19,600
2020-2050	71,000	26,300
Total	240,000	88,900

Table 2 shows that roughly 89,000 new housing units would be needed in the city by the year 2050 to accommodate projected future population increases.

An analysis of Mesa's Draft General Plan indicates an average density for residential lands of about five dwelling units per acre, based upon existing land use plans. At this density ratio, about 17,780 acres of residential lands would need to be developed to accommodate future population increases through 2050. The ratio of commercial, industrial and public land uses relative to residential land uses is about 58%, which would correspond with a required additional 10,300 acres of non-residential development. Mesa's Draft General Plan indicates that about 23% of the City's 172 square mile planning area (or over 25,000 acres) is currently undeveloped. Hence, it is likely that the City will be built out before the end of the period of analysis.

Employment & Economy

According to Arizona Department of Commerce, the primary employment sectors in the City of Mesa are services and retail trade. Manufacturing, and construction are also major employment sectors.

Table 3 Mesa Employment by Industry	
Services	35%
Trade	28%
Manufacturing	13%
Finance, Insur., & Real Estate	9%
Construction	9%
Transport., Comm. & Utilities	6%

Source: Arizona Dept. of Economic Security

The five largest private and public employers are as follows:

Table 4 City of Mesa Largest Employers	
Private	**Public**
Boeing	Mesa Public School System
Motorola	Banner Health System
TRW Safety Systems	City of Mesa
AT&T	Mesa Community College
Empire Southwest Machinery	Salt River Project

Growth in Phoenix MSA population has been due primarily to net migration into the area. Factors contributing to this inmigration include diverse job availability, climate, quality of life, low cost of living, and a strong, diversified industrial base. Inmigration and high graduation levels from Arizona State University have provided local employers with a quality labor force.

The substantial growth in employment opportunities has helped maintain low unemployment rates in the greater Phoenix area in recent years. For example, unemployment rates in the Phoenix-Mesa Metropolitan Area (4.1 percent as of December 2003) have remained below the state (5.0 percent) and the national rates (5.7 percent).

WITHOUT PROJECT CONDITIONS

Without Project Conditions are those conditions projected to prevail over the 50-year period of analysis in the absence of any management measures designed to address the problems and opportunities outlined earlier in this report. They serve as the basis for comparison to determine the benefits of proposed management measures. Hence, without-project conditions must first be calculated in order to ascertain the potential benefits that may result from implementing alternatives.

Environmental Resources

Due to dams and diversions, perennial flows on the Salt River have ceased. This has caused detrimental environmental impacts to natural wildlife habitat and riparian communities along the Salt River. The elimination of natural base flows reduced Salt River flows to summer or fall rainfall-related flood events. The ground water table beneath the river dropped. The soil moisture in the riverbed was virtually eliminated, and the native cottonwoods, willows and riparian ecosystem rapidly died out. Most areas of the Salt River are barren today. The few existing riparian communities in the Study Area are currently supported by wastewater effluent, sporadic flood releases from upstream and local storm-water runoff. Only disturbed riparian vegetation occurs on sandbars and terraces. The vegetation is primarily salt cedar (tamarisk) and desert broom with scattered cottonwood, seep willow and rabbit brush. As wildlife depend on vegetation for food and/or cover, the lack of vegetation in the study area makes the area generally unsuitable as wildlife habitat. Only small birds, small mammals and reptiles tolerant of very disturbed conditions inhabit the study area.

Hydrogeomorphic Model Description

The value of the limited amount of habitat existing in the Study Area has been assessed using a Hydrogeomorphic Modeling (HGM) process. HGM is an evaluation methodology in which the environmental impacts of projects are measured in ecological, rather than monetary terms. As a result, it is not possible to perform a direct benefit/cost analysis. Rather, the focus of HGM analysis, as well as other non-monetary evaluation techniques, is to determine the most cost-effective way to provide an array of environmental outputs. This is typically completed through an incremental cost analysis in which the marginal cost of providing additional environmental outputs is determined.

The U.S. Army Engineer Waterways Experiment Station has developed HGM for the purpose of assessing wetland functions. Wetland functions are a result of the interaction between the structural components of wetlands, such as soil, plants and animals, and the physical, chemical and biological processes that occur in wetlands. The assessment phase of the procedure is to measure the ability of a wetland to perform functions, in terms of its functional capacity. The functional capacity of a wetland is determined using a functional capacity index (FCI).

In HGM, an FCI model is a quantitative estimate of the functional capacity for a wetland. The ideal goal of an FCI model is to quantify and produce an index that reflects the functional capacity at the subject site. The results of an FCI analysis can be quantified on the basis of a standard zero to one scale, where 0.00 represents the lowest functional capacity for the wetland, and 1.0 represents the highest function capacity for the wetland. The FCI model can be defined in words or mathematical equations that clearly describe the rules and assumptions necessary to combine functional capacity indices.

Functional Capacity Units (FCU's) are a quantitative environmental value, considered to be the biological currency in the HGM methodology. FCUs are calculated by multiplying the area of available wetland (quantity) by the quality of the wetland based on functionality, which is represented by values derived from the FCIs. FCU = Area times FCI. Changes in FCUs represent potential impacts or improvements of proposed actions.

HGM Results – Without Project Conditions

Ten FCI functions have been developed specifically for the desert southwest ecosystem along the Salt River to assess the environmental conditions in the Study Area. These functions have been applied to the existing areas of habitat throughout the Study Area to derive estimates of FCUs, both for existing and future without project conditions.

The first four functions (F1-F4) are water-related variables, such as surface and subsurface water storage and channel dynamics. The next three (F5-F7) are biochemical-related variables, such as the presence of required nutrients. Finally, the last three variables (F8-F10) are habitat-related variables, such as the quantity, type and locations of vegetation. Table 5 below summarizes the results. Note that FCUs for each function have been estimated for Target Years 1, 6, 26, and 51 (Target Year 1 being equivalent to the first year of construction). These projected values were then converted into average annual FCUs (AAFCUs) for each function. The total combined AAFCU representative of without project conditions was derived by simply averaging the AAFCU values for each of the ten functions (i.e., no weighting was applied to the different functions, and each was therefore assigned equal importance in terms of measuring the without project condition habitat value).

Table 5
Va Shly Ay Akimel Study Area
Without Project AAFCUs

	T1	T6	T26	T51	AAFCUs
F1	822	762	650	648	689
F2	1,044	951	951	940	955
F3	119	70	70	63	72
F4	204	125	125	125	131
F5	947	793	794	800	805
F6	821	718	718	720	726
F7	767	697	698	693	701
F8	1,484	1,345	1,345	1,339	1353
F9	983	883	883	880	889
F10	930	851	851	844	854
Avg	812	720	709	705	**718**

As shown in Table 5, habitat value is projected to decline considerably (by about eleven percent) through target year 6. Subsequently, habitat values are projected to level off, both in terms of habitat acreages and functional index values. AAFCUs for without project conditions total 718. This is the value that will be the basis for comparison when assessing the potential benefits of proposed restoration alternatives.

Flooding Problems

The Salt River Project maintains four dams on the Salt River, as well as two on the Verde River. Granite Reef Diversion Dam is located about five miles downstream of the confluence of the Salt and Verde Rivers. At this dam site, all water is taken from the Salt River and diverted into the Arizona and South Canals, which deliver drinking and irrigation water to the greater Phoenix area. During significant flood events, the Salt River Project is forced to release water over Granite Reef Dam into the normally dry Salt River.

Historical Flood Damages

The highest release since the construction of the Salt and Verde River dams occurred in February 1980, when 178,000 cubic feet per second was released because of heavy rains and rapid snowmelt in the watersheds. All bridges were forced to close during that flood except the Central Avenue Bridge in the City of Phoenix. Subsequently, most of the remaining bridges crossing the Salt River have been rebuilt to withstand flow rates of 200,000 cfs and greater.

High releases were also experienced in 1993 (approximately 130,000 cfs). Winter floods during the first three months of 1993 caused extensive damage to property and crops throughout Maricopa County. Total flood damages throughout the State during this storm were estimated at over $250 million in current dollars.

Information regarding damage estimates specific to the study reach was not available. However, current hydrologic data for the Salt River through the Study Area shows that peak discharges for the 100-year event are approximately 172,000 cubic feet per second (cfs). Current hydraulic analysis indicates that there are very few structures in the100-year floodplain. Therefore, it is likely that damages throughout the Study Area reach were limited during these storms.

Floodplain Boundaries & Reach Definitions

Before determining potential damages within the floodplain, an inventory of structures susceptible to damage and estimates of the value of these structures must first be developed. **Figure 2** shows the Base Year floodplain boundaries. As shown on Figure 2, the floodplain is primarily confined within the channel, with the exception of two "breakout" areas (labeled "1" and "2" on Figure 2). Breakout Area 1 extends south of the Salt River and is generally bounded by Lehi Road on the east, Harris Street on the west, and McDowell Road on the south. This area is rural and comprised primarily of residential properties east of Gilbert Road and agricultural properties west of Gilbert Road. The other area subject to potential flooding (Breakout Area 2) is also located on the south side of the Salt River, west of Mesa Drive and north of McKellips Road. This area includes more dense development, including mobile homes as well as some commercial and industrial properties. Even for most of these two areas, the probability of flooding in any given year is generally less than one percent.

The floodplain has been further segmented into sub areas, or Reaches, for analysis purposes. Critical factors used to determine reach boundaries include: discharge/frequency characteristics, overflow spatial characteristics, and economic activity. **Figure 3** shows floodplain reach Boundaries. **Table 6** below provides a summary of reach characteristics, including approximate upstream and downstream boundaries.

Table 6
Va Shly Ay Akimel Study Area
Floodplain Reach Definitions

Reach Name	Upstream Limit	Downstream Limit	Notes
1	~ Longmore Road	Pima Freeway	No damages in this reach
2	~ Country Club Drive	~ Longmore Road	Upstream end of this reach contains downstream portion of downstream breakout area. Primarily commercial/industrial area surrounding McKellips & Country Club
3	~ Mesa Drive	~ Country Club Drive	Contains upstream portion of downstream breakout. Primarily mobile homes, with some commercial structures.
4&5	~ Stapley Drive	~ Mesa Drive	No damages in these reaches
6	~ 32nd St.	~ Stapley Drive	Upstream breakout area. West of Gilbert Road is SRPMIC property, primarily agricultural. East of Gilbert Road is mostly residential.
7-10	Granite Reef Dam	~ Stapley Drive	No damages in these reaches

FIGURE 2

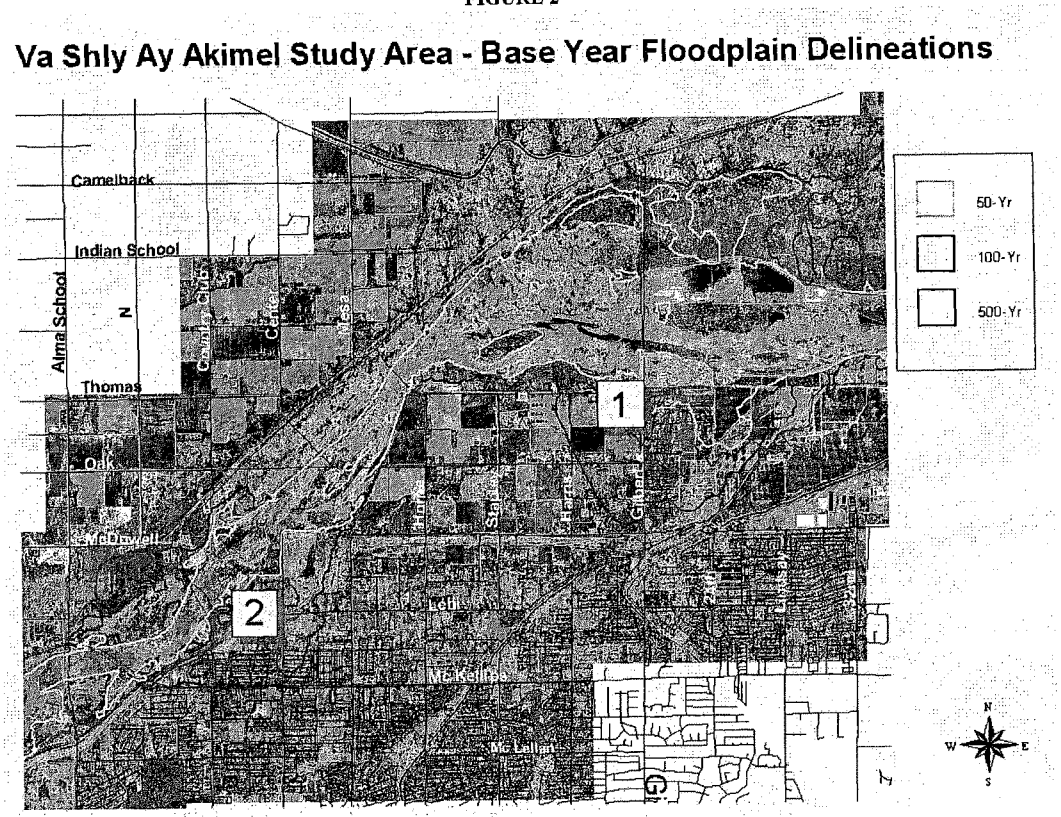
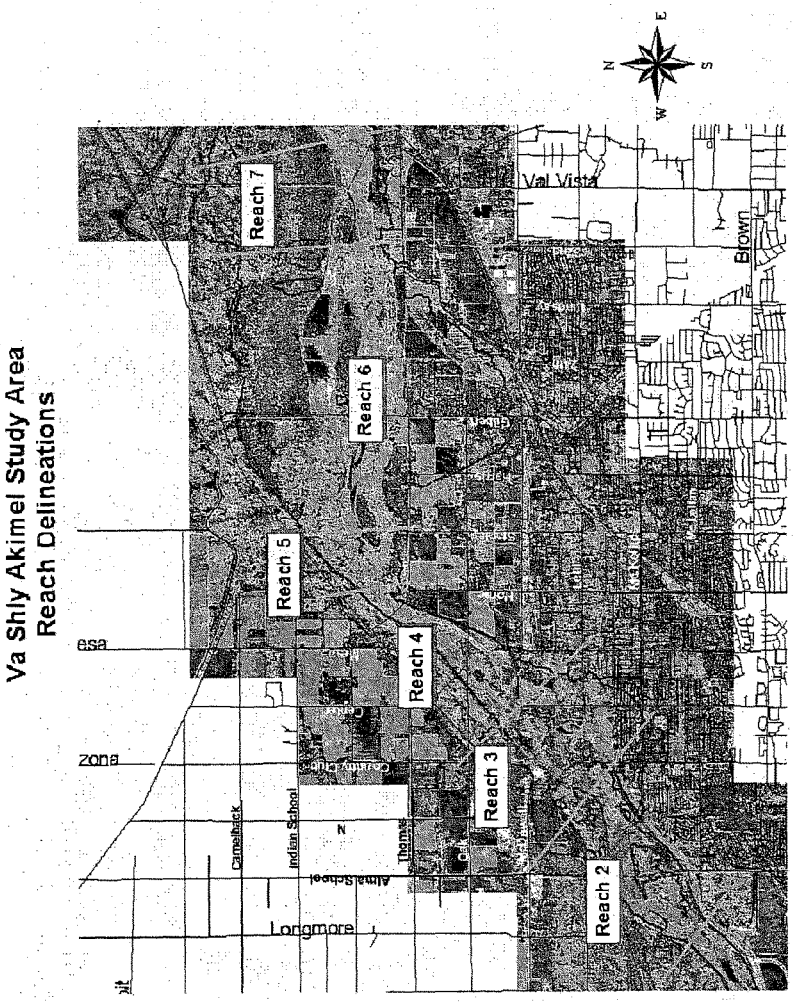

Va Shly Ay Akimel Study Area - Base Year Floodplain Delineations
Camelback
Indian School
Alma School
Thomas
Oak
McDowell
McKellips
1
2
50-Yr
100-Yr
500-Yr
N
W
E
S

FIGURE 3


Va Shly Akimel Study Area
Reach Delineations
Reach 7
Reach 6
Reach 5
Reach 4
Reach 3
Reach 2
Val Vista
Brown
esa
zona
Camelback
Indian School
Thomas
Longmore
N
W
E
S

As indicated in the notes in Table 6 and as can be seen in Figure 3, Reaches 2, 3 and 6 contain all of the floodplain structures. Reaches 2 and 3 include large mobile home parks containing hundreds of mobile home units, as well as commercial and industrial structures along the main streets of McKellips, Country Club and Center. Reach 6 includes large agricultural lots west of Gilbert Road with very few structures. East of Gilbert Road, Reach 6 includes rural residential development with some agricultural acreage as well.

Number of Structures

The number of structures in the 100-year and 500-year floodplains was determined based upon an analysis of aerial photography, parcel maps, real estate assessor's data and a site survey. **Tables 7 and 8** which follow show the number of structures by reach, floodplain and structure type.

Table 7
Va Shly Akimel 100 & 500-Year Floodplains
Number of Structures

Structure Type	100-Year	500-Year
SFR	66	151
MH	137	636
Industrial	18	57
Office/Commercial	13	35
Public	2	4
Total	236	883

Table 7 shows that there are approximately 883 structures in the Va Shly Ay Akimel floodplain. Of this total, nearly 90 percent are residential (sfr/mh). Roughly 236 structures are located within the 100-year floodplain boundaries (about 27 percent of the structures in the 500-year floodplain).

Table 8
Va Shly Ay Akimel 500-Year Floodplain
Number of Structures by Reach

Location	Number of Structures
Reaches 2&3	718
Reach 6	165
Total	883

As indicated in Table 8, most floodplain structures are located in the downstream breakout area (Reaches 2 & 3). Most of these structures are residential, primarily mobile homes.

Value of Structures & Contents

Depreciated structure replacement values were calculated as follows:

1) Square footage for each structure was obtained from real estate assessor's data.
2) Structure construction type and condition were noted during a field survey.
3) Appropriate Marshall & Swift Valuation Service multipliers were determined for each structure based upon its condition, classification and construction type. These multipliers were applied to square footage estimates to derive depreciated structure replacement values.
4) Values were adjusted to reflect local building costs for the Maricopa County area using Marshall & Swift locality multipliers.

Content values were estimated as a percentage of depreciated structure value for each structure. Content ratios by structure type were based upon values derived for several recent Los Angeles District Feasibility Studies. The study areas for all of these projects were located in the Southwestern U.S. Ratios were developed based upon a statistical analysis of content surveys mailed to local residents. The content ratios by structure type used for this study are as follows:

- Residential 50%
- Commercial 140%
- Industrial 171%
- Office 80%
- Public 33%

Tables 9 and 10 provide a summary of floodplain structure and content values, respectively, by structure category and reach. Note that industrial and public percentages do not exactly match the percentages shown above due to rounding of the structure/content values to the nearest $100,000. Content ratios applied to office and commercial structures were 80% and 140%, respectively. The two categories were grouped in Table 9, so the combined values represent structures from both categories (120% ratio).

Table 9
Va Shly Ay Akimel 500 Year Floodplain
Value of Structures & Contents By Structure Type (In $Millions)

Structure Type	Struct Val	Cont Val	Total
SFR	17.5	8.7	26.2
MH	14.8	7.4	22.2
Industrial	4.0	6.8	10.8
Office/Commercial	6.1	7.3	13.4
Public	0.8	0.3	1.1
Total	43.2	30.5	73.7

Table 10
Va Shly Ay Akimel 500-Year Floodplain
Value of Structures & Contents By Reach (In $Millions)

Location	Struct Val	Cont Val	Total
Reaches 2&3	26.6	21.4	48.0
Reach 6	16.6	9.1	25.7
Total	43.2	30.5	73.7

As displayed on Tables 9 and 10, the total estimated value of property in the floodplain is about $73.7 million. Residential properties account for about 66 percent of this total, even though they represent about 90% of the total number of structures. This is attributable to the relatively low value of the residential properties (primarily mobile homes) relative to commercial and industrial structures. As would be expected, most of the floodplain property value is located in the downstream reaches which contain most of the structures.

Without Project Structure & Content Damages

Overview of Methodology

A risk-based analysis (RBA) procedure has been used to evaluate without project flood damages in the study area. Guidance for conducting RBA is included in Corps Engineering Regulation 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability and Economics in Flood Damage Reduction Studies (1 March 1996).*

The guidance specifies that the derivation of expected annual flood damage must take into account the uncertainty in hydrologic, hydraulic and economic factors. Risk and uncertainty are intrinsic in water resource planning and design. They arise from measurement errors and the inherent variability of complex physical, social and economic situations. Best estimates of key variables, factors, parameters and data components are developed, but are often based on short periods of record, small sample sizes, measurements subject to error, and innate residual variability in estimating methods. RBA explicitly analytically incorporates these uncertainties by defining key variables in terms of probability distributions, rather than single-point estimates. The focus of RBA is to concentrate on the uncertainties of variables having the largest impact on study conclusions.

The following are the primary sources of uncertainty for flood damage analysis studies:

1) Discharge/Probability: For a flood or storm event with a given probability of occurrence, there is uncertainty regarding what the resulting discharge will be at a specific location along the stream or river. The reliability of discharge/probability estimates is directly linked to the historical record of stream gauge data available. In cases where records are small or incomplete, the associated uncertainty increases. To address this uncertainty, an analytical or graphical method is typically used to determine statistical distributions of discharge for a range of probabilities at locations throughout the floodplain.

   For this study, discharge/probability uncertainty has been estimated for each reach using the graphical method, based upon an equivalent record length of 105 years.

2) Stage/Discharge: For a given discharge, there is uncertainty regarding what the resulting water surface elevation will be at a given location. Factors contributing to this uncertainty include bed forms, water temperatures, debris or other obstructions, unsteady flow effects, variation in hydraulic roughness with season, sediment transport, channel scour or deposition, changes in channel shape during or as a result of flood events, as well as other factors. To address this uncertainty, standard deviation estimates are developed for stages associated with a range of discharges at locations throughout the floodplain.

   For this study, the standard deviations of error for stages associated with a range of discharges were provided for each reach by Engineering Division. The error values generally increase in value from about 0.1 feet for the 5-year flood event up to about 0.7 feet for 100-year to 500-year flood events.

3) Geotechnical Features: When there are improvements such as levees along a river or stream, there is uncertainty regarding how effective they will be in containing a given flood event. Specifically, there is uncertainty regarding what combination of discharge and stage will result in levee failure. To address this uncertainty, probable failure and non-failure points (elevations) for levees are determined at various locations along the levee's length.

   There are not any existing levees along the Salt River in the Va Shly ay Akimel study area.

4) Structure Elevation: A structure's susceptibility to being inundated is a function of its location within the floodplain and its elevation. There are two sources of potential error in determining elevation. The first is the topographic ground elevation of the structure. This uncertainty is a function of the data source used to derive the elevation estimate. For example, there is greater potential error associated with elevation estimates derived from examining a 5-foot contour

topographic map than a 2-foot aerial survey contour map. The other source of uncertainty is associated with estimates of first floor elevations above ground level (or foundation height). This variable is key, as a structure built on fill or with a large crawl space, for example, may sustain only minor or no damages, even though the surrounding ground is underwater. First floor elevation estimate errors also vary with the methods used to derive them, ranging from best-guess estimates from windshield surveys to professional surveys. Statistical uncertainty in elevation is typically determined by referencing the standard deviation estimates contained in Corp Engineering Manual 1110-2-1619 – *Risk Based Analysis for Flood Damage Reduction Studies (1 August 1996).* This publication presents standard deviation estimates for a wide range of measurement methods.

For this study, ground elevations for each structure were derived from a 10-foot interval digital elevation model in GIS format (which was used in turn to generate 4-foot contour interval shape files). First floor elevations above ground level were estimated during a field survey. Based upon the Engineering Manual cited above, the error associated with first floor elevation estimates is assumed to be normal, with a mean of 0 and a standard deviation of 2.94 feet.

5) Structure Values: Structure values have been determined based upon Marshall & Swift multiplication factors applied to square footage estimates. Square footage estimates were primarily obtained from real estate assessor's data and are determined to be accurate. The primary source of potential error results from misclassification of a given structure in terms of its construction quality and condition. The errors associated with structure value estimates are assumed to be normal, with a mean of 0 and standard deviations ranging from 10 to 21 percent (depending on structure type), based upon upper and lower ranges of M&S factors.

6) Inundation Depth/Percent Damage: There is considerable uncertainty regarding the percentage of damage to structures and contents given a certain level of flooding. The National Flood Insurance Program of FEMA collects damage data following flood disasters and publishes depth/damage functions. These functions are used to derive estimates of damages to non-residential structures. For residential structures, depth-damage functions and associated standard error estimates have been developed by the Institute for Water Resources based upon a statistical analysis of actual flood damages that have occurred throughout the United States. Damage percentages for both structures and contents are based upon corresponding structure values. These functions were used for this analysis.

The Corps of Engineers Hydrologic Engineering Center has developed software specifically designed for conducting RBA, referred to as the HEC-FDA Program (Version 1.2 used for this analysis). This program applies a Monte Carlo simulation process, whereby the expected value of damages is determined explicitly through a numerical integration technique accounting for uncertainty in the basic parameters described above. Data requirements for the program include:

- Structure data, including structure I.D., category (sfr, mfr, etc.), stream location, ground and/or first floor elevation, structure value and content value. This data was developed in a Microsoft Excel spreadsheet and imported into the HEC-FDA program.
- Hydrologic and hydraulic data, including water surface profiles, frequency/discharge relationships, and stage/discharge relationships. For this study, water surface profiles were developed using the HEC-RAZ program. These functions were imported into the HEC-FDA program.
- Depth/Damage functions. Functions for residential and non-residential structures were obtained from the Institute for Water Resources and FEMA's National Flood Insurance Program.
- Risk & Uncertainty Parameters, as described in detail previously, were also entered into the program.

Results – Base Year (2011)

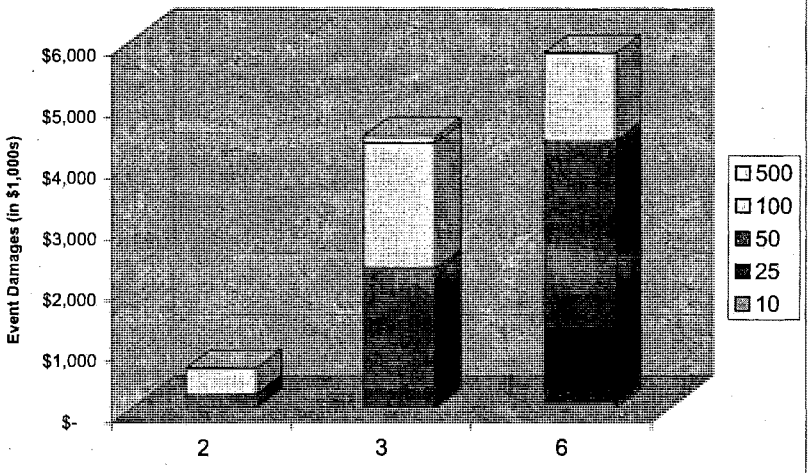
Without project damages by event for Base Year conditions, as calculated by the HEC-FDA program, are shown in **Tables 11** and on **Figure 4.** The non-damaging event is approximately the 10-year event. However, most reaches do not incur damages until less frequent events. Damages calculated for the 25-year event are approximately $1.56 million. Damages increase significantly for the 50-year and 100-year events, with only a marginal increase for the 500-year event.

One important thing to note is that the damage estimates below show damages occurring for flood events such as the 10-year or 25-year, even though overflow delineations show that the area does not sustain flooding until less frequent events. This is attributable to the nature of the risk and uncertainty analysis. The R&U analysis takes into consideration the inherent uncertainties in discharge, water surface elevation, and the estimated topographic elevation of the structure. For example, it is possible that for a given flood frequency, discharge values and water surface elevation values derived from the probability distributions could be substantially higher than the average or median values (upon which the overflow delineations are based). Also, there is significant uncertainty associated with the structure elevations, since they were based upon 10-foot contour maps. It is possible that with more refined mapping and associated reduced uncertainty in structure elevations, the simulation would not yield damage estimates for the more-frequent events.

Table 11
Va Shly ay Average
Without Project Damages By Reach & Event (Base Year - 2011)
(in $1,000s)

Reach	10	25	50	100	500
2	$ -	$ 4	$ 223	$ 650	$ 650
3	$ -	$ 265	$ 2,298	$ 4,344	$ 4,452
6	$ 70	$ 1,293	$ 4,379	$ 5,812	$ 5,812
Total	$ 70	$ 1,562	$ 6,900	$ 10,806	$ 10,914

Figure 4
Va Shly ay Akimel
Without Project Structure & Content Damages by Frequency & Reach
(Base Year)



Expected annual damages by reach and structure type for Base Year conditions are shown on Table 12. Damages to residential structures and contents (sfr/mh) represent about 74% of total damages. Most damages occur in Reach 6 (the upstream breakout area), even though there are many more structures located in Reaches 2 & 3. This is due to the higher probabilities of flooding in the upstream reach. In addition, the residential structures in Reaches 2 & 3 are mostly mobile homes, which have a lower value than the single-family residences located in the upstream reach.

Table 12
Va Shly ay Akimel
Without Project Expected Annual Damages – Base Year
(in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	$ 2.4	$ 9.4	$ 3.6	$ -	$ 15.4
3	$ 53.3	$ 21.0	$ 32.1	$ 1.9	$ 108.3
6	$ 177.7	$ 13.2	$ 2.6	$ -	$ 193.5
Total	$ 233.4	$ 43.6	$ 38.3	$ 1.9	$ 317.2

Results – Future Conditions (2060)

Hydrologic and hydraulic analyses were conducted for future without project conditions to determine the impacts of processes such as sedimentation and channel degradation and the resulting impacts on potential

flooding. Updated water surface profiles and stage/discharge uncertainty data were used to recomputed expected annual damages under future conditions. Table 13 summarizes the results.

Table 13
Va Shry ay Akimel
Without Project Expected Annual Damages – Future Conditions (2060)
(in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	$ 1.2	$ 5.3	$ 2.1	$ -	$ 8.6
3	$ 23.5	$ 13.4	$ 19.8	$ 1.0	$ 57.7
6	$ 24.1	$ 1.4	$ -	$ -	$ 25.5
Total	$ 48.8	$ 20.1	$ 21.9	$ 1.0	$ 91.8

Without project expected annual damages actually decrease from about $317,000 under Base Year conditions to about $92,000 under future conditions (a drop of over 71 percent). The most dramatic decline was in Reach 6, which shows a damage reduction of about 87% relative to Base Year conditions. Water surface elevations are generally lower throughout the Study Area under future conditions (refer to Hydraulic appendix for details). This is depicted in **Figure 5**.

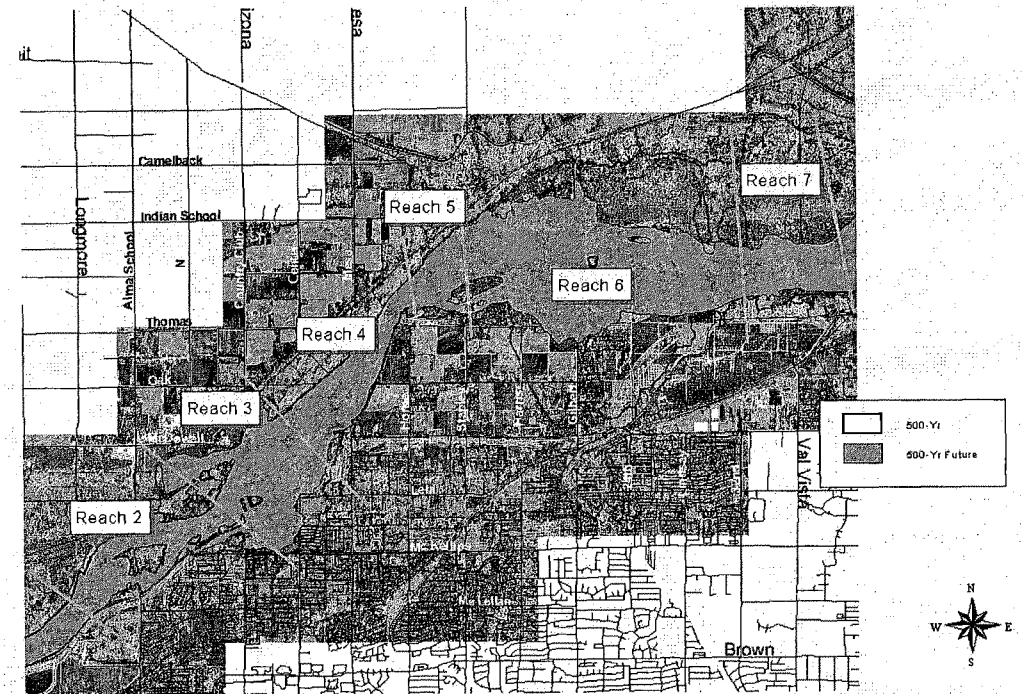
Equivalent annual damages were computed based upon forecast annual damages using a discount rate of 5 5/8% (see Table 14). As shown below, equivalent annual damages total about $251,000, with over 71% of damages associated with residential structures, and over 57% located within Reach 6.

Table 14
Va Shry ay Akimel
Without Project Equivalent Annual Damages (50 Yrs, 5 5/8%)
(in $1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
2	$ 2.0	$ 8.2	$ 3.2	$ -	$ 13.4
3	$ 44.6	$ 18.8	$ 28.5	$ 1.7	$ 93.6
6	$ 132.8	$ 9.8	$ 1.8	$ -	$ 144.4
Total	$ 179.4	$ 36.8	$ 33.5	$ 1.7	$ 251.4

Figure 5

Va Shly ay Akimel - Base Year vs. Future Conditions 500-Year Floodplain



Without Project Emergency & Cleanup Costs

Cleanup, Debris Removal & Public Infrastructure Repairs

Emergency costs are defined as those expenses resulting from a flood that would not otherwise be incurred. Emergency costs include such items as emergency protective measures, post-flood cleanup and debris removal, utility repairs, and evacuation, reoccupation and temporary housing costs for floodplain residents.

Emergency costs related to public infrastructure repairs, debris removal and post-flood cleanup have been calculated by applying an average per acre cost to the number of developed acres inundated by flood event. Based upon several recent Los Angeles District studies, per acre costs for these items may range from $1,250 to $7,500 per acre1. In accordance with this range, $5,000 per acre has been assumed for this analysis.

Per acre costs are applied to floodplain acreage with existing development. Floodway, undeveloped and agricultural acreage are not included (agricultural cleanup costs are calculated separately and included under Agricultural Damages). ArcView GIS software was utilized to determine acreage by flood event that would require cleanup, public repairs and debris removal. Table 15 displays without project cleanup related costs by frequency, while Table 16 displays expected annual costs by reach.

Table 15
Va Shly ay Akimel
Without Project Cleanup Costs
(in $1,000s)

Event	Acres	Costs
20	0	$ 0
50	100	$ 500
100	295	$ 1,475
500	845	$ 4,225
Expected Annual Damages		**$ 44.5**

Table 16
Va Shly ay Akimel
Without Project Expected Annual Cleanup Costs
By Reach (in $1,000s)

Reach	Expected Annual Costs
2	$1.4
3	$5.1
6	$38.0
Total – All Reaches	**$44.5**

Temporary Evacuation, Relocation and Housing Assistance Costs

FEMA provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster and being an expenditure that

1 *Lower Mission Creek, Santa Barbara County, CA and Rio de Flag, Coconino County, AZ Feasibility Studies, LA District.*

would not be undertaken except for the disaster falls under the emergency cost guidance of ER 1105-2-100. Therefore, the funds expended by FEMA for temporary housing assistance in the event of flooding are NED flood damages.

An Internet database search of FEMA disaster reports for flood and storm damage was performed. Data was collected and analyzed for ten recent flood disasters, including the October/November 2000 flooding in Maricopa and La Paz counties in Arizona. For these ten disasters, 18,799 housing assistance claims were approved for a total payout of $27.93 million. This represents an average amount per claim of approximately $1,500.

To estimate temporary housing costs by flood event for this study, the number of houses and mobile homes inundated by frequency was ascertained through an analysis of HEC-FDA output files, and the per housing unit claim of $1,500 was applied. Table 17 shows the results.

Table 17
Va Shly ay Ak ne
Without Project Temporary Housing Costs
(in $1,000s)

Event	Structures	Costs
20	0	$ 0
50	20	$ 30
100	203	$ 305
200	515	$ 773
500	787	$ 1,181
Expected Annual Damages		**$ 8.9**

Table 18 shows expected annual without project temporary housing costs by reach.

Table 18
Va Shly ay Akchin
Without Project Expected Annual Temporary Housing Costs
By Reach (in $1,000s)

Reach	Expected Annual Costs
2	$1.3
3	$4.9
6	$2.7
Total – All Reaches	**$8.9**

Without Project Agricultural Damages

Reach 6 contains agricultural croplands susceptible to flood damages. The following table shows agricultural land area by floodplain and crop type. Please refer to attached Addendum 1 for a detailed description of the agricultural crop damage analysis. Addendum 2 documents the supporting hydrologic and hydraulic analysis used to derive agricultural flood damage estimates.

Table 19
Ya Shiy Ay Akimel
Estimate of Floodplain Crop Acreages (Reach 6)

	Number of Acres Enclosed within Floodplain Demarcation Line			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

For each of the crop types listed above, monthly crop budgets were developed to determine potential direct production losses based upon the stage of production when a potential flood event could occur. According to information furnished by Engineering Division, it is highly probable that any major flood event would occur during the months of January through March. This is a critical factor when determining potential flood damages. For example, alfalfa hay is typically harvested in mid-April, so cumulative production expenses by the end of March are relatively high. For cotton, however, land preparation activities are typically not completed until mid-March, so cumulative production expenses during the months most likely to experience flooding are minimal.

Tables 20 shows expected annual flood damages based upon direct production losses, not taking into consideration seasonal flood probabilities or potential inundation durations. Table 21 factors in the monthly probabilities of major flood events. Also, although duration data was not available, damages presented in Table 21 were derived by taking an average of potential damages for inundation durations ranging from less than one day to more than one week.

Table 20
Ya Shiy Ay Akimel
Estimate of Crop Prod. Losses by Flood Event (Reach 6)
Not Discounted for Seasonal Flood Probabilities or Duration Impacts

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$4,700	$1,900	$314,400	0.0	$320,900
100	$13,400	$5,300	$409,300	0.0	$428,000
200	$47,200	$18,800	$528,800	$13,600	$608,400
500	$50,600	$20,100	$618,900	$121,300	$810,900
EAD	$500	$200	$11,400	$400	$12,500

Table 21
Ya Shiy Ay Akimel
Estimate of Crop Prod. Losses by Flood Event (Reach 6)
Adjusted for Seasonal Flood Probabilities & Potential Duration Impacts

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$200	$700	$39,300	0.0	$40,200
100	$500	$2,000	$51,200	0.0	$53,700
200	$2,100	$7,100	$66,200	$3,400	$78,800
500	$2,300	$7,600	$77,400	$30,300	$117,600
EAD	$20	$70	$1,430	$90	$1,600

As shown on Table 21, expected annual direct production losses are minimal when reflecting the low probability of inundation, the seasonal nature of flooding, and a range of potential durations. In addition, the damages to the orchards could actually be lower than the values shown above if the durations were short. For purposes of this analysis and based upon the information available, it is assumed that without project expected annual damages equal $1,600.

These losses do not account for potential income/revenue losses. In order to accurately assess revenue impacts, it would be necessary to analyze the potential for replanting, as well as whether or not the replanting would result in reduced yield. Due to the limited flooding impacts to agricultural areas, this additional analysis was not conducted. However, estimates were developed of the maximum expected annual losses for each crop under the assumption that flood events occurred after all production expenses were incurred, but before any of the harvest could be sold. This value is simply the gross revenue loss assuming a complete loss of the harvest. As shown in the Addendum, even using these values, expected annual damages only total $3,100. Since the harvest times vary for the crops, and the probability that flooding would occur at such a time as to result in complete loss of any of the crops harvested is very low, it was not deemed appropriate to base damage estimates on this value. Rather, damages are based upon direct production losses, although this underestimates potential agricultural losses to a small extent.

In addition to direct production losses, flooding of agricultural areas would also require cleanup. Cleanup costs per acre can vary significantly, depending on the stage of production cycle, duration and timing of the flood event. For purposes of this analysis, cleanup costs were derived by applying a cost per acre of $1,000 to the acreage estimates shown in Table 19. Resulting average annual agricultural cleanup costs total $5,700.

Adding estimated average annual direction production losses to agricultural cleanup costs results in total average annual agricultural damages of $7,300.

Without Project Flood Damage Analysis Summary

Without project flood damages are summarized on Table 22.

Table 22
Va Shly ay Akimat
Without Project Equivalent Annual Damages
(in $1,000s)

Reach	Structure & Content	Cleanup	Temp. Housing	Agricultural*	Total
2	$ 13.4	$ 1.4	$ 1.3	$ -	$ 16.1
3	$ 93.6	$ 5.1	$ 4.9	$ -	$ 103.6
6	$ 144.4	$ 38.0	$ 2.7	$ 7.3	$ 192.4
Total	$ 251.4	$ 44.5	$ 8.9	$ 7.3	$ 312.1

* *Including Direct Production Losses & Cleanup*

Total without project equivalent annual damages total approximately $312,000. About 62 percent of total damages are concentrated in Reach 6. This reach contains fewer structures than the downstream breakout area. However, this area has a higher probability of flooding, and the floodplain boundaries for the 50 through 500-year floods are significantly larger. As a result, structure/content and cleanup damages are higher in this area. Temporary housing costs are higher in the downstream breakout area due to the much greater number of structures, which is the basis for these cost estimates.

Recreation

As demonstrated earlier in this report, the City of Mesa, as well as the entire Phoenix metropolitan area has experienced rapid population growth. As the Phoenix MSA population has now expanded to over three million people, so has the demand for both passive and active recreation opportunities. Envisioned recreational opportunities coinciding with habitat restoration projects for the study area consist primarily of passive recreation, such as bird watching, walking, jogging, hiking, bike riding, horse-back riding, picnicking, and other passive uses of open space.

Existing Recreation Resources in Market Area

Based upon conversations with representatives from the City of Mesa, SRP-MIC, the Arizona Game and Fish Department and other agencies, the proposed habitat and recreation features would attract visitors throughout the Phoenix metropolitan area, particularly the East Valley (Scottsdale, Tempe, Mesa, Gilbert, Chandler and Apache Junction). The greater Phoenix area does not currently have any significant riparian habitat areas with supporting recreation facilities. The major existing parks in the area consist primarily of desert mountain preserves, which do not contain the types of habitat that could be supported in the study area. For purposes of this analysis, the market area will be defined as the greater Phoenix metropolitan area, which would include Maricopa and Pinal Counties, and the SRP-MIC, although it is likely that many visitors would be drawn from even greater distances.

The following presents the primary recreation areas in the greater Phoenix area. This does not include the area's numerous golf courses and man-made lakes.

National Trails Systems

- North Mountain Trail: Nine miles of trails located in Northwest Phoenix.
- South Mountain Trail: Fourteen miles of desert trails in the center of South Mountain Park, providing for hiking and horseback riding.
- Sun Circle Trail: Includes 110 miles of urban to open desert trails forming a loop around the Phoenix Valley for hiking and bicycling.
- Squaw Peak Trail: 1.2 miles of urban wilderness area.

State Parks

- Painted Rocks State Park: 140 acre historical park located 15 miles west of Gila Bend.
- Lost Dutchman State Park: 300 acres of desert park on the Apache Trail located near the Maricopa/Pinal County border. Includes 35 campsites, picnic facilities, and restrooms.

BLM Lands

- Greenbelt Resource Conservation Area located south of Buckeye -- includes hunting and hiking.

State Game & Fish Department

- Usery Mountain Shooting Range: 1,092 acres located northeast of Mesa
- Black Canyon Shooting Range: 1,290 acres located 20 miles north of Phoenix.
- Base and Meridian: 173 acres of wildlife habitat located three miles south of Cashion.
- Gila River Wildlife Area: 6,896 acres of wildlife habitat extending from Avondale to the Gillespie Dam.

Major Water Bodies

- Apache Lake Marina: Located approx. 35 miles east of Phoenix in Maricopa and Gila County.
- Bartlett Lake: Maricopa County (approx. 45 miles northeast of Mesa).
- Canyon Lake: Maricopa County (approx. 30 miles east of Phoenix).

- Saguaro Lake: Maricopa County (approx. 25 miles east of Phoenix).

Maricopa County

- McDowell Mountain Park: One of Maricopa County's largest parks, covering 21,099 acres, with camping, trails, and a nature center.
- Santan Mountains Area: 10,118 acres, currently with no recreation improvements. Phase I development will establish picnic areas, camping, a trailhead, and utilities.
- Usery Mountain Recreation Area: 3,648 acres, including campgrounds, a day-use area, picnic sites with grills, tables, ramadas and water fountains, hiking, mountain biking and horseback riding. A horse staging area is available with picnic areas and hitching posts.
- Estrella Regional Park: 18,000 acres located three miles south of Goodyear.
- Maricopa County Flood Control District Reach 6 Floodway Trail: Two-mile stabilized granite trail from Princess Park to Broadway Rd. along the RWCD canal in Mesa.

Major Municipal Parks & Other Recreation Areas

Red Mountain District Park	Fitch Park
Papago Park	South Mountain Park
Salt River Project Canal Banks (Trails)	Echo Canyon Recreation Area
Phoenix Mountain Preserve	

Red Mountain Park is one of the largest recreation areas listed above which is nearby the study area. Red Mountain Park is the only regional park in the City of Mesa. The park consists of 1,146 acres and is located between Power and Ellsworth Road, just north of McDowell and spans just south of Brown. At this time the majority of the park (1,028 acres) is undeveloped open space, which serves as a tribute to the beautiful Arizona Sonoran Desert. The park amenities include: six lit soccer fields, two lit basketball courts, four lit concrete volleyball courts, picnic areas, ramadas, a playground, walking trails, an artificial riparian habitat area and an urban fishing lake. The lake is also a Department of Water Resources recharge facility that utilizes three wells that permit water from the lake to enter the wells and thereby recharge the underground water aquifer. The City of Mesa estimates the annual visitation at Red Mountain Park at over five million.

South Mountain Park and Papago Park are two of the largest recreation areas in the greater Phoenix Metropolitan Area. South Mountain Park is located about three miles south of the Salt River and extends from about 48th Street on the east to 43rd Avenue on the west -- a distance of over 10 miles. The park encompasses about 17,000 acres of desert mountain landscape and is the largest municipal park in the U.S. It is bounded on the north by Baseline Road and on the south by Chandler Boulevard, and is over three miles wide in some places. It contains an activity complex, hiking and riding trails (extending over 40 miles), an interpretive center, lookouts, ramadas, picnic areas and restrooms. According to the *Sonoran Preserve Master Plan*, annual park visitation during the 1990s exceeded 3 million.

Papago Park is located just north of the Salt River in eastern Phoenix and western Tempe. It includes about 1,400 acres bounded on the north by Oak Street, on the south by State Highway 202, on the west by 52nd Street and on the east by 68th Street. The park includes: rock formations dating back 15 million years, ramadas, picnic facilities, three fish ponds stocked with rainbow trout and channel catfish, a baseball stadium, a softball complex, volleyball courts, the Phoenix Zoo, botanical gardens, a state historical museum, two golf courses, an archery shooting range, nature trails and restrooms. Annual visitation at this park exceeds 2 million.

In addition to South Mountain Park, Phoenix Mountain Preserve is the other major mountain preserve area in greater Phoenix. Located in the northeastern section of Phoenix, the Phoenix Mountains are a combination of

regional parks and preserves. The regional parks represent the partially developed areas while the preserves represent the areas which are completely undeveloped except for trails. There are about 1,800 acres of regional parks embedded within the preserves, including the North Mountain, Squaw Peak, and Shaw Butte recreation areas. These parks include an extensive trails system, picnic areas and restrooms. North Mountain recreation area also features basketball and volleyball facilities and a playground. The combined visitation at North Mountain and Squaw Peak Recreation Areas has totaled approximately 1.5 million in recent years.

Existing Recreation Resources in Study Area

Recreation along the Salt River corridor is highly dependent upon the availability of surface water and riparian habitat, both of which are dependent upon the supply and availability of ground water. The Salt River through the SRP-MIC and the City of Mesa consists of dry river bottom. As a result, virtually no recreation activities take place. The only improved recreation area is Riverview Park, which is adjacent to the Salt River at the west end of the Study Area. The Park contains 51 acres within its boundaries, and includes baseball and softball fields, basketball and volleyball courts, picnic facilities, ramadas and a three-acre urban fishing lake. Riverview Golf Course (a 9-hole course) is adjacent to the park. Annual attendance is estimated at approximately one million.

Some of the other park facilities in the City of Mesa include:

Park/Facility	Annual Visitation	Features
Quail Run Park	432,000	38 acre park with 4 lit soccer fields, 4 lit 90ft baseball fields, a playground, picnic facilities, ramadas, and a fenced dog area
Hohokam Park	2,024,000	37 acres, with professional level baseball stadium with 14,000 seating and training facilities, 2 lit and 2 unlit soccer fields.
Gene Autry Park	670,000	Professional level spring training complex with 3 lit baseball fields and clubhouse, 16-court tennis center with 4 volleyball courts, a playground, and picnic facilities.
Park of the Canals	125,000	This is a historically significant park with ancient Hohokam canals and dwellings, public rest rooms, picnic facilities, playground, and botanical garden.
Fitch Park	2,755,000	4 lit baseball fields, 4 lit reservable racquetball courts, 4 lit basketball courts, 2 playgrounds, picnic facilities, reservable ramadas, rest rooms,
Usery Mountain Recreation Area	73,600	This Maricopa County facility of 3,324 acres includes an archery range, 71 camp sites, 27.3 miles of trails, 1 group camp ground, 60 picnic sites, 3 playgrounds, 19 ramadas, 7 rest rooms, 4 restrooms with showers and a private water system.

The SRP-MIC has a limited number of outdoor recreation facilities nearby the study area. The two primary facilities include the Salt River Baseball Field and the Salt River Little League Field.

Other existing and planned recreation facilities along the Salt River downstream of the Study Area include Tempe Town Lake, the Rio Salado Project, and the Tres Rios Project.

The Rio Salado Project stretches from an upstream limit of 32nd street to a downstream limit of 19th Avenue and is comprised of environmental restoration and passive recreation components along the Salt River. Approximately five miles (and 580 acres) of the Salt River will be restored to create riparian and wetland habitat. Passive recreation facilities, including over ten miles of trails and interpretive signage are also included. Construction commenced on the project in 2000. Recreation project features include parking lots, information kiosks, a visitor center, overlooks, shade structures, bridges, trails, a staging area, signage and landscaping. Recreation activities provided by the plan include: walking, hiking, biking, horseback riding,

roller blading, picnicking, and bird watching. Scenic overlooks will be included for the enjoyment of the restored desert riparian habitat. Information kiosks and the visitor center will provide education on the resource, including restoration of the habitat, the hydro cycle, a historical perspective of the Salt River, and flora and fauna within the project area. As documented in the Rio Salado Feasibility Study, annual visitation is anticipated to exceed 500,000.

In addition to the Rio Salado Project, the Tres Rios project, located downstream of the 91st Avenue Wastewater Treatment Plant, will also provide recreation opportunities. Components of this plan include new levee alignments for flood control, the establishment of wetland, marsh and riparian habitat and passive recreation/environmental education facilities.

Immediately upstream of the Rio Salado Project is Tempe Town Lake. The lake was constructed within the existing Salt River flood control channel (about 850 feet in width), extending from the Salt River's confluence with Indian Bend Wash to approximately two miles downstream. The river's flood control conveyance capacity is retained through the use of a system of rubber dams which can be deflated during significant floods.

The lake contains about 220 surface acres and 20,000 feet of shoreline supporting paddle-boating, canoeing, sailing and fishing. Tempe is hoping to establish the state's largest urban fishing program. Over 1,000 acres of adjacent land has been dedicated for recreational development and open space. Activities will include picnicking, hiking, bicycling, horseback riding, softball/baseball, volleyball, golfing, water slides and play areas. Other possible recreational uses include soccer and major sports events, such as marathons.

Future recreation facilities being planned for the Mesa area include:

- South Canal Multi-use Path: Will include 6.5 miles of lit, paved multi-use trails along the Salt River Project South Canal bank from McKellips Road to Granite Reef Dam along the Salt River.
- Metro Park: 132 acres of undeveloped land in northeast Mesa to be developed as a Metro Park with trails, picnic facilities, sports courts and possibly lit sports fields pending public input.
- Development of the Crimson homestead site: 3.5-acre historic homestead with farmhouse, out buildings and citrus trees. A trailhead for the South Canal Multi-use path may be developed here.

Recreation Demand

As noted earlier, recreation options likely to be considered for this study would be passive in nature, complimenting the primary project purpose of providing habitat restoration along the Salt River. Many factors contribute to make the proposed riparian habitat area extremely attractive in terms of recreation potential. They include:

1) Environment: Demand for recreation opportunities must be considered in the context of the surrounding environment. Although there are many recreation areas throughout Mesa and the Phoenix metropolitan area, the only recreation facilities located within wetland/riparian habitat areas are those which will be provided downstream of the study area by the Rio Salado and Tres Rios projects. Most of the existing parks are small community parks. The larger regional parks are located in desert mountain terrain (e.g., Red Mountain Park and South Mountain Park) and not in wetland and riparian habitat areas. This is expected to result in significant recreation demand at the study area if such habitat is established. As discussed previously, riparian habitat would also attract wildlife to the area. According to the 1991 *National Survey of Fishing, Hunting and Wildlife-Associated Recreation (Arizona)*, published by the U.S. Fish and Wildlife Service, over 1.1 million Arizona residents 16 years and older (or 40 percent of the population) participated in non-consumptive activities where the

enjoyment of wildlife was the primary purpose of the activity. Such activities include observing, feeding and photographing wildlife. Nearly 3.3 million trips were taken by Arizona residents to participate in non-consumptive activities one mile or greater from their residence.

2) Location: In a study conducted for the 1994 Arizona Statewide Comprehensive Outdoor Recreation Plan (SCORP), over 1,200 respondents were asked what the primary barriers were to outdoor recreation participation. After lack of time, the number two and three barriers cited were: 2) recreation areas are too far away; and 3) don't know where to go. The 1991 Fish and Wildlife Survey indicated that Arizona residents travel an average distance of nearly 30 miles to participate in non-consumptive recreation activities. The closest major water bodies to the city of Phoenix are located approximately 30 miles away. These barriers would not be associated with recreation at the study area. According to the publication, *Arizona Trails 2000*, prepared by the Arizona State Parks Board (October 1999), the number one reason given by recreation trail users for preferring a particular area is its proximity to home.

The study area is located within the Phoenix metropolitan area, which has a population exceeding three million. Portions of the study area are located within minutes of downtown Mesa, and are thus easily and quickly accessible to the public. This provides the area with tremendous exposure, and would likely attract many who would otherwise not frequent such a park.

Family and lifestyle changes also contribute to high demand for more local recreation facilities. As described in the *Town Lake Capacity and Needs Study: Rio Salado Project* (BRW Moffatt & Nichol Engineers, 1996), "More single-parent families, more families where both spouses work full-time, moderate growth in income and less time for leisure time activities all contribute to heavy pressure on local park and recreation facilities. People are looking for park and recreation facilities which are close, offer a variety of water-based and land-based activities and are in an attractive setting."

3) Attitudes: Arizonans place high importance on the state's outdoor recreation resources. In the 1994 SCORP survey, 94 percent of respondents stated that parks and recreation areas are important to their everyday lifestyles. There is also strong support for protecting natural and cultural resources and for environmental education. Arizonans care deeply about the state's air, water and riparian areas. Seventy-five percent (75%) favor preserving rivers and stream-side habitats, even if it means limiting some uses of privately owned lands. A separate study conducted by the Arizona Game & Fish Heritage Fund (*Attitudes Toward Urban Wildlife Management, Volume 1, May 1995*) supports these statistics. A statewide survey was conducted of 1,200 residents. In the Heritage Fund survey, 89 percent of respondents stated that the continued presence of wildlife in their town is important to them. The importance placed on protecting water-based habitat and recreation areas can be attributed to the limited amount of surface water available. Arizona has approximately 113,642 square miles of land surface, but only about 360 square miles are water-covered.

The *Mesa 2025* publication referenced earlier in this report also provides feedback on the attitudes of local residents regarding recreation. Surveys conducted for the study concluded that residents desire more parkland, particularly more passive recreation facilities. Participants support the City taking an active roll in identifying and pursuing a variety of partnerships with public and private entities to create new recreation facilities.

4) Activities: Potential recreational activities for the study area include trails for hiking, biking, jogging, and horseback riding, birdwatching, and picnicking. In addition, interpretive centers and lookout points could be established along the banks of the river at key scenic vantage points. In a ranking of overall demand for outdoor activities in the recent SCORP, visiting outstanding scenic areas was ranked first, picnicking ranked fourth, and walking ranked fifth. Other envisioned recreation features for the study area were ranked as follows: day trail hiking (10); bicycling (14); using a park playground (15); horseback riding (18); mountain biking in a natural setting (26); nature study/birdwatching (27); and jogging/running (36). Among those activities identified as having the greatest latent or unmet demand, picnicking, visiting outstanding scenic areas, walking, trail hiking, horseback riding and bicycling all ranked in the top fifteen. In terms of public funding priorities, visiting outstanding scenic areas, picnicking, trail hiking, using a park playground and walking all ranked in the top ten.

Mesa's 2025 report also details the demand by local residents for the types recreation that could be provided at the study area. When survey respondents were asked to identify the leisure activities they most frequently participate in, among the top thirteen responses were: walking/jogging (58%), picnicking (37%), biking (31%), hiking (30%) and visiting nature preserves (28%).

According *Arizona Trails 2000*, over half of Arizona residents consider themselves non-motorized recreation trail users. Surveys indicated that trail users spent an average of 22 days using trails during the prior year. Over 70 percent of respondents indicated that they supported using state funds to develop trails. Survey results are supported by the fact that Arizona State parks have experienced a 16 percent increase in visitation over the past five years.

There is also a shift in the types of recreation demanded by Americans in general. The National Survey on Recreation and the Environment conducts periodic surveys on public recreation use and demand. From 1983 to 1995, the percentage of Americans involved in such activities as fishing and hunting actually declined. On the other hand, the activities that have seen the most dramatic increases in demand have been hiking (+94%), birdwatching (+155%) and backpacking (+73%).

5) Population Growth: As demonstrated earlier in this report, the greater Phoenix area has experienced tremendous growth. For example, Maricopa County's population has grown from 2.12 million to over three million between 1990 and 2000 (or nearly 45 percent), and is expected to reach over 4.5 million by the year 2020. With this projected growth, there will be increasing demand for outdoor recreation opportunities. As quoted in the 1994 SCORP report (p. 68),

"This large and rapidly growing population in our two metropolitan counties has several implications for outdoor recreation. Most obvious, local providers are hard-pressed to keep up with demand for facilities and services. As development continues to expand, providing and protecting open space becomes an important issue. Increasingly, city dwellers mention a major barrier to participation that recreation providers must address: outdoor recreation areas are too far away."

6) Education: The establishment of riparian habitat would attract diverse wildlife to the study area. Elementary and high schools would frequent the area for class field trips, and colleges could utilize the area for environmental-related research.

According to the article, "Assessing Recreation Demand", posted on the U.S. Department of Transportation Statistics' Internet site, the use of population based standards represents one of the most widely used methods for assessing community demand and need for open space and recreation. This is attributed to the fact that they are easily understood and administratively convenient. Such standards are considered most useful as a means for generating alternatives for consideration and as a means for supporting participation data. The National Recreation and Parks Association (NRPA) established a range of standards, but also recommended that each community develop individual standards to the most appropriate range, quantity and quality of recreation facilities within their fiscal restrictions.

Mesa has developed standards for various types of recreation, in terms of desired and ideal service levels on a per capita basis. The desired levels are lower than the national standards, as set by NRPA. However, target levels were adjusted to reflect the realities of the limited amount of available land and funding. Table X summarizes the current and target service levels.

As shown on Table 23, the City currently has a supply of about 4.2 acres per thousand residents in the western portion of the City and about 8.5 acres per thousand residents in the eastern portion of the City. For the City as a whole, there is currently about 2,918 acres of park property, accounting for about 6.7 acres per thousand residents. In light of land and funding constraints, the City has established desired service level ratios of 4.65 acres/1000 for the west and 8.5 acres/1,000 for the east. These ratios are well below the national standard often referenced of 10 acres per thousand residents, which was also the standard previously adopted by the City in its 1996 General Plan. Even with these reduced standards, the City still falls below target levels, and the supply deficit will worsen over time due to the projected population growth. Table 23 shows that the City will need to add over 700 acres of new parks over the next 25 years to meet the demands of the growing population.

TABLE 23
City of Mesa Recreation Supply & Future Needs

Facilities Category	2000 Total (acres)	Current Population/ Facility Ratio Mesa-West (acres)	Current Population/ Facility Ratio Mesa-East (acres)	Mesa - West Guidelines	Mesa - East Guidelines	Add'l Acres Needed in West by 2006	Add'l Acres Needed in East by 2006	Add'l Acres Needed in West by 2010	Add'l Acres Needed in East by 2010	Add'l Acres Needed in West by 2025	Add'l Acres Needed in East by 2025
Neighborhood Parks (3-15 acres)	215.1	194.5 .56 ac/1,000	20.6 .23 ac/1,000	.65 ac/1,000	1 ac/1,000	20	50	20	50	10	60
Community Parks (15-40 acres)	382.7	294.2 1.17 ac/1,000	88.5 1 ac/1,000	1 ac/1,000	1.5/1,000	40	40	40	80	40	80
Metro Parks (40-200 acres)	269.9	269.9 .78 ac/1,000	0 .00 ac/1,000	1 ac/1,000	1.5 ac/1,000	50	160	50	50	50	80
Regional Parks (+200 acres)	1144.5	572 1.65 ac/1,000	572.5 6.40 ac/1,000	1.5 ac/1,000	4 ac/1,000						350
Special Use Facilities	118.4	118.4 .34 ac/1,000	0 .00 ac/1,000	.5 ac/1,000	.5 ac/1,000	10	20	15	30	10	40
All Parks (Subtotal)	2130.6	1449 4.17 ac/1,000	681.6 7.63 ac/1,000	4.65 ac/1,000	8.5 ac/1,000	120	270	125	210	110	610
Retention Basins (City maintained only)	424.4	243.4	181	Ratio of Total Parks/Open Space to 2000 Mesa Population = 6.69 ac/1,000							
Golf Courses (City-owned)	362.9	230.9	132								
Total Parks/Open Space	**2917.9**	**1923.3**	**994.6**								

Source: Mesa 2025 – A Shared Vision (June 2002)

WITH PROJECT CONDITIONS

Environmental Resources

The objective of this study was to develop alternatives that increased native riparian vegetation, increased vegetation connectivity, and stabilized bank sections, where necessary.

Fifteen overall alternatives have been developed, each with two irrigation options. The alternatives vary with respect to vegetation layout, river channelization, reshaping and method for distributing water. Levees, bank stabilization and water sources (groundwater and/or surface water) were also examined. These features can be applied to any of the alternatives and do not change the design of the vegetation or irrigation systems.

TABLE 24
Va Shly Ay Akimel
Environmental Restoration Alternatives

Alternative Name	Alternative Letter
LOAD	A
MEAD	B
HIAD	C
MINE	D
VHAD	E
F-MAX	F
CWAD	G
MSAD	H
CHNL	I
BRAD	J
NODL	K
POCK	L
WET	M
N-MAX	N
O-MAX	O

General Management Measures

Water Sources

There are five water sources for the project: 1) The surface water available for use by the Pima Maricopa Indian Community via existing water sources, 2) groundwater from existing and new wells, 3) storm water, 4) City of Mesa Wastewater Treatment Facility water, and 5) irrigation tailwater. The current alternatives rely primarily on surface water and groundwater from the Salt River Pima Maricopa Indian Community (SRPMIC) and effluent from the City of Mesa Wastewater Treatment Facility. Groundwater is considered a secondary source of water.

Water Distribution System

The water distribution system refers to the infrastructure needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, well, or effluent line) to the vegetated areas. Surface water from the SRPMIC will be the primary source of water.

Irrigation Techniques

Surface water from the storm water sources, irrigation canals and ditches will be diverted to various vegetated areas by a network of lined irrigation channels and buried pipes. To irrigate the vegetated areas it is recommended that either a Surface Braided Irrigation Network, (SBIN), flood irrigation, or drip irrigation be used.

Reshaping

Many of the alternatives require surface reshaping. Four types of reshaping categories are discussed in this project: 1) Channelization, 2) Surface Reshaping, 3) Vegetation Reshaping and 4) Irrigation Reshaping. Channelization is defined as the material moved in the process of constructing the 200 ft wide low flow channel. Surface Reshaping is defined as the material moved to alter significant features such as large mounds, filling quarry pits and reducing the side slopes of the quarry walls. Vegetation Reshaping is defined as minor reshaping required for planting purposes and to ensure that gravity irrigation systems will be feasible. Irrigation Reshaping is defined as the construction of irrigation and drainage ditches.

Vegetation

Five vegetation types were evaluated: 1) Cottonwood/Willow, 2) Mesquite, 3) Wetlands, 4) Sonoran Desert, and 5) River Bottom:

1) Cottonwood/Willow (CW) – CW stands are restricted to the near over bank area of streams and rivers, or other areas with saturated soil conditions. Due to the relative high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands will rely on flood irrigation or SBIN for its water needs.

2) Mesquite (MS) – MS are commonly found 5-20 feet above the river channel where water is adequate. A drip irrigation system may be necessary to establish the MS. However, once established, the MS will rely on a flood irrigation or SBIN for its water needs.

3) Wetland (WT) - WT areas can consist of open water, submerged vegetation or muddy shorelines, all requiring a high water table level at or near the surface. Due to the porous soils found in this project area, lining the WT will be required to maintain surface water. To distribute water from the WT laterally, a series of drainage ditches will be constructed from the WT and divert water to other areas that require irrigation. The WT will also be designed with an outlet channel leading to the main channel.

4) Sonoran Desert (SD) – The specific vegetation species can vary depending upon the site's soil aggregate type. However, proposed vegetation types will not require saturated soil conditions. The SD may need to be periodically inundated the first 1-5 yrs to establish the vegetation. Once established, SD should be sustained by annual precipitation or with periodic inundation, via flood irrigation, during extreme drought periods.

5) River Bottom (RB) - RB will require only surface reshaping, including partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. River bottom areas may also require hydro-seeding with a variety of native river bottom shrub species to help establish vegetation. These plants will be sustained with natural precipitation and any tail water that may enter the river from other feature irrigation systems. Irrigation is not required.

In addition to the planting of the vegetation, some reshaping may be necessary to provide the proper landscape to maintain and encourage the future propagation of the vegetation.

River Channelization

Some alternatives require segments of the Salt River to be channelized, offsetting the reduction in water conveyance, due to planting of vegetation within the main channel. The river bottom will be excavated to form a low flow channel with a bottom width of 200 ft, and 4 to 8 ft in depth. The channel will be free to migrate. The excavated material can be used to create benches along the channel, to fill quarry pits and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. Maintenance of the channel may be necessary after flow events. A two hundred foot buffer on both sides of the low flow channel will be incorporated to allow for the migration of the low flow channel.

Portions of the low flow channel will be designed with a semi impervious soil substrate to support wetland areas. It is recommended that Sonoran desert vegetation be planted along the low flow channel to increase stability of the overbank area.

Grade Control Structure

A grade control structure may be needed to protect the Gilbert Road Bridge due to the extensive mining that has occurred downstream of the bridge. Results indicate that the head cut could undermine the bridge and also damage features directly upstream of the quarry. The grade control structure would need to span the entire width of the riverbed and be designed to the estimated scour depth.

Bank Stabilization

Several areas require bank stabilization to protect commercial and culturally significant areas from channel erosion. Four general bank stabilization measures have been evaluated: 1) riprap, 2) buried groins, 3) bendway weirs (wingdams, groins), and 4) soil cement. The preferred method of bank stabilization is soil cement.

Description of Alternatives

Please refer to the Main Report for a detailed description of alternatives. In general:

- Alternatives A through C focus on xero-riparian vegetation, ranging from a minimal level of vegetation under Alternative A to an extensive amount under Alternative C.

- Alternatives D through F focus on meso-riparian vegetation, including a mix of cottonwood, mesquite and xero-riparian vegetation. Again, each successive alternative includes greater amounts of vegetation.

- Alternatives G and H feature extensive amounts of cottonwood and mesquite, respectively. In addition, both of the alternatives feature a braided channel network.

- Alternatives I through K focus on cottonwood vegetation. Alternative I also features a channelized stream. Alternatives J and K include more vegetation than Alternative I. The primary difference between Alternatives J and K is that Alternative J includes reshaping of sand and gravel mining operations within the channel, while Alternative K does not.

- Alternative L is focused on cottonwood and mesquite vegetation, with an emphasis on locating the vegetation in high visibility areas.
- Alternative M is the only hydro-riparian dominate alternative.
- Alternative N is a modification of Alternative F, but with reduced channel modifications.
- Alternative O is a modification of Alternative N, with added vegetation in the downstream reaches.
- For each alternative, two irrigation options were analyzed. Option 1 includes a drip irrigation system for each alternative, and Option 2 includes a braided irrigation network for each alternative. These options are distinguished in each alternative by the naming convention of A1, A2, B1, B2, etc.

Benefits of Alternatives

Based upon the individual features proposed for each alternative, the number of acres and functional capacity indices were projected in order to derive with-project estimates of average annual functional capacity units (AAFCUs). The same methodology as was employed for assessing without project conditions was also employed to assess the habitat output of each alternative. Benefits are defined as the increase in AAFCUs for each alternative relative to without project conditions. Table 25 shows the results. Note that benefits are assumed to be the same for the two irrigation options for each alternative, so separate benefit estimates are not shown.

TABLE 25
VA SHLY AY AKIMEL STUDY AREA
WITH PROJECT AVERAGE ANNUAL FUNCTIONAL CAPACITY UNITS (FCUs)

	Without Project	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H	Alt I	Alt J	Alt K	Alt L	Alt M	Alt N	Alt O
F1	689	1088	1250	1317	1114	1452	1368	1371	1362	1108	1280	1175	1204	1235	1288	1316
F2	955	1362	1578	1772	1589	1942	2084	1975	1860	1771	1902	1710	1839	1899	1977	2038
F3	72	383	636	863	683	954	1227	1051	1011	803	973	833	816	934	963	1023
F4	131	203	371	431	514	527	825	683	666	720	771	750	823	908	783	788
F5	805	1129	1227	1397	1326	1495	1658	1555	1398	1407	1522	1377	1476	1472	1617	1656
F6	726	1001	1095	1192	1080	1293	1313	1280	1187	1135	1234	1130	1202	1202	1291	1316
F7	701	1086	1322	1513	1323	1655	1804	1692	1659	1365	1602	1417	1453	1531	1613	1677
F8	1353	1922	2162	2368	2080	2578	2601	2530	2393	2105	2397	1881	2273	2306	2480	2546
F9	889	1423	1729	1954	1644	2157	2266	2146	2036	1655	2020	1509	1836	1913	2067	2131
F10	854	1308	1741	2081	1804	2379	2376	2321	2104	1861	2197	1668	1832	2066	2224	2309
Avg	718	1091	1311	1489	1316	1643	1752	1660	1568	1393	1590	1345	1475	1547	1630	1680
Increase	T0-T50	**373**	**594**	**771**	**598**	**926**	**1035**	**943**	**850**	**675**	**872**	**627**	**758**	**829**	**913**	**963**
Increase	PY1-PY50	**389**	**619**	**807**	**628**	**966**	**1084**	**986**	**891**	**707**	**914**	**658**	**792**	**867**	**955**	**1006**

1154

As shown on Table 25, the proposed alternatives result in increased AAFCUs (relative to without project conditions) ranging from 373 for Alternative A to 1,035 for Alternative F.

The above AAFCU values were calculated for the time period Target Year 0 (T0) through T50, with T0 being "base conditions" (prior to construction), and T1 being the first year of construction. Planning guidance specifies that benefits and costs for all alternatives should be analyzed over the same time period. For this study, a Base Year of 2011 was established based upon estimates of Feasibility Study completion, project authorization, and completion of engineering, design and construction. Construction is estimated to be completed within a three-year period for all alternatives. Therefore, T1 would correspond with three years prior to the Base Year, and T4 would correspond with the Base Year. AAFCUs were recalculated for the 50-year period commencing with the Base Year (PY1 through PY50), which corresponds with T4-T53. Although the results do not change significantly, it was deemed appropriate to make the adjustment for temporal consistency of benefits and costs. These results are shown in the last line of the table.

Cost Estimates

Tables 26 and 27 which follow show costs by alternative. Table 26 shows costs based upon a drip irrigation system (Option 1), while Table 27 shows costs based upon a braided irrigation system (Option 2). Table 28 shows a comparison of costs for the two water delivery systems.

TABLE 26
VA SHLY AY AKIMEL STUDY AREA
WITH PROJECT AVERAGE ANNUAL COSTS BY ALTERNATIVE (in $1,000s) - DRIP IRRIGATION OPTION

	Alt A1	Alt B1	Alt C1	Alt D1	Alt E1	Alt F1	Alt G1	Alt H1	Alt I1	Alt 1J1	Alt 1K1	Alt L1	Alt M1	Alt N1	Alt O1
Construction	$25,106	$62,128	$96,590	$91,796	$90,579	$155,599	$141,758	$144,398	$139,815	$101,980	$91,673	$86,282	$137,022	$89,927	$94,607
Contingency (25%)	$6,277	$15,532	$24,147	$22,949	$22,645	$38,900	$35,440	$36,100	$34,954	$25,495	$22,918	$21,571	$34,255	$22,482	$23,652
PED/EDC (11%)	$2,762	$6,834	$10,625	$10,098	$9,964	$17,116	$15,593	$15,884	$15,380	$11,218	$10,084	$9,491	$15,072	$9,892	$10,407
S&A (6.5%)	$1,632	$4,038	$6,278	$5,967	$5,888	$10,114	$9,214	$9,386	$9,088	$6,629	$5,959	$5,608	$8,906	$5,845	$6,149
Monitoring/Adaptive Mgmt.	$1,431	$3,541	$5,506	$5,232	$5,163	$8,869	$8,080	$8,231	$7,969	$5,813	$5,225	$4,918	$7,810	$5,126	$5,393
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	$46,930	$109,800	$164,853	$151,471	$158,795	$263,249	$236,021	$239,041	$221,502	$176,607	$160,037	$145,346	$227,197	$156,498	$165,157
IDC	$1,049	$4,452	$8,963	$8,226	$8,642	$21,762	$19,500	$19,746	$18,268	$9,607	$8,708	$7,899	$18,769	$8,515	$8,987
Gross Investment	$47,979	$114,252	$173,816	$159,697	$167,437	$285,011	$255,522	$258,787	$239,770	$186,214	$168,745	$153,246	$245,965	$165,013	$174,144
Annualized Invest. Cost	$2,886	$6,872	$10,455	$9,606	$10,071	$17,143	$15,369	$15,566	$14,422	$11,200	$10,150	$9,217	$14,794	$9,925	$10,474
Associated Cost (Water)	$93	$204	$347	$340	$426	$778	$533	$378	$461	$571	$591	$525	$608	$725	$801
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$266	$232	$231	$107	$229	$118	$131
Total Annual Cost	$3,035	$7,268	$11,042	$10,154	$10,726	$18,245	$16,172	$16,211	$15,151	$12,003	$10,971	$9,849	$15,631	$10,768	$11,406

TABLE 27
VA SHLY AY AKIMEL STUDY AREA
WITH PROJECT AVERAGE ANNUAL COSTS BY ALTERNATIVE (in $1,000s) - BRAIDED IRRIGATION OPTION

	Alt A2	Alt B2	Alt C2	Alt D2	Alt E2	Alt F2	Alt G2	Alt H2	Alt I2	Alt 1J2	Alt 1K2	Alt L2	Alt M2	Alt N2	Alt O2
Construction	$18,857	$50,120	$81,382	$82,485	$72,737	$134,040	$124,332	$127,527	$129,496	$85,777	$75,280	$73,203	$120,818	$72,451	$75,871
Contingency (25%)	$4,714	$12,530	$20,345	$20,621	$18,184	$33,510	$31,083	$31,882	$32,374	$21,444	$18,820	$18,301	$30,204	$18,113	$18,968
PED/EDC (11%)	$2,074	$5,513	$8,952	$9,073	$8,001	$14,744	$13,677	$14,028	$14,245	$9,435	$8,281	$8,052	$13,290	$7,970	$8,346
S&A (6.5%)	$1,226	$3,258	$5,290	$5,361	$4,728	$8,713	$8,082	$8,289	$8,417	$5,575	$4,893	$4,758	$7,853	$4,709	$4,932
Monitoring/Adaptive Mgt.	$1,075	$2,857	$4,639	$4,702	$4,146	$7,640	$7,087	$7,269	$7,381	$4,889	$4,291	$4,173	$6,887	$4,130	$4,325
Real Estate	$9,722	$17,727	$21,707	$15,429	$24,557	$32,651	$25,936	$25,043	$14,296	$25,472	$24,178	$17,477	$24,131	$23,226	$24,949
Total First Cost	$37,668	$92,004	$142,314	$137,671	$132,354	$231,299	$210,196	$214,037	$206,209	$152,593	$135,743	$125,964	$203,183	$130,598	$137,390
IDC	$844	$3,735	$7,744	$7,480	$7,212	$19,134	$17,376	$17,689	$17,010	$8,308	$7,394	$6,851	$16,793	$7,114	$7,485
Gross Investment	$38,512	$95,739	$150,058	$145,151	$139,566	$250,433	$227,572	$231,726	$223,219	$160,901	$143,137	$132,814	$219,976	$137,712	$144,875
Annualized Invest. Cost	$2,316	$5,759	$9,026	$8,731	$8,395	$15,063	$13,688	$13,938	$13,426	$9,678	$8,609	$7,989	$13,231	$8,283	$8,714
Associated Cost (Water)	$149	$326	$554	$544	$681	$1,246	$854	$605	$738	$913	$946	$840	$973	$1,160	$1,283
O&M	$57	$192	$241	$208	$229	$323	$270	$268	$268	$232	$231	$107	$229	$118	$131
Total Annual Cost	$2,522	$6,276	$9,821	$9,483	$9,304	$16,632	$14,812	$14,811	$14,432	$10,823	$9,786	$8,935	$14,433	$9,561	$10,127

TABLE 28
VA SHLY AY AKIMEL STUDY AREA
COMPARISON OF DRIP VS. BRAIDED IRRIGATION SYSTEM COSTS BY ALTERNATIVE (IN $1,000s)

	Alt A	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H	Alt I	Alt 1J	Alt 1K	Alt L	Alt M	Alt N	Alt O
Total First Cost															
Drip	$ 46,930	$ 109,800	$ 164,853	$ 151,471	$ 158,795	$ 263,249	$ 236,021	$ 239,041	$ 221,502	$ 176,607	$ 160,037	$ 145,346	$ 227,197	$ 156,498	$ 165,157
Braided	$ 37,668	$ 92,004	$ 142,314	$ 137,671	$ 132,354	$ 231,299	$ 210,196	$ 214,037	$ 206,209	$ 152,593	$ 135,743	$ 125,964	$ 203,183	$ 130,598	$ 137,390
Total O&M&Water Cost															
Drip	$ 150	$ 396	$ 587	$ 548	$ 654	$ 1,102	$ 803	$ 646	$ 729	$ 803	$ 822	$ 632	$ 837	$ 843	$ 932
Braided	$ 205	$ 518	$ 795	$ 752	$ 910	$ 1,569	$ 1,123	$ 873	$ 1,006	$ 1,145	$ 1,176	$ 947	$ 1,202	$ 1,278	$ 1,413
Total Annual Cost															
Drip	$ 3,035	$ 7,268	$ 11,042	$ 10,154	$ 10,726	$ 18,245	$ 16,172	$ 16,211	$ 15,151	$ 12,003	$ 10,971	$ 9,849	$ 15,631	$ 10,768	$ 11,406
Braided	$ 2,522	$ 6,276	$ 9,821	$ 9,483	$ 9,304	$ 16,632	$ 14,812	$ 14,811	$ 14,432	$ 10,823	$ 9,786	$ 8,935	$ 14,433	$ 9,561	$ 10,127

As shown on Table 28, first costs vary significantly among the alternatives, ranging from as low as $37.7 million for Alternative A2 (Alternative A, braided irrigation system), to $263.2 million for Alternative F1 (Alternative F, drip irrigation system). First costs are higher for the drip irrigation options, but associated (water supply) costs are lower. Average annual costs for the two options are fairly close for each alternative, but for each alternative, the braided irrigation system has lower expected annual costs.

Cost Effectiveness & Incremental Cost Analysis

Average Cost per Average Annual Function Capacity Unit

Table 29 summarizes average annual output and cost by alternative, as well as average annual cost per AAFCU.

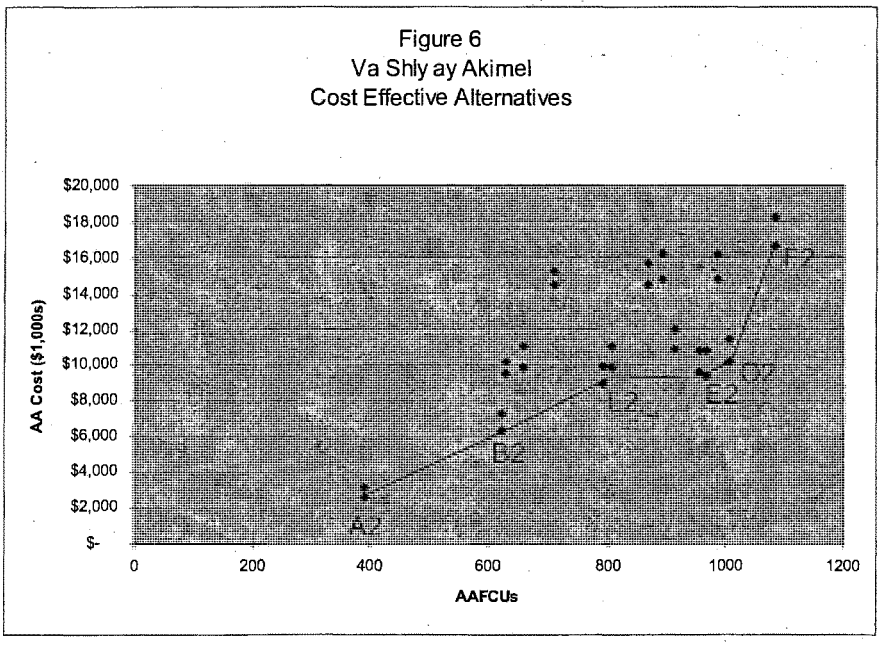
	AAFCU	AA COST	AAC/AAFCU
Alt A1	389	$ 3,035	$ 7.8
Alt A2	389	$ 2,522	$ 6.5
Alt B1	619	$ 7,268	$ 11.7
Alt B2	619	$ 6,276	$ 10.1
Alt C1	807	$ 11,042	$ 13.7
Alt C2	807	$ 9,821	$ 12.2
Alt D1	628	$ 10,154	$ 16.2
Alt D2	628	$ 9,483	$ 15.1
Alt E1	966	$ 10,726	$ 11.1
Alt E2	966	$ 9,304	$ 9.6
Alt F1	1084	$ 18,245	$ 16.8
Alt F2	1084	$ 16,632	$ 15.3
Alt G1	986	$ 16,172	$ 16.4
Alt G2	986	$ 14,812	$ 15.0
Alt H1	891	$ 16,211	$ 18.2
Alt H2	891	$ 14,811	$ 16.6
Alt I1	707	$ 15,151	$ 21.4
Alt I2	707	$ 14,432	$ 20.4
Alt J1	914	$ 12,003	$ 13.1
Alt J2	914	$ 10,823	$ 11.8
Alt K1	658	$ 10,971	$ 16.7
Alt K2	658	$ 9,786	$ 14.9
Alt L1	792	$ 9,849	$ 12.4
Alt L2	792	$ 8,935	$ 11.3
Alt M1	867	$ 15,631	$ 18.0
Alt M2	867	$ 14,433	$ 16.6
Alt N1	955	$ 10,768	$ 11.3
Alt N2	955	$ 9,561	$ 10.0
Alt O1	1006	$ 11,406	$ 11.3
Alt O2	1006	$ 10,127	$ 10.1

Cost Effectiveness Analysis

Alternatives are considered cost effective if there are not any other alternatives which provide greater output for the same cost or provide the same output for a lesser cost. This step eliminates alternatives that are inefficient from further consideration. Table 30 shows the cost effective plans.

	AAFCU	AA COST	AAC/AAFCU
A2	389	$ 2,522	$ 6.5
B2	619	$ 6,276	$ 10.1
L2	792	$ 8,935	$ 11.3
E2	966	$ 9,304	$ 9.6
O2	1006	$ 10,127	$ 10.1
F2	1084	$ 16,632	$ 15.3

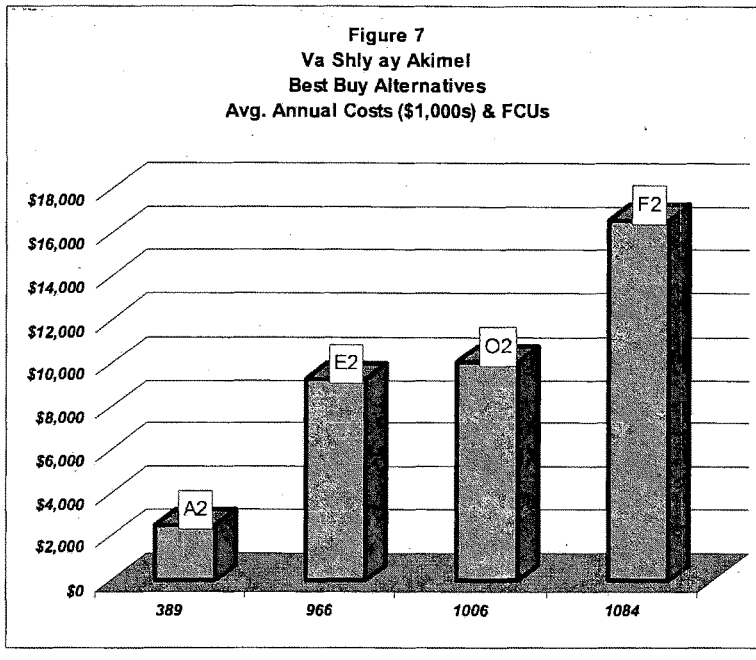
Table 30 (and Figure 6 below) shows that only six alternatives are cost effective.

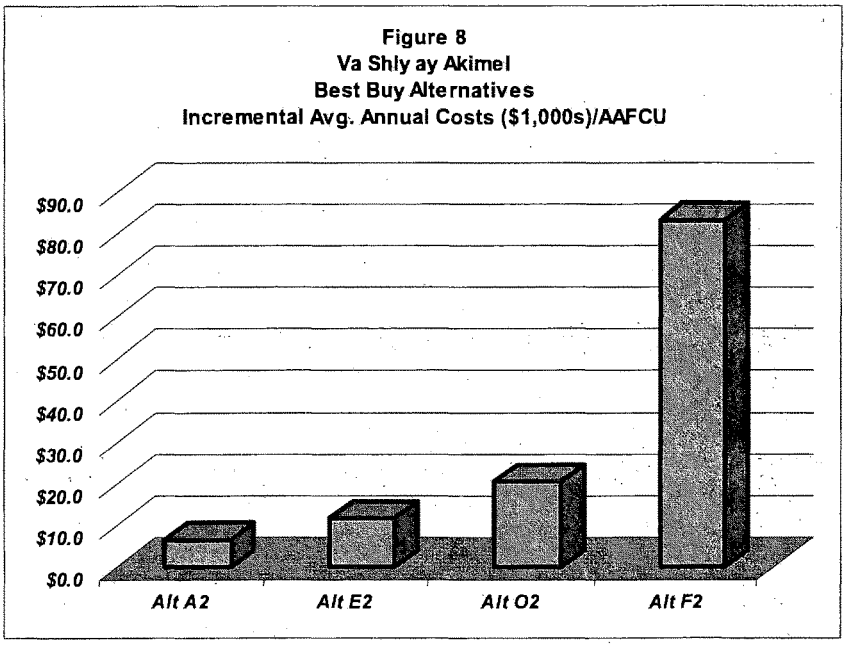


Incremental Cost Analysis

Incremental Cost Analysis goes beyond cost effectiveness analysis to identify "best buy" plans. Best Buy plans are those that have the lowest incremental average annual cost per incremental increase in output. Table 31 and Figures 7 and 8 show the results of the Incremental Cost Analysis.

	AAFCU	Incremental AAFCU	AA COST	Incremental AA Cost	Incremental AAC/AAFCU
Alt A2	389	389	$2,522	$2,522	$6.5
Alt E2	966	577	$9,304	$6,783	$11.8
Alt O2	1006	40	$10,127	$823	$20.6
Alt F2	1084	78	$16,632	$6,505	$83.4





Alternative A2 has the lowest average annual cost per AAFCU, and is therefore the first point on the ICA curve. ICA analysis then determines which alternative has the lowest incremental average annual cost (relative to Alternative A2) per incremental increase in output (relative to Alternative A2). Based upon this methodology, Alternative E2 is identified as the next Best Buy plan. Alternative E2 provides an increase of 577 AAFCUs for an additional average annual cost of about $6.8 million. The next Best Buy plan is Alternative O2, which provides an additional 40 AAFCUs relative to Alternative E2, for an additional average annual cost of $823,000. As the largest of all plans in terms of output, Alternative F2 is also shown on the final list of alternatives under the ICA analysis. However, this can be somewhat misleading, since this alternative is included because it serves as an "end point" and not because it is necessarily a good buy. For example, Alternative F2 only provides an extra 78 AAFCUs relative to Alternative O2, but has a 64 percent higher cost. As a result, the incremental AAC/AAFCU for Alternative F2 is equal to $83,400, which is more than four times higher than the incremental AAC/AAFCU for Alternative O2. Hence, from an ICA perspective, it would seem difficult to justify the additional costs for Alternative F2.

Although the above alternatives represent the best buys of the proposed alternatives, it should be pointed out that there are several alternatives that have similar output and cost to these alternatives. For example, Alternative N2 provides similar output and has similar costs relative to O2.

Recommended Ecosystem Restoration Plan

Based upon the CE/ICA analysis, Alternative O2 has been identified as the NER Plan. Although Alternative A2 has the lowest average annual cost per unit of output, it provides substantially lower environmental benefits than the other Best Buy plans. Alternatives E2, O2, and F2 all have similar output, and Alternatives E2 and O2 have similar average annual costs. However, Figure 8 clearly shows that the incremental costs associated

with Alternative F2 are very high relative to the other Best Buy plans, which is the basis for eliminating this alternative from further consideration.

While Alternative O2 only provides an extra 40 AAFCUs relative to Alternative E2, the additional cost was determined to be justified for reasons outlined in the Main Report. As shown in Table 31, the incremental average annual cost per incremental increase in output is estimated at $20,600. The Local Sponsors have also indicated that this is their preferred alternative, and therefore Alternative O2 is also designated as the Recommended Plan. Figure 9 shows the layout of the major features of the Recommended Plan. The following sections present detailed MCACES cost estimates for the Recommended Plan, as well as an analysis of with-project flood damages.

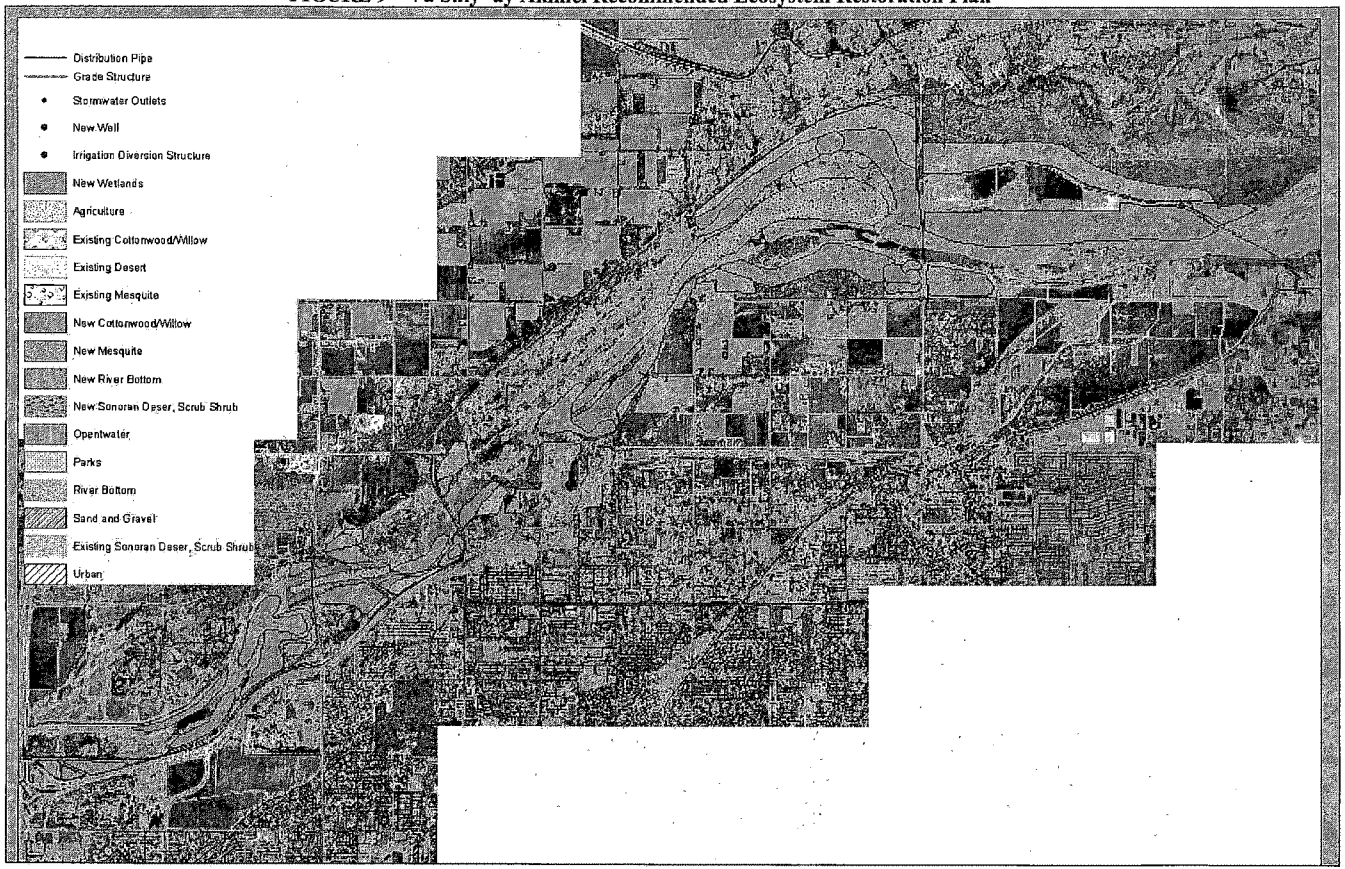
MCACES Cost Estimate

A more detailed estimate of construction costs was developed for the Recommended Plan utilizing the MCACES cost estimating software. The following table summarizes the results. It should also be noted that Monitoring, Adaptive Management and Real Estate costs were added to the construction costs to derive a Total First Cost estimate.

Table 32
Ve Shiy'ay Akimel
Detailed Cost Estimate
Recommended Plan (Alternative O2)
FY04 Price Levels, 5.5% Discount Rate

Low Flow Channel	$	1,401,000
Channel Reshaping	$	20,714,000
Wetland Features	$	24,911,000
Planting	$	4,163,000
Water Well	$	244,000
Grade Control Structure	$	7,323,000
Water Distribution System	$	1,282,000
Road Crossing	$	5,000
Planting Irrigation System	$	6,315,000
SRPMIC Irrigation Channel	$	43,000
Debris Removal	$	9,332,000
Cultural Mitigation	$	300,000
Construction Cost	$	76,033,000
Contingency (25%)	$	19,008,300
PE&D (10%)	$	7,603,300
EDC (1%)	$	760,300
S&A (6.5%)	$	4,942,100
Total Construction Cost	$	108,347,000
Monitoring & Adaptive Mgt. (4%)	$	4,334,000
Real Estate	$	24,949,400
Total First Cost (Rounded)	$	137,630,000
Interest During Construction	$	7,742,000
Gross Investment	$	145,372,000
Annualized Investment Cost	$	8,744,000
OMRR&R	$	131,000
Associated Cost (Water Supply)	$	1,283,000
Total Annual Cost	**$**	**10,158,000**

FIGURE 9 – Va Shly' ay Akimel Recommended Ecosystem Restoration Plan



Flood Damage Analysis

Ecosystem restoration alternatives were developed with the goal of maximizing environmental benefits without inducing flood damages. For the Recommended Plan, design considerations were incorporated to assure that flood damages would *at a minimum* be no higher than existing conditions. The following table shows with-project expected annual structure and content damages and damages reduced for the Recommended Plan for Base Year conditions.

Table 33
Via Shiya Akimel
With-Project Flood Damage Analysis (Structure & Content)
Base Year (in $1,000s)

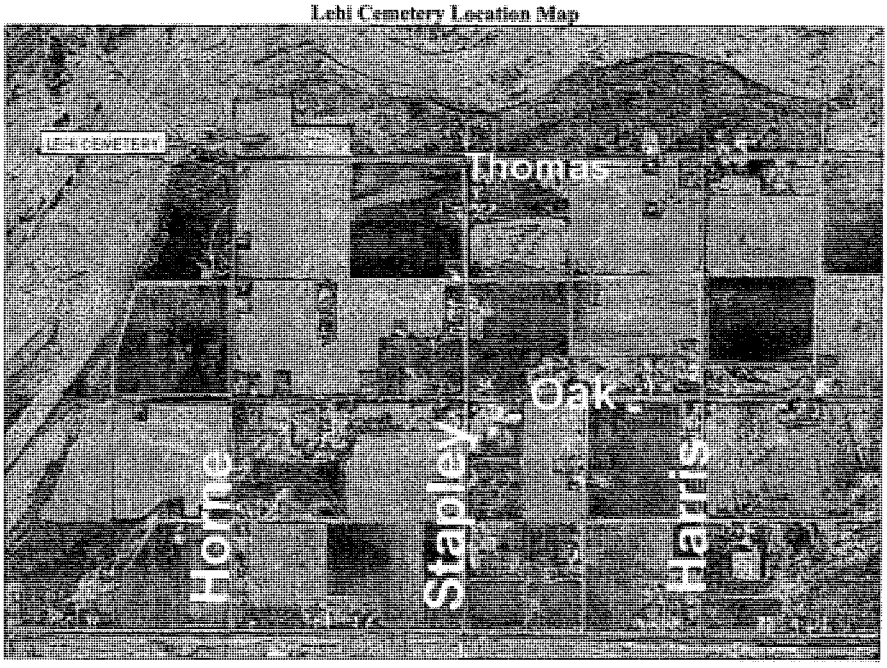
Reach	Structure & Content Without Project	With Project	Damages Reduced
2	$ 15.4	$ 12.1	$ 3.3
3	$ 108.3	$ 98.2	$ 10.1
6	$ 193.5	$ 174.6	$ 18.9
Total	$ 317.2	$ 284.9	$ 32.3

The analysis verifies that the Recommended Plan actually lowers Base Year flood damages marginally. Including other damage categories (e.g., emergency, cleanup, etc.), with-project expected annual flood damages for Base Year conditions are estimated to be about $38,000 less than under without project conditions. Future with-project damages have not been calculated. However, it is possible that future with-project damages could be higher than future without-project damages, since the Recommended Plan would reduce the channel degradation and erosion which are the primary factors that result in the expected decline in future without project damages.

Erosion Analysis

The Lehi Cemetery is located on SRP-MIC property on the south side of the Salt River just north of Thomas Road (see Figure 10).

Figure 10
Lehi Cemetery Location Map



Local sponsors have expressed concern that bank erosion occurring near the Lehi Cemetery will affect/damage the cemetery in the near future. To address these concerns, an engineering analysis was conducted to determine: 1) if there is erosion occurring at Lehi Cemetery; and 2) if so, at what rate is it occurring and how long will it take to impact the Lehi Cemetery.

1) Based on aerial photos from 1935 to 2002, the south bank has been migrating south, towards Lehi Cemetery. This migration can be attributed to flow events which have periodically occurred (on average once every three years) in the Salt River. Mining may have also contributed to the erosion.

2) Using the location of the bank line position from 1935 to 2000, the long-term erosion rate was estimated to be on average 11 ft/yr. This rate is dependent on the frequency, discharge and duration of flow events and also the channel geometry. Due to the current hydrologic condition (continuing drought conditions and increased storage in the Salt River Watershed) the erosion rate may be less. But to address the sponsors concerns it has been assumed that the future without project erosion rate is 11ft/yr. Based on this rate, Lehi Cemetery will be impacted by erosion in 33 years. That is, the south bank line will reach the cemetery in 33 years.

Given that the engineering analysis indicates that impacts from erosion are not projected to occur until more than 30 years in the future, conducting a detailed benefit/cost analysis is not warranted at this time. The discounted present value of the avoided costs would be very small, making it extremely difficult to economically justify any incremental expenditures specifically for the purpose of streambank erosion protection.

Recreation

The VSA project provides a unique opportunity to enhance resource-based recreation and environmental education. The restoration of the dry Salt River channel will bring a riparian open space feature to the rapidly expanding planning areas. Drawing on a population base of over three million in the metropolitan Phoenix area, it is estimated that visitation to the VSA project could be significant. Primary use times for this unique resource would coincide with the "visitor season" between October and May when temperatures are moderate.

The goal of the environmental education and recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of Salt Rivers on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the Study Area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle or horseback. Recognizing the diverse local society, the VSA project would employ design components ranging from areas adapted for special needs to multi-lingual signage.

Proposed Recreation Alternatives

Three recreational trail alternatives were developed. In addition to trailheads with small parking lots located approximately every four miles of trail length, all trail options include a larger parking lot and restroom facility, which would also feature utilities, lighting, a habitat interpretive center, picnic facilities, benches and signage. It should also be noted that the Local Sponsors have indicated a potential desire to locate a cultural center complex that may cost in excess of $10 million in the location designated for the parking and restroom facility. However, Federal cost sharing would be based upon the cost sharable options included in this analysis. More aggressive recreational components, such as lakes, sporting centers, parks, ball fields, etc. were rejected as out-of-harmony with the character of this project. Please refer to the Main Report for a detailed description of recreation alternatives.

Trail Option A In Option A, a trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. In Option A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete.

Trail Option B Option B is the same as Option A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive. This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly.

Trail Option C Option C includes all of the features of Option A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (Loop 101 Freeway) and Val Vista Drive. Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

All trails would be available for use by pedestrians, bicyclists and equestrians (i.e., "multi-use"). Motorized vehicles of all types would be prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

Major features planned for trail improvements include:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar
- Trail lined with boulders or curbing to define the trail location.
- Mileage markers.
- Plaques or similar markers at significant project features to educate the public relative to cultural, biological or environmental aspects of the project
- Concrete benches located approximately every quarter mile.
- Bike stop/ rest stations spaced approximately one per mile (perhaps overlooking significant project features and having the plaques or markers discussed above)
- Integral art that highlights the cultural, biological and/or environmental theme of the project (e.g., artwork incorporated into the design of such things as ramadas, bike racks, the trail surface, etc.)
- Signs at major mile cross streets

Benefit Analysis

National Economic Development benefits arising from recreation opportunities created by a project are measured in terms of aggregate willingness to pay. Corps Principles and Guidelines describes three techniques which have been developed to estimate recreation demand and value. They include: 1) the Travel Cost Method; 2) the Contingent Value Method; and 3) the Unit Day Method. The Unit Day method was the method chosen for this analysis.

The Unit Day method does not attempt to account for the impact of price on visitation to a recreation site. Instead, an assigned user day value is applied to the total number of estimated visitors. User day values are simulated market values judgmentally derived from a range of values agreed to by Federal water resource agencies. It is intended to represent the users average willingness to pay for a day of recreation activity at the site. When a properly formulated unit day value is applied to estimated use, an approximation of the area under the site demand curve is obtained, which is used in estimating recreation benefits.

A national schedule is available showing a range of values for both specialized and general recreation opportunities. A point rating system can be used to select a specific value from the published schedule of value ranges. Once alternatives have been formulated and recreation and environmental components identified and described, then unit day values can be selected with the input of Corps and local government agencies. These values are then applied to projected visitation.

Visitation Projections

National Recreation and Parks (NRPA) standards for trail capacity and use range from 40 to 90 users per day per trail mile (or between 14,600 to 32,850 users per year per trail mile). The City of Mesa has estimated an average annual use of 40 users per day (or 14,600 per year) per mile, based upon use of existing trail systems, proximity to existing development and the unique features of the proposed environmental restoration project. This ratio reflects an average of 30 users per day per mile for the summer months of June through September, and 45 users per day per mile during the remaining months. Visitation for each recreation option has been estimated by applying this visitation factor to the proposed length of trails.

Transfers of visitation from competing facilities are expected to be minimal due to the unique recreation opportunities and setting offered at the restoration site. The primary transfers are expected to be in the categories of education field trips, bird watchers, passive nature watchers, joggers and recreational cyclists.

Unit Day Point Value Estimates

Unit day values will be calculated by assigning points to each activity (based upon Federal guidelines) and then converting total points to dollar recreation values (per the conversion table included in Economic Guidance Memorandum 04-03). Point values are derived by ranking the potential recreation resource according to five different criteria:

Criteria	Key Variables	Range of Point Values
Recreation Experience	Number & type of activities	0-30
Availability of Opportunity	# of similar opportunities nearby	0-18
Carrying Capacity	Adequacy of facilities for activities	0-14
Accessibility	Ease of access to and within site	0-18
Environmental	Esthetic quality of site	0-20
Total		0-100

Based upon the total number of points assigned, UDV's (FY 04) can range from $3.00 to $9.01 per recreation day.

Separate UDV point values were derived for trail features (included in all options) and the cultural center (included in Options 3 and 4). The following shows the results.

Table 34
Va Stby ay Animas Recreation Analysis
Unit Day Value Assessment

Trails	General Rec.		
Criteria	Max Points	Total Points	Discussion
Recreation Experience	30	20	Several general recreational activities, e.g., hiking, bike riding, horseback riding, but in high quality setting
Availability of Opportunity	18	8	Several trail systems within a one hour travel time, but few in similar environment (e.g., Rio Salado Project)
Carrying Capacity	14	8	Adequate facilities to conduct recreation without deterioration of the resource
Accessibility	18	15	Good access to site provided by roads due to urban setting & links to existing parks
Environmental	20	15	High quality esthetic setting adjacent to environmental restoration project
	100	66	UDV Dollar Equivalent = $7.17

Based upon the visitation estimates and UDV values discussed above, Table 35 shows the expected annual benefits for each of the proposed recreation options.

Table 35 Va Shly ay Akimel Recreation Analysis Benefits By Alternative			
Benefits	1	2	3
Trails			
Trail Length	7.8	5.1	13.6
Avg Users/Mile (Oct-May)	45	45	45
Avg. Users/Mile (June-Sept)	30	30	30
Avg. Users/Mile/Year	14,600	14,600	14,600
Estimated Annual Visitation	113,442	74,898	199,144
Less Transfers (5%)	5,672	3,745	9,957
Estimated Annual Visitation	107,770	71,153	189,187
Unit Day Value	$ 7.17	$ 7.17	$ 7.17
Annual Benefits	**$ 772,495**	**$ 510,025**	**$ 1,356,091**

Recreation Costs & Benefit/Cost Analysis

Table 36 shows estimated costs for each recreation option. In addition, net benefits and benefit/cost ratios are also presented.

Table 36 Va Shly ay Akimel Recreation Analysis Costs By Alternative & Benefit/Cost Analysis			
Costs	1	2	3
Trail Length (Miles)	7.77	5.13	13.64
Trail Construction Cost	$ 1,227,303	$ 798,700	$ 2,121,783
Restrooms/Interpretive Center	$ 140,000	$ 140,000	$ 140,000
Total Construction Cost	$ 1,367,303	$ 938,700	$ 2,261,783
Contingency (25%)	$ 341,826	$ 234,675	$ 565,446
PED/EDC (11%)	$ 150,403	$ 103,257	$ 248,796
S&A (6.5%)	$ 88,875	$ 61,016	$ 147,016
Total First Cost	$ 1,948,400	$ 1,337,600	$ 3,223,000
IDC (1 Yr Const. Period)	$ 54,000	$ 37,100	$ 89,400
Gross Investment	$ 2,002,400	$ 1,374,700	$ 3,312,400
Annualized Investment Cost	$ 120,400	$ 82,700	$ 199,200
O&M*	$ 388,500	$ 256,500	$ 682,000
Total Annual Cost	$ 508,900	$ 339,200	$ 881,200
Annual Benefits	$ 772,500	$ 510,000	$ 1,356,100
Net Benefits	$ 263,600	$ 170,800	$ 474,900
Benefit/Cost Ratio	1.52	1.50	1.54

*** O&M Includes $50,000/mile of trail.*

Table 36 shows that each of the recreation options is economically justified.

ADDENDUM 1

AGRICULTURAL DAMAGE ANALYSIS

7-21-03
Revised

Agricultural Flood Damage Analysis For

Va Shly'Ay Akimel Salt River Restoration Project

Economic Section

INTRODUCTION

Purpose

The purpose of this section is for calculating National Economic Development (NED) benefits for agricultural flood damage reduction pertaining to the Va Shly' Ay Akimel Salt River Restoration Project. The method and procedures follows the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) and the manual on Agricultural Flood Damage (IWR Report 87-R-10).

Process

Crop Flood Damage Analysis Process

The major crops located in the project area consist of alfalfa, cotton, and citrus orchards. A small nursery tree farm exists in the project area, but of a limited exposure. The flood events of 50, 100, 200, and 500 –years were examined. The areas of these flood events are graphically mapped and outlined in the following map. The following table and map were provided by the City of Mesa, Arizona. The table shows the estimated agricultural acreages affected by the different flood events.

Table 1 – Crop Acreage

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

8/12/2002

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

The following map identifies the crops in the various fields. Description of the legends is as follows:

PF = Permanently fallow. The parcel has the appearance of being farmed some time in the past (5-10 year ago), but has not be farmed in the last few years. The land can be re-activated for farming at anytime.

R = Residential areas. These areas are not used for commercial farming. Some contain citrus trees, fruit trees, livestock, and home gardens but of commercial nature.

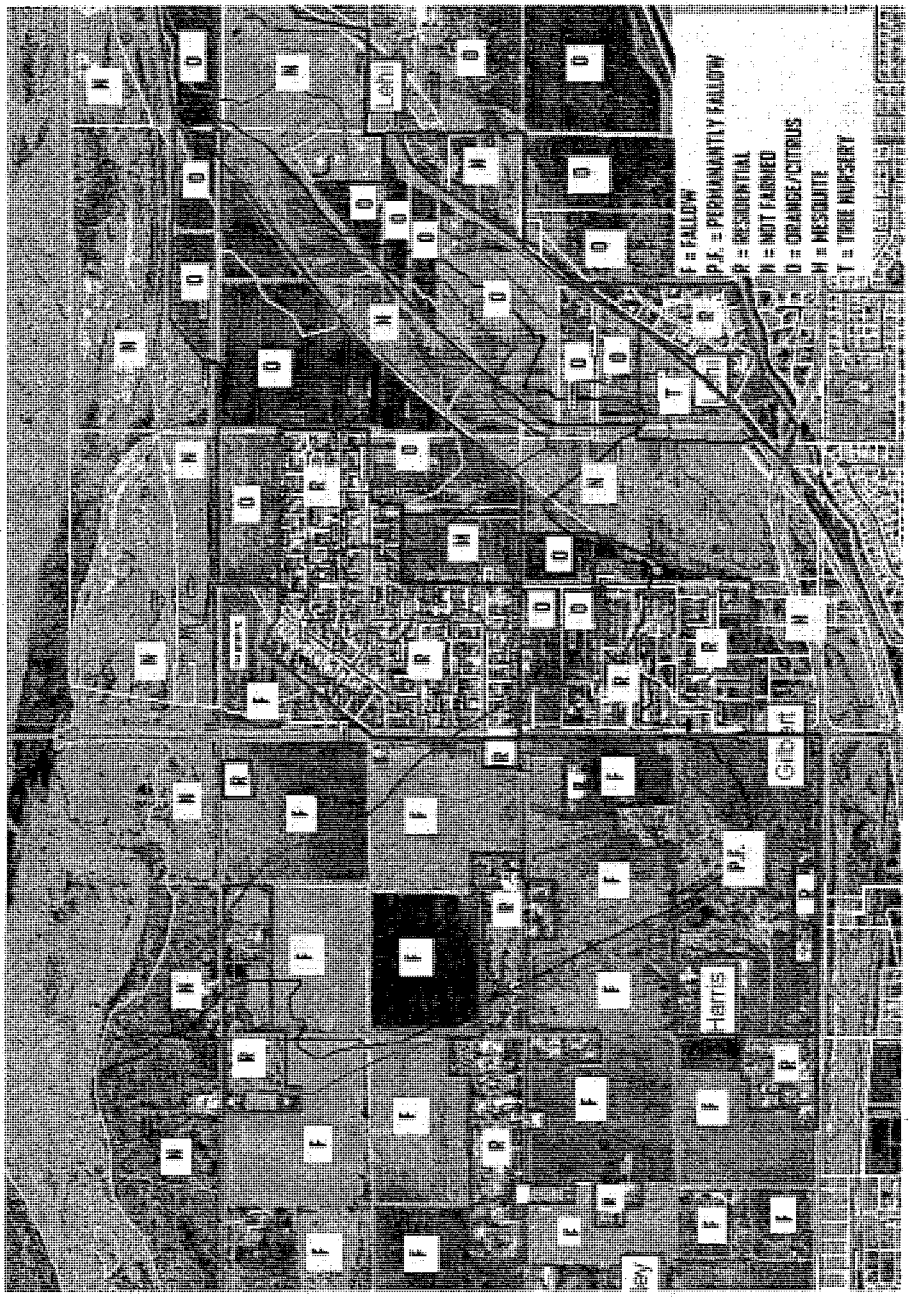
N = Not farmed. As described by Gordon Haws, these areas have not been farmed in the past few years nor at anytime within the past 15 years. This includes the land purchased for ongoing freeway extension.

O = Orange and/or other citrus grove areas.

M = Mesquite and other desert vegetation. Mentioned as used for cattle range land.

T = Tree nursery. A parcel of land used as a commercial nursery. The parcel contained trees of palm and citrus.

Figure 1 - Map of Flood Event Area



Analysis

Agricultural Crop Damage Function

Information has been collected from various resources in regards to production cost of the crops within the various flood plains (500, 200, 100, and 50 year). Separate crop budgets have been collected for alfalfa hay, cotton, and orange/grapefruit/lemon orchards in Maricopa County. Crop damage functions were estimated from these crop budgets and are presented here. For each crop budget the following was done:

- Establish Monthly Crop Budget and Flood Loss Potential
- Derive Cumulative Production Expenses subject to flood loss by dates
- Develop by date the damage function in dollars
- Graph the potential direct production loss (data from damage function).

This approach may under value the crop damages in that income/revenue losses are not accounted for initially. The market crop value method is more robust but tends the over value the crop damage losses. Also information has been obtained from the University of Arizona (Yuma Mesa Agriculture Center) regarding citrus costs, which substantiates and backups the results.

Table 2 – Harvest Season, Arizona

Crop	Period
Alfalfa Hay	April - September
Cotton	September – October
Grapefruit	August – December
Lemon	September – February
Valencias Oranges	February - June

Crop

Alfalfa Hay

Maricopa County

Table 3

Setup for Crop Budget and Flood Loss Potential
crop - alfalfa hay - maricopa co.
note to file: a difference between cash cost basis and total cost basis

Item	unit	quantity	price/unit	Total/acre
INCOME	ton	8.5	$98.10	$833.85

		Costs		Flood Loss Potential		
Production Item	Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	3.91	2.74	1.17	1.17	2.74	3.91
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	50.72		50.72	50.72		50.72
cash land prep & growing exp-water	112.5		112.5	112.5		112.5
cash land prep & growing exp-etc	66.09		66.09	66.09		66.09
Harvest Machinery						
cash harvest & post harvest exp	94.58	81.42	13.16		81.42	81.42
Harvest others						
cash harvest & post harvest exp-other mat.	23.83		23.83		0	0
harvest & post harvest exp-oper overhead-pickup	10.19		10.19		0	0
harvest & post harvest exp-oper interest at 10%	32.03		32.03		0	0
Labor						
cash land prep & growing exp	48.26		48.26	48.26	0	48.26
cash harvest & post harvest exp	39.65		39.65	0	0	0
Real Estate Taxes						
* land cost/ownership(100% equity) prop tax	13.98	13.98			13.98	13.98
Return to Land & Managemnet						
* cash overhead exp-taxes,housing,ins,farm mach	10.01	10.01			10.01	10.01
* cash overhead exp-gen&office (5% of t. oper exp)	24.09	24.09			24.09	24.09
* cash overhead exp-gen farm maint(3% of t oper exp)	14.45	14.45			14.45	14.45
* cap alloc(100% equity) -stand est(3yr crop)	110.89	110.89			110.89	110.89
* **cap alloc(100% equity)-cap repl,mach,vehicles**	**68.7**	68.7			68.7	68.7
* **cap alloc(100% equity)-int on equity,mach,veh**	**5.41**	5.41			5.41	5.41
* **land cost/ownership(100% equity) opp int. on land**	**37.14**	37.14			37.14	37.14
* land cost/ownership(100% equity) water assmt.	20	20			20	20
* **management ser (8% of total oper. Exp)**	**38.54**	38.54			38.54	38.54
Total (per acre)	824.97	427.37	397.6	278.74	427.37	706.11

* = ownership cost

file: crops.xls

Table 4

Cumulative production expenses subject to flood loss for alfalfa hay

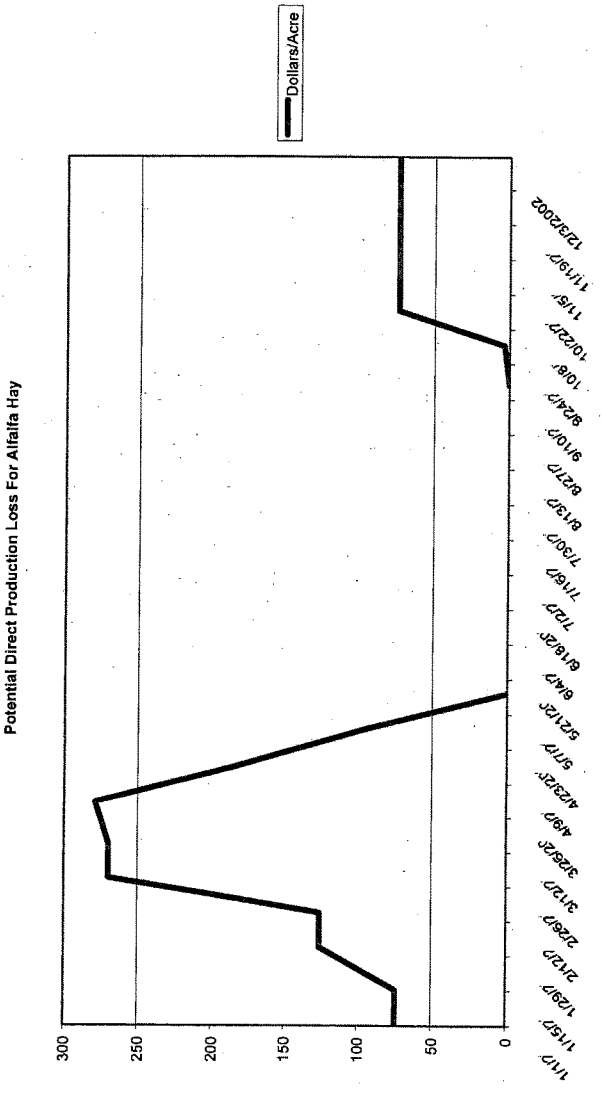
(Dollars per acre)

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
15-Sep	0.00				land preparation			
1-Oct	3.21				land preparation	renovate	3.21	3.21
15-Oct	74.40				planting	plant	71.19	74.4
1-Nov	74.40				growing			74.4
15-Nov	74.40				growing			74.4
1-Dec	74.40				growing			74.4
15-Dec	74.40				growing			74.4
1-Jan	74.40				growing			74.4
15-Jan	74.40				growing			74.4
1-Feb	125.72				growing	irrigate	51.32	125.72
15-Feb	125.72				growing			125.72
1-Mar	269.72				growing	irrigate, herbicide	144	269.72
15-Mar	269.72				growing			269.72
1-Apr	278.74				growing	apply insecticide, Air	11.76	281.48
15-Apr	185.83				harvest	swathing,ranking,baling,roadsiding	158.05	439.53
1-May	92.91							439.53
15-May	0.00							439.53
1-Jun								439.53
15-Jun								439.53
1-Jul								439.53
15-Jul								439.53
1-Aug								439.53
15-Aug								439.53
1-Sep								439.53
15-Sep								439.53
1-Oct								439.53
					pickup use		10.19	449.72
					oper int. at 10.0		32.03	481.75
								481.75
DPI=	278.74							481.75

Direct Production Investments

file: crops.xls

Figure 2


Potential Direct Production Loss For Alfalfa Hay
Dollars/Acre
300
250
200
150
100
50
0
1/1/2002
1/15/2002
1/29/2002
2/12/2002
2/26/2002
3/12/2002
3/26/2002
4/9/2002
4/23/2002
5/7/2002
5/21/2002
6/4/2002
6/18/2002
7/2/2002
7/16/2002
7/30/2002
8/13/2002
8/27/2002
9/10/2002
9/24/2002
10/8/2002
10/22/2002
11/5/2002
11/19/2002
12/3/2002

Crop

Cotton

Maricopa County

Table 5

Setup for Crop Budget and Flood Loss Potential

crop - cotton, Upland - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

Item	unit	quantity	price/unit	sub Total/acre	Total/acre
INCOME-lint	lb	1227	$0.58	$714.11	$869.99
cottonseed	ton	1.08	144.33	$155.88	

Production Item	Total	Costs Fixed	Variable	Flood Loss Potential Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	40.34	23.88	16.46	16.46	23.88	40.34
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	204.96		204.96	204.96		204.96
cash land prep & growing exp-water	30		30	30		30
cash land prep & growing exp-etc	33.84		33.84	33.84		33.84
Harvest Machinery						
cash harvest & post harvest exp	60.07	51.72	8.35		51.72	51.72
Harvest others						
cash harvest & post harvest exp-other chem	28.16		28.16		0	0
cash harvest & post harvest exp-custom H.&postH.	10.18		10.18		0	0
cash harvest & post harvest exp-cotton ginning	104.66		104.66		0	0
cash harvest & post harvest exp-crop assessment	8.98		8.98		0	0
harvest & post harvest exp-oper overhead-pickup	15.29		15.29		0	0
harvest & post harvest exp-oper interest at 10%	25.68		25.68		0	0
Labor						
cash land prep & growing exp	66		66	66	0	66
cash harvest & post harvest exp	22.33		22.33	0	0	0
Real Estate Taxes						
* land cost/ownership(100% equity) prop tax	13.98	13.98			13.98	13.98
Return to Land & Managemnet						
* cash overhead exp-taxes,housing,ins,farm mach	10.72	10.72			10.72	10.72
* cash overhead exp-gen&office (5% of t. oper exp)	32.52	32.52			32.52	32.52
* cash overhead exp-gen farm maint(3% of t oper exp)	19.51	19.51			19.51	19.51
* cap alloc(100% equity) -cash basis	0	0			0	0
* **cap alloc(100% equity)-cap repl,mach,vehicles**	**74.9**	74.9			74.9	74.9
* **cap alloc(100% equity)-int on equity,mach,veh**	**31.41**	31.41			31.41	31.41
* **land cost/ownership(100% equity) opp int. on land**	**37.14**	37.14			37.14	37.14
* land cost/ownership(100% equity) water assmt.	20	20			20	20
* **management ser (8% of total oper. Exp)**	**52.04**	52.04			52.04	52.04
Total (per acre)	942.71	367.82	574.89	351.26	367.82	719.08

* = ownership cost

Table 6

Cumulative production expenses subject to flood loss for cotton

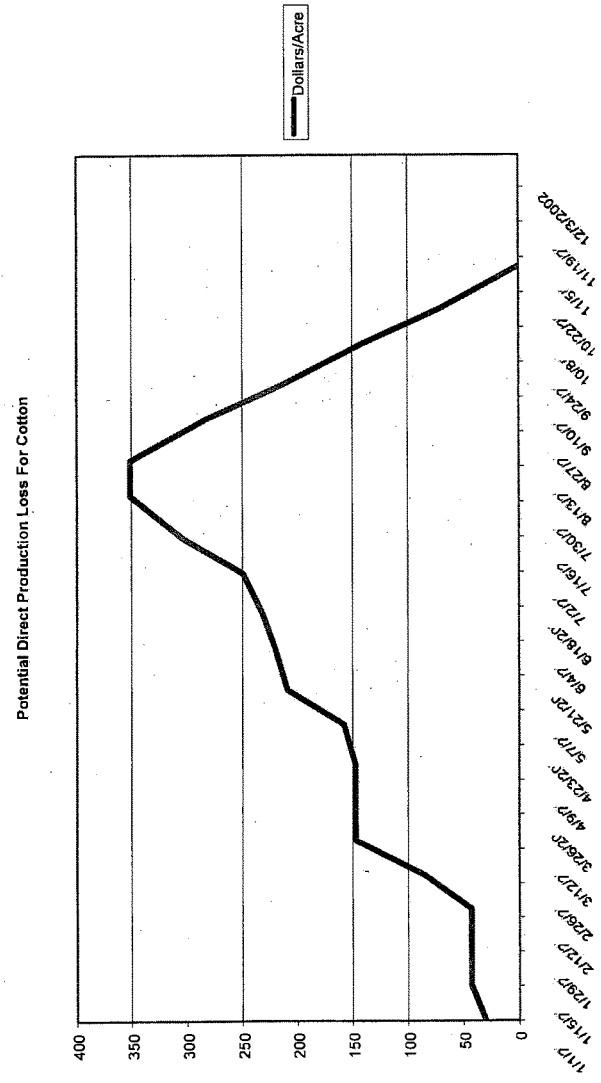
(Dollars per acre)

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	30.53				land preparation	rip,disk,landplane	30.53	30.53
15-Jan	43.08				land preparation	apply herb,list	12.55	43.08
1-Feb	43.08				land preparation			43.08
15-Feb	43.08				land preparation			43.08
1-Mar	86.03				land preparation	mulch,plant	42.95	86.03
15-Mar	147.17				growing	buck row, irrigate	61.14	147.17
1-Apr	148.01				growing	disk ends	0.84	148.01
15-Apr	148.01				growing			148.01
1-May	158.18				growing	Cultivate	10.17	158.18
15-May	209.26				growing	apply fert/ground	51.08	209.26
1-Jun	220.79				growing	hand week,apply insecticide	11.53	220.79
15-Jun	232.14				growing	apply growth regulator	11.35	232.14
1-Jul	249.49				growing	apply insecticide	17.35	249.49
15-Jul	303.75				growing	apply insecticide	54.26	303.75
1-Aug	351.26				growing	apply insecticide	54.25	358
15-Aug	351.26				growing/harvest	apply defoliant/air spray	31.16	389.16
1-Sep	281.01				harvest	apply defoliant/air spray	7.71	396.87
15-Sep	210.76				harvest			396.87
1-Oct	140.50				harvest	prepare ends	0.96	397.83
15-Oct	70.25				harvest	cotton,first pick,make modules	53.49	451.32
1-Nov	0.00				harvest/post	cotton,second pick,haul,ginning	130.29	581.61
15-Nov					harvest/post	cotton second pick,rood	5.38	586.99
1-Dec					harvest/post	classing,assessment,cut stalks	16.11	603.1
15-Dec					land preparation	disk residue	6.41	609.51
								609.51
					pickup use		15.29	624.8
					oper int. at 10.0		25.68	650.48

DPI= 351.26

Direct Production Investment

Figure 3


Potential Direct Production Loss For Cotton
Dollars/Acre
400
350
300
250
200
150
100
50
0
1/1P
1/15P
1/29P
2/12P
2/26P
3/12P
3/26P
4/9P
4/23P
5/7P
5/21P
6/4P
6/18P
7/2P
7/16P
7/30P
8/13P
8/27P
9/10P
9/24P
10/8P
10/22P
11/5P
11/19P
12/3P2002

Crop

Citrus – Grapefruit

Maricopa County

Table 7

Setup for Crop Budget and Flood Loss Potential

crop - citrus (generic- template Texas citrus - mature 10th yr) - Mature Grapefruit orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

THIS IS ONLY ILLUSTRATIVE				sub	
Item	unit	quantity	price/unit	Total/acre	Total/acre
INCOME-grapefruit	ton	23	$125.00	$2,875.00	$2,875.00

		Costs			Flood Loss Potential		
Production Item		Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery							
cash land prep & growing exp		0	0	0	0	0	0
Seed/Chemicals/etc.							
cash land prep & growing exp-chem		627.5		627.5	627.5		627.5
cash land prep & growing exp-water		56		56	56		56
cash land prep & growing exp-etc(int.)		65.19		65.19	65.19		65.19
Harvest Machinery							
cash harvest & post harvest exp	1.35	0	0	0		0	0
Harvest others							
cash harvest & post harvest exp-other chem		0		0		0	0
cash harvest & post harvest exp-custom H.&postH.		0		0		0	0
cash harvest & post harvest exp-halding		160		160		0	0
cash harvest & post harvest exp-crop assessment		0		0		0	0
harvest & post harvest exp-oper overhead-pickup		0		0		0	0
harvest & post harvest exp-oper interest at 10%		0		0		0	0
Labor							
cash land prep & growing exp		66.5		66.5	66.5	0	66.5
cash harvest & post harvest exp		640		640	0	0	0
Real Estate Taxes							
* land cost/ownership(100% equity) prop tax		186.09	186.09			186.09	186.09
Return to Land & Managemnet							
* cash overhead exp-taxes,housing,ins,farm mach		115	115			115	115
* cash overhead exp-gen&office		35	35			35	35
* cash overhead exp-gen farm maint(3% of t oper exp)		0	0			0	0
* cap alloc(100% equity) -cash basis		0	0			0	0
* **cap alloc(100% equity)-cap repl,mach,vehicles**		**43.42**	43.42			43.42	43.42
* **cap alloc(100% equity)-int on equity,mach,veh**		**0**	0			0	0
* **land cost/ownership(100% equity) perennial crop**		**186.53**	186.53			186.53	186.53
* land cost/ownership(100% equity) water assmt.		0	0			0	0
* **management ser (8% of total oper. Exp)**		**0**	0			0	0
Total (per acre)		2181.23	566.04	1615.19	815.19	566.04	1381.23

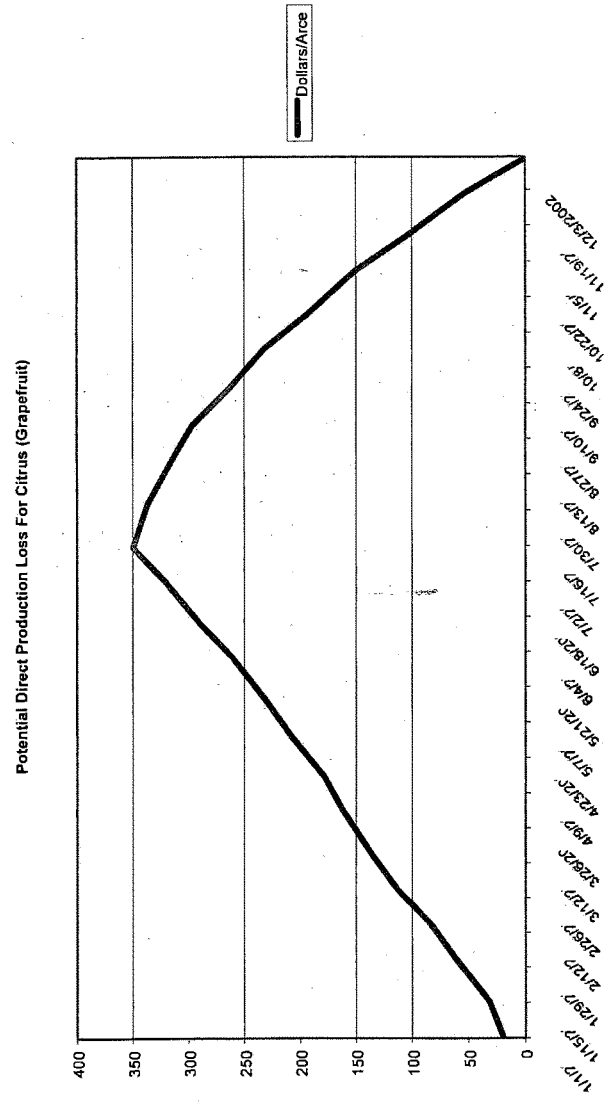
* = ownership cost

Table 8

Cumulative production expenses subject to flood loss
for citrus-Grapefruit per az ext.
(Dollars per acre) 815.19

Date	Full Season	Early Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	19.38			open	water,sprayingPOF,i	19.38	19.38
15-Jan	31.42			open	sprayingPOF ,i	12.04	31.42
1-Feb	61.25			growing	fertilizing,water, sprayingHPOF,i	29.83	61.25
15-Feb	83.75			growing	fertilizing, sprayingHPOF,i	22.50	83.75
1-Mar	113.58			growing	fertilizing,water, sprayingHPOF,i	29.83	113.58
15-Mar	136.08			growing	fertilizing, sprayingHPOF,i	22.50	136.08
1-Apr	160.79			growing	fertilizing,water, sprayingPOF,i	24.71	160.79
15-Apr	178.17			growing	fertilizing, sprayingPOF,i	17.38	178.17
1-May	208.00			growing	fertilizing,water, sprayingSPOF,i	29.83	208.00
15-May	230.50			growing	fertilizing, sprayingSPOF,i	22.50	230.50
1-Jun	260.33			growing	fertilizing,water, sprayingSPOF,i	29.83	260.33
15-Jun	290.17			growing	fertilizing,water, sprayingSPOF,i	29.83	290.17
1-Jul	320.00			growing	fertilizing,water, sprayingSPOF,i	29.83	320.00
15-Jul	349.83			growing	fertilizing,water, sprayingSPOF,i	29.83	349.83
1-Aug	336.90			growing/harvest	water, sprayingSPOF,i	24.50	374.33
15-Aug	319.07			growing/harvest	water, sprayingSPOF,i	24.50	398.83
1-Sep	296.33			growing/harvest	water, sprayingSPOF,i	24.50	423.33
15-Sep	264.30			growing/harvest	sprayingSPOF,i	17.17	440.50
1-Oct	232.50			growing/harvest	water, sprayingSPOF,i	24.50	465.00
15-Oct	192.87			growing/harvest	sprayingSPOF,i	17.17	482.17
1-Nov	150.46			growing/harvest	water, sprayingPOF,i	19.38	501.54
15-Nov	102.72			growing/harvest	sprayingPOF,i	12.04	513.58
1-Dec	53.30			growing/harvest	water, sprayingPOF,i	19.38	532.96
15-Dec	0.00			growing/harvest	sprayingPOF,i	12.04	545.00
							545.00
				pickup use		7.00	552.00
				oper int. at 10.0		23.00	575.00
					sprayingH = preemerge herbicide		
					sprayingS = spot herbicide		
					sprayingP = Pesticide		
					sprayingF = Fungicides		
					i = interest		
DPI=					sprayingO = other chemicals		
Direct Production Investment				file:	crops.xls		

Figure 4


Potential Direct Production Loss For Citrus (Grapefruit)
Dollars/Arce
400
350
300
250
200
150
100
50
0
1/1/P
1/15/P
1/29/P
2/12/P
2/26/P
3/12/P
3/26/ZE
4/9/P
4/23/ZE
5/7/P
5/21/ZE
6/4/P
6/18/ZE
7/2/P
7/16/P
7/30/P
8/13/P
8/27/P
9/10/P
9/24/P
10/8/P
10/22/P
11/5/P
11/19/P
12/3/ZE02

Crop

Citrus – Lemon

Maricopa County

Table 9

Setup for Crop Budget and Flood Loss Potential

crop - citrus (fr AZ univ ext cost of prod maricopa co) - Mature lemon orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

PLEASE NOTE THIS DOES NOT INCLUDE HARVESTING COST

Item	unit	quantity	price/unit	sub Total/acre	Total/acre
INCOME-lemon	cartons	310	$4.05	$1,255.50	$1,255.50

	Costs			Flood Loss Potential		
Production Item	Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	87	0	0	0	0	0
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	295		295	295		295
cash land prep & growing exp-water	56		56	56		56
cash land prep & growing exp-etc(int.)	0		0	0		0
Harvest Machinery - Excluded - cost by harvesting company						
cash harvest & post harvest exp	0	0	0		0	0
Harvest others - Excluded - cost by harvesting company						
cash harvest & post harvest exp-other chem	0		0		0	0
cash harvest & post harvest exp-custom H.&postH.	0		0		0	0
cash harvest & post harvest exp-halding	0		0		0	0
cash harvest & post harvest exp-crop assessment	0		0		0	0
harvest & post harvest exp-oper overhead-pickup	0		0		0	0
harvest & post harvest exp-oper interest at 10%	0		0		0	0
Labor						
machine operations	48		48	48	0	48
Irrigation	54		54	0	0	0
other labor,Hand	26					
Real Estate Taxes (or rent)						
land cost/ownership(100% equity) prop tax	200	200			200	200
Return to Land & Managemnet						
cash overhead exp	41	41			41	41
cash overhead exp-gen&office	0	0			0	0
cash overhead exp-gen farm maint(3% of t oper exp)	0	0			0	0
cap alloc(100% equity) -cash basis	0	0			0	0
cap alloc(100% equity)-cap repl,mach,vehicles	**52**	52			52	52
cap alloc(100% equity)-int on equity,mach,veh	**0**	0			0	0
land cost/ownership(100% equity) perennial crop	**0**	0			0	0
land cost/ownership(100% equity) water assmt.	0	0			0	0
management serices	**46**	46			46	46
Total (per acre)	905	339	453	399	339	738
oper int and pickup use	31					
file: crops.xls	936					

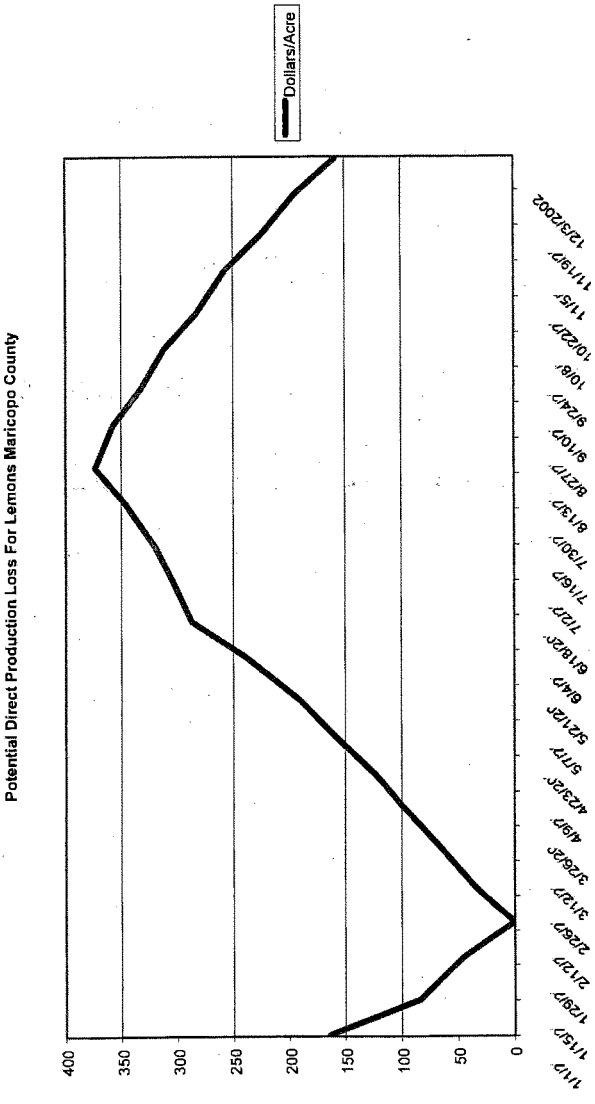
Table 10

Cumulative production expenses subject to flood loss
for Lemon per az ext. & UCCE Riverside Cnty templete

(Dollars per acre) 815.19

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	163.85				growing/harvest	water,sprayingPO	16.38	491.54
15-Jan	83.43				growing/harvest	sprayingPO	9.04	500.58
1-Feb	44.75				growing/harvest	water,sprayingPOH	36.38	536.96
15-Feb	0.00				growing/harvest	sprayingPOH	29.04	566.00
1-Mar	34.38				open	water,sprayingPOF	34.38	34.38
15-Mar	61.42				open	sprayingPOF	27.04	61.42
1-Apr	95.79				growing	water,sprayingPOF	34.38	95.79
15-Apr	122.83				growing	sprayingPOF	27.04	122.83
1-May	160.46				growing	water,sprayingPO,fertilizing	37.63	160.46
15-May	190.75				growing	sprayingPO,fertilizing	30.29	190.75
1-Jun	238.88				growing	water,sprayingPOS,fertilizing	48.13	238.88
15-Jun	287.00				growing	water,sprayingPOS,fertilizing	48.13	287.00
1-Jul	303.38				growing	water,sprayingPO	16.38	303.38
15-Jul	319.75				growing	water,sprayingPO	16.38	319.75
1-Aug	346.63				growing	water,sprayingPOS	26.88	346.63
15-Aug	373.50				growing	water,sprayingPOS	26.88	373.50
1-Sep	357.39				growing/harvest	water,sprayingPO	16.38	389.88
15-Sep	332.43				growing/harvest	sprayingPO	9.04	398.92
1-Oct	311.47				growing/harvest	water,sprayingPO	16.38	415.29
15-Oct	282.89				growing/harvest	sprayingPO	9.04	424.33
1-Nov	257.08				growing/harvest	water,sprayingPO	16.38	440.71
15-Nov	224.88				growing/harvest	sprayingPO	9.04	449.75
1-Dec	194.22				growing/harvest	water,sprayingPO	16.38	466.13
15-Dec	158.39				growing/harvest	sprayingPO	9.04	475.17
		note formulas in harvest period					566.00	566.00
					pickup use		7.00	573.00
					oper int. at 10.0		24.00	597.00
						sprayingH = preemerge herbicide		
						sprayingS = spot herbicide		
						sprayingP = Pesticide(insecticide)		
						sprayingF = Fungicides		
						i = interest		
DPI=						sprayingO = other chemicals		
Direct Production Investment					file:	crops.xls		

Figure 5


Potential Direct Production Loss For Lemons Maricopa County
Dollars/Acre
400
350
300
250
200
150
100
50
0
1/1/P
1/15/P
1/29/P
2/12/P
2/26/P
3/12/P
3/26/P
4/9/P
4/23/P
5/7/P
5/21/P
6/4/P
6/18/P
7/2/P
7/16/P
7/30/P
8/13/P
8/27/P
9/10/P
9/24/P
10/8/
10/22/P
11/5/
11/19/P
12/3/2002

Crop

Citrus – Valencias Oranges

Maricopa County

Table 11

Setup for Crop Budget and Flood Loss Potential

crop - citrus (fr AZ univ ext cost of prod maricopa co) - Mature Valencias Orange orchard production - maricopa co.

note to file: a difference between cash cost basis and total cost basis , item have been made bold.

PLEASE NOTE THIS DOES NOT INCLUDE HARVESTING COST sub

Item	unit	quantity	price/unit	Total/acre	Total/acre
INCOME-valencias orange	cartons	460	$3.30	$1,518.00	$1,518.00

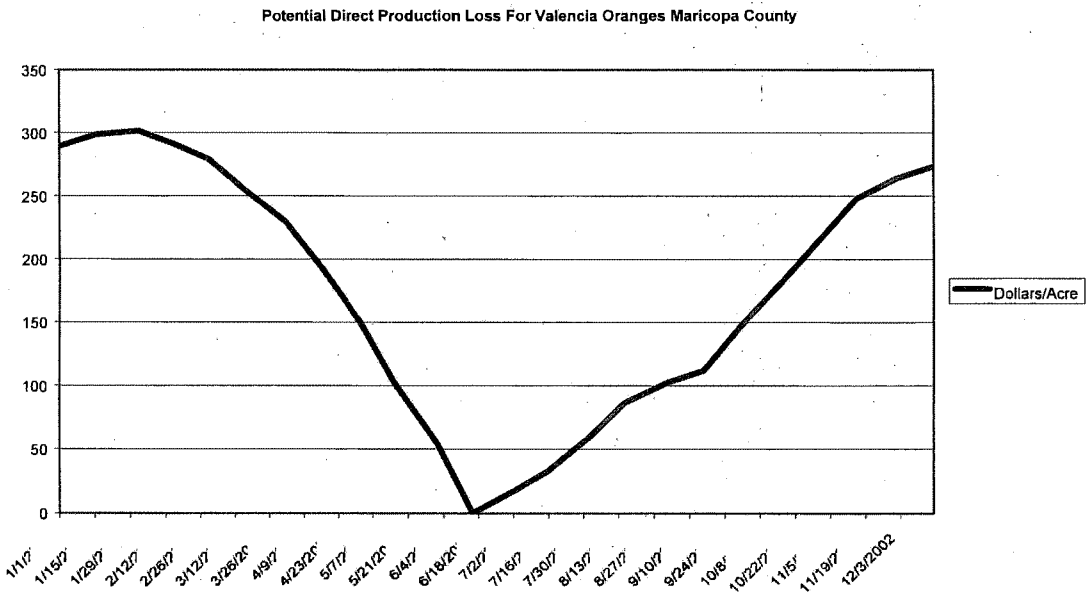
		Costs		Flood Loss Potential		
Production Item	Total	Fixed	Variable	Direct costs	Income Loss	Total
Preharvest Machinery						
cash land prep & growing exp	87	0	0	0	0	0
Seed/Chemicals/etc.						
cash land prep & growing exp-chem	295		295	295		295
cash land prep & growing exp-water	56		56	56		56
cash land prep & growing exp-etc(int.)	0		0	0		0
Harvest Machinery - Excluded - cost by harvesting company						
cash harvest & post harvest exp	0	0	0		0	0
Harvest others - Excluded - cost by harvesting company						
cash harvest & post harvest exp-other chem	0		0		0	0
cash harvest & post harvest exp-custom H.&postH.	0		0		0	0
cash harvest & post harvest exp-halding	0		0		0	0
cash harvest & post harvest exp-crop assessment	0		0		0	0
harvest & post harvest exp-oper overhead-pickup	0		0		0	0
harvest & post harvest exp-oper interest at 10%	0		0		0	0
Labor						
machine operations	48		48	48	0	48
Irrigation	54		54	0	0	0
other labor,Hand	26					
Real Estate Taxes (or rent)						
land cost/ownership(100% equity) prop tax	200	200			200	200
Return to Land & Managemnet						
cash overhead exp	41	41			41	41
cash overhead exp-gen&office	0	0			0	0
cash overhead exp-gen farm maint(3% of t oper exp)	0	0			0	0
cap alloc(100% equity) -cash basis	0	0			0	0
cap alloc(100% equity)-cap repl,mach,vehicles	**52**	52			52	52
cap alloc(100% equity)-int on equity,mach,veh	**0**	0			0	0
land cost/ownership(100% equity) perennial crop	**0**	0			0	0
land cost/ownership(100% equity) water assmt.	0	0			0	0
management serices	**46**	46			46	46
Total (per acre)	905	339	453	399	339	738
oper int and pickup use	31					
file: crops.xls	936					

Table 12

Cumulative production expenses subject to flood loss
for Valencia Oranges per az ext. & UCCE Riverside Cnty templete
(Dollars per acre) 815.19

Date	Full Season	Early Replant	Replant	Late Replant	notes => Usual Plantng	description operation	total cash expenses	culum expenses
1-Jan	289.54				growing	water,sprayingPO	16.38	289.54
15-Jan	298.58				growing	sprayingPO	9.04	298.58
1-Feb	301.46				growing/harvest	water,sprayingPOH	36.38	334.96
15-Feb	291.20				growing/harvest	sprayingPOH	29.04	364.00
1-Mar	278.86				growing/harvest	water,sprayingPOF	34.38	398.38
15-Mar	255.25				growing/harvest	sprayingPOF	27.04	425.42
1-Apr	229.90				growing/harvest	water,sprayingPOF	34.38	459.79
15-Apr	194.73				growing/harvest	sprayingPOF	27.04	486.83
1-May	150.96				growing/harvest	water,sprayingPO	16.38	503.21
15-May	102.45				growing/harvest	sprayingPO	9.04	512.25
1-Jun	53.91				growing/harvest	water,sprayingPOS	26.88	539.13
15-Jun	0.00				growing/harvest	water,sprayingPOS	26.88	566.00
1-Jul	16.38				open	water,sprayingPO	16.38	16.38
15-Jul	32.75				open	water,sprayingPO	16.38	32.75
1-Aug	59.63				growing	water,sprayingPOS	26.88	59.63
15-Aug	86.50				growing	water,sprayingPOS	26.88	86.50
1-Sep	102.88				growing	water,sprayingPO	16.38	102.88
15-Sep	111.92				growing	sprayingPO	9.04	111.92
1-Oct	149.54				growing	water,fertilizing,sprayingPO	37.63	149.54
15-Oct	179.83				growing	fertilizing,sprayingPO	30.29	179.83
1-Nov	217.46				growing	water,fertilizing,sprayingPO	37.63	217.46
15-Nov	247.75				growing	fertilizing,sprayingPO	30.29	247.75
1-Dec	264.13				growing	water,sprayingPO	16.38	264.13
15-Dec	273.17				growing	sprayingPO	9.04	273.17
	note formulas in harvest period						566.00	566.00
					pickup use		7.00	573.00
					oper int. at 10.0		24.00	597.00
						sprayingH = preemerge herbicide		
						□prayings = spot herbicide		
						sprayingP = Pesticide(insecticide)		
						sprayingF = Fungicides		
						I = interest		
						sprayingO = other chemicals		
					file:	crops.xls		

Figure 6


Potential Direct Production Loss For Valencia Oranges Maricopa County
350
300
250
200
150
100
50
0
1/1/?
1/15/?
1/29/?
2/12/?
2/26/?
3/12/?
3/26/2?
4/9/?
4/23/2?
5/7/?
5/21/2?
6/4/?
6/18/2?
7/2/?
7/16/?
7/30/?
8/13/?
8/27/?
9/10/?
9/24/?
10/8/
10/22/?
11/5/
11/19/?
12/3/2002
Dollars/Acre

Estimation of Crop Damages and Benefits

The actual crop damages will be estimated using normalized prices to smooth out the effects of short-term fluctuation and provide a more realistic basis for the evaluation of the project. The table of normalized prices for the state of Arizona is shown along with a table showing the historical prices for crops of cotton, alfalfa (hay), and citrus orchards (oranges and grapefruits)

Table 13 – Normalized Prices

Arizona

Va Shly' Akimel Salt River Restoration Project

Year	Hay All Baled per Ton	Cotton Lint Upland per pounds	Oranges per Box	Lemons per Box *	Grapefruit per Box
2002	$98.10	$0.582	$8.89	not available	$4.44
2001	$97.22	$0.613	$9.16	not available	$4.58
2000	$94.64	$0.693	$9.36	$7.46	$4.60
1999	$90.96	$0.675	$5.74	$6.67	$4.20

* not normalized, source:USDA Arizona - at packinghouse door

source: The Economic Research Service (ERS)

Table 14 - Crop Prices

Cotton – AZ – pound	$0.582
Hay (Baled) – Ton	$98.10
Oranges – AZ – Box	$8.89
Grapefruit – AZ – Box	$4.44

Tables on Market Values and Direct Production Losses

The numbers in the following tables are based upon the **total estimated crop acres** in the Va Shly' Ay Akimel Salt River Restoration Project. Numbers have not been discounted but used normalized prices and current estimates of citrus and nursery tree values.

Table 15 - Market Value Analysis

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

Table 16 - Market Values per Acre

Estimate of Crop Mkt. Values Per Acre in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm
50	$870	$834	$6,840	0.0
100	$870	$834	$6,840	0.0
200	$870	$834	$6,840	$104,544
500	$870	$834	$6,840	$104,544

* 152 trees per acre, each tree $45

one acre = 43,560 square feet w eff usage at 60% w 1 gal = 1tree @$4.00

NOTE a tree ready for planting valued at $8.00

Table 17 - Market Losses

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$11,553	$5,537	$589,471	0.0	$606,561
100	$33,297	$15,957	$767,380	0.0	$816,634
200	$117,095	$56,115	$991,526	$27,181	$1,191,918
500	$125,366	$60,079	$1,160,474	$242,542	$1,588,461

Table 18 – Direct Production Losses Analysis

Va Shly' Ay Akimel Salt River Restoration Project (COM Project No. 02-001)

Estimate of Crop Acreages in Gilbert Road "Break-out" Area

	Number of Acres Enclosed within Flood Event Demarcation Line (acres)			
Flood Event	Cotton*	Alfalfa**	Citrus	Nursery Tree Farm
50	13	7	86	0.0
100	38	19	112	0.0
200	135	67	145	0.3
500	144	72	170	2.3

* Assumed to be 2/3 of the currently fallow acres.

**Assumed to be 1/3 of the currently fallow acres.

Table 19 – Direct Production Losses per Acre

Estimate of Crop Prod. Values Per Acre in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus *	Nursery Tree Farm
50	$351	$279	$3,648	$0
100	$351	$279	$3,648	$0
200	$351	$279	$3,648	$52,272
500	$351	$279	$3,648	$52,272

* 152 trees per acre, each tree $24

one acre = 43,560 square feet w eff usage at 60% w 1 gal = 1tree @$2.00

NOTE a tree ready for planting valued at $8.00

Table 20 – Direct Production Losses

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

Flood Event	Cotton	Alfalfa	Citrus	Nursery Tree Farm	Total
50	$4,661	$1,851	$314,385	0.0	$320,897
100	$13,434	$5,334	$409,269	0.0	$428,037
200	$47,242	$18,758	$528,814	$13,591	$608,405
500	$50,579	$20,083	$618,920	$121,271	$810,853

Conclusion

The expected values of damages resulting from flooding are very small. When the damage numbers are shown on an annualized basis the economic impacts are rather insignificant. The losses of these crops on a national level will not affect prices because the quantities are relatively small. The following table 1s based upon 100 percent losses within the flooded areas.

Table 21 – Crop Losses (Without Project)

Expected Annual Damages
(Not discounted for seasonality, flood duration or limiting losses)

Category	Based on Market Prices	Based on Production Losses
Cotton	$1,205	$487
Alfalfa	$576	$193
Citrus	$21,464	$11,448
Nursery Tree Farm	$715	$357
Total	$23,961	$12,485

Expected Annual Damages ranges from $12,485 based upon maximum Production losses to $23,961 based upon maximum Market losses. These results do not take into account factors of flood duration and seasonality.

It is not realistic to assume 100 percent losses are going to occur. Therefore, the following table takes into account the factors of duration, season, and distribution of the flooding during the year. H&H provided seasonality information. Information on duration was not readily available instead a representative distribution was inserted.

Table 22 – Crop Losses (Without Project)

Expected Annual Damages
(Discounted for seasonality, flood duration or limiting losses)

Category	Based on Market Prices	Based on Production Losses
Cotton	$56	$22
Alfalfa	$219	$73
Citrus	$2,684	$1,431
Nursery Tree Farm	$179	$89
Total	$3,138	$1,615

Factoring in seasonal flood distribution probabilities, and duration the EAD is estimated to be approximately $1,615 based upon Production losses and $3,138 based upon Market value losses.

Appendix

Summary Analyses

Of

Flood Loss Calculation

As Function of Flooding Durations

50-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season r6-03
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
2-3 days of standing flood water will kill if covered or cause disease
rain/flood in march could delay plants 1 - 3 weeks which could afftect the yield at harvest time.

Alfalfa hay notes
grown the year around the roots remain the the ground for several gowing seasons
alfalfa hay are harvest several times in a year
Alfalfa fields are flooded for irrigration however standing water over 2-3 day will cause the onsit of disease.
Alfalfa fields can drown if covered by water over the top the stocks, need to be above the water the breath.
growing season march 5-6 weeks
growing season february 6 weeks
growing season in summer months 28-30 days
cut alfalfa hay in the field covered in standing water for 2-3 days will be damaged

Citrus notes
flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.438	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.247	$0	$86	$71	$143	$285	$585
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$585

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.315	$0	$52	$87	$174	$349	$662
February	0	10	50	100	100	0.438	$0	$73	$121	$243	$485	$922
March	0	10	50	100	100	0.247	$0	$41	$68	$137	$274	$520
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$2,104

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.315	$0	$0	$0	$4,638	$18,553	$23,191
February	0	0	0	25	50	0.438	$0	$0	$0	$6,458	$25,833	$32,292
March	0	0	0	25	50	0.247	$0	$0	$0	$3,640	$14,561	$18,201
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$73,684

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.438	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.247	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
2-3 days of standing flood water will kill if covered or cause disease
rain/flood in march could delay plants 1 - 3 weeks which could afftect the yield at harvest time.

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alfalfa hay are harvest several times in a year
Alfalfa fields are flooded for irrigration however standing water over 2-3 day will cause the onsit of disease.
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growing season march 5-6 weeks
growing season february 6 weeks
growing season in summer months 28-30 days
cut alfalfa hay in the field covered in standing water for 2-3 days will be damaged

Citrus notes
flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.438	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.247	$0	$35	$29	$58	$115	$236
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$236

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.315	$0	$17	$29	$58	$117	$221
February	0	10	50	100	100	0.438	$0	$24	$41	$81	$162	$308
March	0	10	50	100	100	0.247	$0	$14	$23	$46	$91	$174
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$703

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.315	$0	$0	$0	$2,474	$9,895	$12,369
February	0	0	0	25	50	0.438	$0	$0	$0	$3,444	$13,778	$17,222
March	0	0	0	25	50	0.247	$0	$0	$0	$1,941	$7,766	$9,707
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$39,298

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 50 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.315	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.438	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.247	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

100-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season rev6-03
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
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In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
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alfalfa hay are harvest several times in a year
Alfalfa fields are flooded for irrigration however standing water over 2-3 day will cause the onsit of disease.
Alfalfa fields can drown if covered by water over the top the stocks, need to be above the water the breath.
growing season march 5-6 weeks
growing season february 6 weeks
growing season in summer months 28-30 days
cut alfalfa hay in the field covered in standing water for 2-3 days will be damaged

Citrus notes
flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.432	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.216	$0	$216	$180	$360	$720	$1,476
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$1,476

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.351	$0	$168	$280	$561	$1,121	$2,130
February	0	10	50	100	100	0.432	$0	$207	$345	$690	$1,380	$2,622
March	0	10	50	100	100	0.216	$0	$104	$173	$345	$690	$1,311
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$6,064

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.351	$0	$0	$0	$6,740	$26,962	$33,702
February	0	0	0	25	50	0.432	$0	$0	$0	$8,296	$33,184	$41,480
March	0	0	0	25	50	0.216	$0	$0	$0	$4,148	$16,592	$20,740
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$95,922

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.432	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.216	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
2-3 days of standing flood water will kill if covered or cause disease
rain/flood in march could delay plants 1 - 3 weeks which could afftect the yield at harvest time.

Alfalfa hay notes
grown the year around the roots remain the the ground for several gowing seasons
alfalfa hay are harvest several times in a year
Alfalfa fields are flooded for irrigration however standing water over 2-3 day will cause the onsit of disease.
Alfalfa fields can drown if covered by water over the top the stocks, need to be above the water the breath.
growing season march 5-6 weeks
growing season february 6 weeks
growing season in summer months 28-30 days
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Citrus notes
flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.432	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.216	$0	$87	$73	$145	$290	$595
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$595

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.351	$0	$56	$94	$187	$375	$712
February	0	10	50	100	100	0.432	$0	$69	$115	$231	$461	$877
March	0	10	50	100	100	0.216	$0	$35	$58	$115	$231	$438
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$2,027

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.351	$0	$0	$0	$3,595	$14,380	$17,975
February	0	0	0	25	50	0.432	$0	$0	$0	$4,425	$17,698	$22,123
March	0	0	0	25	50	0.216	$0	$0	$0	$2,212	$8,849	$11,061
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$51,159

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 100 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.351	$0	$0	$0	$0	$0	$0
February	0	0	0	50	100	0.432	$0	$0	$0	$0	$0	$0
March	0	0	0	50	100	0.216	$0	$0	$0	$0	$0	$0
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$0

200-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season Rev6-03
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
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growing season march 5-6 weeks
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Citrus notes
flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.356	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.423	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.220	$0	$775	$645	$1,291	$2,582	$5,293
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$5,293

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.356	$0	$600	$1,000	$2,000	$3,999	$7,599
February	0	10	50	100	100	0.423	$0	$712	$1,187	$2,375	$4,749	$9,023
March	0	10	50	100	100	0.220	$0	$371	$619	$1,237	$2,475	$4,702
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$21,324

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.356	$0	$0	$0	$8,833	$35,333	$44,166
February	0	0	0	25	50	0.423	$0	$0	$0	$10,489	$41,958	$52,447
March	0	0	0	25	50	0.220	$0	$0	$0	$5,466	$21,862	$27,328
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$123,941

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.356	$0	$0	$0	$484	$1,937	$2,422
February	0	0	0	50	100	0.423	$0	$0	$0	$575	$2,300	$2,876
March	0	0	0	50	100	0.220	$0	$0	$0	$300	$1,199	$1,498
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$6,795

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season
source: Tom Shea UC Coop. Extension - citrus 909-683-6491 ex 224
Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
no damage possible in the months of Jan & Feb. when no plants are in the ground
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flood damage to citrus can be of two aspects: one harvest crop and the other loss of
1. harvest crop loss or reduction
2. the loss of the tree by flood uprooting or root rot from standing water on the root.
Water standing of 7 days would cause about 50% of treee loss.
Tree damage is detect by checking for loss of leave foliage.

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.356	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.423	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.220	$0	$312	$260	$521	$1,042	$2,135
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$2,135

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.356	$0	$201	$334	$668	$1,337	$2,540
February	0	10	50	100	100	0.423	$0	$238	$397	$794	$1,588	$3,016
March	0	10	50	100	100	0.220	$0	$124	$207	$414	$827	$1,572
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$7,128

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.356	$0	$0	$0	$4,711	$18,844	$23,555
February	0	0	0	25	50	0.423	$0	$0	$0	$5,594	$22,377	$27,972
March	0	0	0	25	50	0.220	$0	$0	$0	$2,915	$11,660	$14,575
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$66,102

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 200 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.356	$0	$0	$0	$242	$969	$1,211
February	0	0	0	50	100	0.423	$0	$0	$0	$288	$1,150	$1,438
March	0	0	0	50	100	0.220	$0	$0	$0	$150	$599	$749
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$3,398

500-Year Flood Event

Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

this spreadsheet collects the information on effective loss by crop by season Rev6-16-03
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Mike Rethwisch- Agr Commissioner Office - Blythe 760-921-7884 - cotton, alfalfa hay

Cotton notes
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In california cannot plant until March 1, 2002 or when the soil temperature is 50 to 60F
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Estimate of Crop Mkt. Losses in Gilbert Road "Break-out" Area

COTTON	percent by flood duration						0.3	0.3	0.1	0.1	0.2	1
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	0	0	0.370	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.407	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.222	$0	$836	$696	$1,393	$2,786	$5,711
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$5,711

ALFALFA HAY	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	10	50	100	100	0.370	$0	$668	$1,113	$2,225	$4,450	$8,456
February	0	10	50	100	100	0.407	$0	$734	$1,224	$2,448	$4,895	$9,301
March	0	10	50	100	100	0.222	$0	$401	$668	$1,335	$2,670	$5,073
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$22,830

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.370	$0	$0	$0	$10,745	$42,981	$53,726
February	0	0	0	25	50	0.407	$0	$0	$0	$11,820	$47,279	$59,098
March	0	0	0	25	50	0.222	$0	$0	$0	$8,447	$25,788	$32,235
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$145,059

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.370	$0	$0	$0	$4,492	$17,966	$22,458
February	0	0	0	50	100	0.407	$0	$0	$0	$4,941	$19,763	$24,703
March	0	0	0	50	100	0.222	$0	$0	$0	$2,695	$10,780	$13,475
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$60,636

Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

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Estimate of Crop Prod. Losses in Gilbert Road "Break-out" Area

COTTON	**percent by flood duration**						0.3	0.3	0.1	0.1	0.2	1
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	0	0	0	0	0.370	$0	$0	$0	$0	$0	$0
February	0	0	0	0	0	0.407	$0	$0	$0	$0	$0	$0
March *	0	10	25	50	50	0.222	$0	$337	$281	$562	$1,124	$2,304
April	0	20	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	30	75	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	40	100	100	100	0.000	$0	$0	$0	$0	$0	$0
* no planting allowed until 3/1						1.000						$2,304

ALFALFA HAY	**percent by flood duration**											
	0-day	**1-day**	**3-day**	**7-day**	**>7-day**	at 500 yr	**0-day**	**1-day**	**3-day**	**7-day**	**>7-day**	
January	0	10	50	100	100	0.370	$0	$223	$372	$744	$1,488	$2,827
February	0	10	50	100	100	0.407	$0	$245	$409	$818	$1,636	$3,109
March	0	10	50	100	100	0.222	$0	$134	$223	$446	$893	$1,696
April	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
May	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
June	0	10	50	100	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$7,632

CITRUS - crop	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	25	50	0.370	$0	$0	$0	$5,731	$22,923	$28,654
February	0	0	0	25	50	0.407	$0	$0	$0	$6,304	$25,215	$31,519
March	0	0	0	25	50	0.222	$0	$0	$0	$3,438	$13,754	$17,192
April	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	25	50	0.000	$0	$0	$0	$0	$0	$0
						1.000						$77,365

CITRUS - t farm	percent by flood duration											
	0-day	1-day	3-day	7-day	>7-day	at 500 yr	0-day	1-day	3-day	7-day	>7-day	
January	0	0	0	50	100	0.370	$0	$0	$0	$2,246	$8,983	$11,229
February	0	0	0	50	100	0.407	$0	$0	$0	$2,470	$9,881	$12,352
March	0	0	0	50	100	0.222	$0	$0	$0	$1,347	$5,390	$6,737
April	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
May	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
June	0	0	0	50	100	0.000	$0	$0	$0	$0	$0	$0
						1.000						$30,318

Appendix

Table of Citrus Costs

By Glenn Wright, PhD.

Estimated Value of mature trees located in Maricopa County

	Estimated Value per acre	Estimated Value per tree	Trees per acre	Distance between rows	Distance between trees	1994-2001 Average Yield[1]	1994-2001 Average Yield	1994-2001 On-tree Returns	Preharvest Costs[2]
	$ per acre	$ per tree		ft.	ft.	Cartons per acre[3]	Cartons per tree	$ per carton	$
White Grapefruit	($401.19)	$2.63	75.6	24	24	334.14	4.42	$0.60	$600.00
Red Grapefruit	($37.31)	$7.44	75.6	24	24	334.14	4.42	$1.68	$600.00
Navel Orange	$179.35	$10.60	75.6	24	24	243.57	3.22	$3.29	$622.00
Valencia Orange	$222.87	$11.17	75.6	24	24	380.57	5.03	$2.22	$622.00
Lemon	$1,041.97	$22.00	75.6	24	24	502.71	6.65	$3.31	$622.00

1 Yield data and On-tree returns from Arizona Agriculture Statistics and conversations with packinghouse managers.

2 Preharvest Costs estimated from Arizona Citrus Budgets

3 Carton Weights: Grapefruit = 33.9 lbs., Oranges = 37.5 lbs., Lemons = 38 lbs.

Raw numbers of annual maximum discharges

period in years	500	200	100	50	20
jan	200	160	130	79	25
feb	220	190	160	110	46
mar	120	99	80	62	37
apr					
SUM	540	449	370	251	108

Monthly probability % of flooding

period in years	500	200	100	50	20
jan	0.370	0.356	0.351	0.315	0.231
feb	0.407	0.423	0.432	0.438	0.426
mar	0.222	0.220	0.216	0.247	0.343
apr					
SUM	1	1	1	1	1

note: meeting held with H&H on October 1, 2002 at 2pm 12th floor conference room.
Duration discussed - further resolution ongoing

10-2-02 contact - University of California Cooperative Extension
Peggy Mauk 909-683-6491 ext 221
Tom Shea 909-6491 ext 224

10-8-02 contacted - Agr Commissioner Office
Mike Rethwisch 760-921-7844
Knows alfalfa hay and cotton

ADDENDUM 2

HYDROLOGIC ANALYSIS SUPPORTING AGRICULTURAL FLOOD DAMAGE ANALYSIS

SUBJECT: HYDROLOGY TO SUPPORT DETERMINATION OF AGRICULTURAL DAMAGES, Salt River below Granite Reef Diversion Dam (Va Shly'ay Akimel Restoration Study)

TO: CESPL-ED-HH

FROM: CESPL-ED-HH, Nick N. Adelmeyer (x3570)

DATE: 16 April 2003

Background

The Los Angeles District (LAD), Corps of Engineers, developed discharge-frequency relationships for the Salt River through the City of Phoenix in order to establish the Water Control Plan for Modified Theodore Roosevelt Dam (Roosevelt Dam). The Water Control Plan is an explicit statement of how releases from the flood control pool at Roosevelt Dam should be scheduled when reservoir stage reaches certain key elevations within that pool. Discharge-frequency relationships were determined based upon simulation of long-term inflows to the upstream Salt River Project (SRP) reservoir system, with the system operated in accordance with existing criteria, objectives, and obligations. This included the existence of Roosevelt Dam on the Salt River, and five other dams and reservoirs on the lower Salt and on the Verde River which comprise the storage facilities that make up the SRP. The simulation period was from 1889 through 1993.

Based upon the analysis described above and thoroughly documented in reference a), below, the probability that a specified discharge would be exceeded during any given year was determined for the Salt River below Granite Reef Diversion Dam and other locations. In addition, the probability that specified discharges for certain durations would be exceeded during any given year was also determined.

In the Va Shly'ay Akimel (VSA) study area, overflows from the Salt River may inundate farmable land within the Salt River floodplain. Hydraulic analysis indicates that the limiting channel capacity within the study reach is approximately 160,000 ft^3/s. Hence, flow rates in excess of 160,000 ft^3/s might escape the river and flood surrounding land. Inundation maps for the VSA study reach of the Salt River were prepared for hypothetical floods ranging from the 20% annual exceedance event (5-year annual maximum peak discharge) to the 0.2% annual exceedance event (500-year annual maximum). This information, as well as discharge-frequency values, is published in the Hydraulic Appendix (ref. b)).

However, to adequately address potential agricultural damages, more detailed hydrologic information is often necessary. *Annual maximum discharges* may not capture the variation in impact resulting *from seasonally-variable* or even *monthly-variable* discharge-frequency results. To estimate the damage potential from inundation of agricultural areas by Salt River overflows, monthly-variable, discharge-frequency values were requested to perform economic evaluations. This kind of detailed information is useful for determining the flood threat to a variety of crops during the planting, growing, and harvesting seasons. Hence, the following analysis describes

the variability in flood threat throughout the year with special emphasis given to the season in which the greatest potential threat to the agricultural area exists – viz., January through March.

1. References.

a) "Section 7 Study for Modified Theodore Roosevelt Dam, Arizona (Theodore Roosevelt Dam)", Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam", U.S. Army Corps of Engineers, Los Angeles District, dated March 1996.

b) "Va Shly'Ay Akimel, Hydraulic & Sedimentation Analysis, Volumes 1 – 3", prepared for Los Angeles District, U.S. Army Corps of Engineers by WEST Consultants, dated September 20, 2002.

c) "Santa Cruz River Watershed Management Study: Mixed Population Discharge-Frequency Analysis, Pima County, Arizona, Continental Road to Cortaro Road", Hydrology Appendix (E1), Los Angeles District, U.S. Army Corps of Engineers, dated 29 September 2000.

d) "Mixed-Population Frequency Analysis", Training Document No.17, The Hydrologic Engineering Center, dated April 1982.

e) HEC-FFA, Flood Frequency Analysis.

2. Drainage Area Description.

a) *MODIFIED ROOSEVELT DAM TO GRANITE REEF DIVERSION DAM.* The Salt River originates on the eastern portion of the Mogollon Plateau, in the White Mountains, with peaks as high as 11,590 feet (Baldy Peak). The Salt River is formed by the confluence of two westward flowing streams, the White and Black rivers, and drains the rugged central section of Arizona, which is marked by isolated mountain ranges with steep-walled canyons and gorges. The Salt River drains directly into Theodore Roosevelt Lake where it is joined by Tonto Creek, which flows southward out of the Tonto Basin at the base of the Mogollon Plateau. The United States Geological Survey (USGS) operates streamgages on both the Salt River (near Roosevelt) and Tonto Creek (above Gun Creek), which measure inflow to Modified Roosevelt Dam from 4,981 sq. mi. of the contributing drainage area. The total contributing drainage area upstream of Modified Roosevelt Dam, including Theodore Roosevelt Lake, is approximately 5800 sq. mi. The total drainage area of the Salt River at the most downstream facility - Stewart Mountain Dam - is approximately 6200 sq. mi. Releases from the Salt River system reservoirs are measured by the USGS at a streamgage located 3.5 mi. downstream of Stewart Mountain Dam. The Salt River is joined by its major tributary, the Verde River, approximately 9.5 mi. below Stewart Mountain Dam.

b) *VERDE RIVER TO THE SALT RIVER CONFLUENCE.* The Verde River flows south out of the Chino valley, which is bounded on the west by the Juniper and Santa Maria

Mountains, and is separated from Tonto Basin on the east by the Mazatzal Mountains. Horseshoe Dam, which has a contributing drainage area of 5657 sq. mi., excluding Aubrey Basin which is closed, is 9 miles downstream from the USGS streamgage located on the Verde River below Tangle Creek, and is the upstream SRP dam on the Verde River. Bartlett Dam is the downstream SRP facility on the Verde River and is approximately 15 miles below Horseshoe Dam and 25 miles upstream from the confluence with the Salt River. The total drainage area at Bartlett Dam is 5851 sq. mi., excluding the 373 sq. mi. Aubrey Basin. Releases from the Verde River system reservoirs are measured by the USGS approximately 2.1 mi. downstream of Bartlett Dam. Sycamore Creek (drainage area = 164 sq. mi.) is the major tributary of the Verde River downstream of Bartlett Dam. The Verde River joins the Salt River approximately 25 miles downstream of Bartlett Dam. The effective drainage area at the mouth (excluding the Aubrey Basin) is approximately 6300 sq. mi.

c) *SALT-VERDE CONFLUENCE TO THE GILA RIVER.* Granite Reef Diversion Dam, located about 3 mi. downstream of the Salt River and Verde River confluence, is the final SRP dam on the Salt River. This dam normally diverts upstream SRP releases from the Salt River into the Arizona Canal to the north of the dam and the South Canal to the south of the dam. During periods of high flows, water passes over the dam and continues down the Salt River. The Salt River ultimately joins the Gila River at mile 198 (measured from the mouth of the Gila River at Yuma, Arizona, and approximately 40 miles downstream of Granite Reef Diversion Dam. The Salt River drains a total area of about 13,000 sq. mi. (excluding Aubrey Basin) to the Gila River, of which nearly 12,600 sq. mi. above the Granite Reef Diversion Dam is regulated.

3. Operation of the Salt River Project Reservoir System (SRP).

a) *GENERAL.* The SRP system is comprised of six reservoirs on the Salt and Verde Rivers, including Modified Roosevelt Dam, and a diversion dam located 3 miles downstream of the Salt River and Verde River confluence. The other reservoirs on the Salt River are Horse Mesa Dam, Mormon Flat Dam and Stewart Mountain Dam; Horseshoe Dam and Bartlett Dam are located on the Verde River, and Granite Reef Diversion Dam is located below the confluence of the Salt River and the Verde River. The reservoirs receive runoff from a combined watershed of more than 12,600 sq. mi. (excluding Aubrey Basin). Modified Roosevelt Dam is the oldest and has the largest reservoir storage. The SRP reservoir system in central Arizona provides water supply for much of the metropolitan Phoenix area. Hydroelectric power is also generated within the system.

b) *SALT RIVER RESERVOIRS.* Normal[1] releases from Modified Roosevelt Dam generate hydropower as they pass through the hydroelectric generating facilities downstream of Modified Roosevelt Dam and the three downstream regulatory dams - Horse Mesa Dam,

[1] Normal releases refers specifically to releases made, when the reservoir pool is within the allocated water supply space, to satisfy downstream demand, rather than releases which are necessary, when the reservoir pool is within the allocated flood control space, due to excess inflow, and which must be "wasted" to the Salt River downstream of Granite Reef Diversion Dam.

Mormon Flat Dam, and Stewart Mountain dam. The "normal" releases from Modified Roosevelt Dam and the other Salt River dams are generally scheduled for the warmest months of the year, when runoff is low and demand for both electrical power and water are highest. During the winter months, when runoff is generally greater, downstream demand is typically satisfied by releasing water from the Verde River reservoirs. The storage space in the Verde River reservoirs is considerably smaller than in the Salt River reservoirs[2], which makes carry-over storage on the Verde side impractical. In addition to the considerably greater quantity of storage space available within the Salt River reservoirs, this storage space is more flexible because of pump-back storage capability, which allows hydroelectric power generation during periods of peak demand without "wasting" water. To fully utilize the pump-back storage system, the lake levels in the 3 reservoirs downstream of Modified Roosevelt Dam are typically maintained at about 90% full. The remaining space allows capture and regulation of local inflow.

c) *VERDE RIVER RESERVOIRS.* The Verde River reservoirs generally store water during the high runoff season (i.e., the winter months) and release this water at a rate compatible with the demand. As discussed in the previous section, releases from Bartlett Dam are normally made in the winter, when demands are less, because there is insufficient space in the Verde River reservoirs to allow carry-over storage until the warmer summer months, which are accompanied by an increase in demand. During periods when the water available in the Verde River reservoirs is insufficient to meet the downstream demand, surface water from the Salt River reservoirs and/or groundwater may be utilized to meet that demand. During periods of excess inflow, it may be necessary to "waste" water by making releases from the Verde River spillways, which exceed the downstream demand. No hydropower facilities exist at Horseshoe and Bartlett dams.

4. <u>Precipitation.</u> Average annual precipitation for the upper Salt River and Verde Rivers (above the SRP system reservoirs) ranges from about 20 inches near Cibecue on the west to nearly 30 inches in the higher elevations of the White Mountains on the east. Two precipitation gages in the area - at McNary and Whiteriver - have recorded a mean annual precipitation of 24.9 and 17.4 inches, respectively. Precipitation in this region occurs throughout the year, with the wettest periods being during the monsoon months of July and August. The maximum average monthly precipitation at the two reference gages occurs in August, 3.95 and 3.49 inches, respectively. The precipitation is distributed somewhat evenly between the summer months (May through October) and winter months (November through April), although the heaviest short-duration showers occur in the summer and early fall. Certain sections of Arizona *average* more than one thunderstorm per day in July and August; the southern slopes of the White Mountains may experience between 80 and 90 thunderstorms during these two midsummer months. In the higher parts of the plateau section more than 75% of the winter precipitation falls as snow. These areas typically receive between 8 and 11 feet of snow annually, with more than 100 inches falling in a single month during unusually cold and wet periods. Precipitation is characterized by the season in which it occurs, and is described accordingly below:

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[2] The Salt River reservoirs can store approximately 2.5 million ac-ft of water (including approximately 560,000 ac-ft within the flood pool at Modified Roosevelt Dam). In comparison, the Verde River reservoirs can only store approximately 310,000 ac-ft, all of which is water supply space.

a) *SUMMER MONTHS.* The summer "monsoon" season (typically June through September) is characterized by intense local precipitation, often in the form of thunderstorms, of short duration and small areal extent. Smaller drainage areas (< 500 sq. mi.) are more responsive to this type of rainfall event, resulting in higher peak flows in such basins.

b) *WINTER MONTHS.* The winter season (typically November through March) is characterized by more general precipitation, less intense in nature, and covering large areas for extended periods of time. Larger drainage areas (> 1000 sq. mi.) are more responsive to this type of rainfall, and higher peaks will result; runoff will continue for a longer duration.

c) *LATE SUMMER TO EARLY FALL.* Occasionally a late-summer to early fall (typically August through October) event resulting from a dissipating tropical depression or hurricane (such as the August 1951 General Summer Storm or the Labor Day 1970 storm) may occur; this type of storm may include intensities characteristic of thunderstorms with areal extent and duration associated with the general winter storms. Such an event might produce high peak flow as well as volume from all size drainage areas.

d) *SPRING MONTHS.* During the late spring-early summer (April though May) period there is typically less precipitation. Most runoff occurring in this period is the result of snowmelt, and occasionally accompanied by rainfall.

5. Runoff. In general, the larger drainage areas (such as the Salt and Verde Rivers) respond more to general winter precipitation (i.e. the maximum discharge occurs in the winter), while for smaller drainage areas, the larger peak discharges may occur during summer months. During the winter months, snowmelt often contributes to runoff during warm rainstorms; general accelerated snowmelt may also occur during early spring when above-normal temperatures prevail. The percentage of precipitation which contributes immediately to runoff in this area, as in other high elevation areas in Arizona, is considerably less than in low-lying desert areas, and more sparsely vegetated transition areas of the state. The upper Salt and Verde Rivers, as well as headwater streams, are perennial. During major storms, streamflow increases rapidly, and in combination with steep gradients and often-barren slopes, results in major floods. Snowmelt is a contributing factor in most winter floods.

Because of construction of SRP dams and the operation of the SRP reservoir system, most runoff is stored for later downstream use. The simulated flood history of the Salt River below Granite Reef Diversion Dam (ref. a), Fig.1 below) indicates that with the existing dam and reservoir system in place, and operated according to today's criteria, there are 34 years in the 105-year simulation period in which water is wasted over Granite Reef Diversion Dam ("spills") due to an excess of upstream inflow and impounded water compared to demand.

Based upon historical information and long-term simulated flood history (105-year period from 1889 through 1993) representative of *existing condition*", a summary of spills for the meteorological cases described above is summarized in the following and displayed graphically in Figure 2.

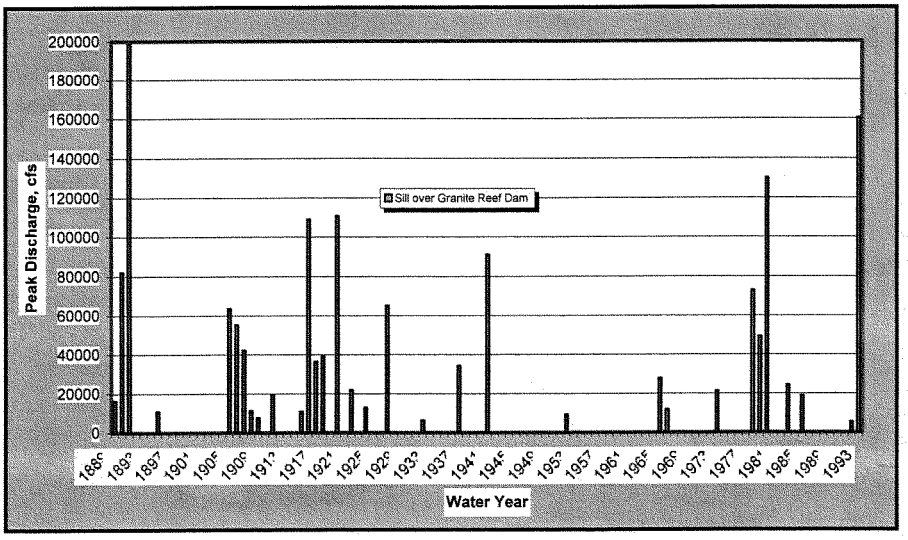

Figure 1. Simulated Spill History: Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 – 2003.

The impact of the upstream dams on the Salt and Verde Rivers on flood flows in the Salt River below Granite Reef is partially portrayed in Table 1. This table summarizes the peak flow rates for many of the largest events shown in Figure 1 for both *existing conditions* and *natural conditions*, i.e. without the SRP system in place. It should also be noted that the gaps in "spills" over Granite Reef Diversion Dam (Figure 1) would not be present under *natural conditions*. In the absence of upstream SRP dams, flows intercepted by the dams and stored in the reservoirs would continue downstream during most years.

Table1. Comparison Of Significant Floods Of Record, Simulated Existing Versus Natural Runoff[1], Peak Discharge In Salt River At Granite Reef Diversion Dam

Water Year	Month	Existing Conditions	Natural[2]
1890	February	97,000	190,000
1891	February	199,000	300,000
1906	November	*No spill*	220,000
1906	March	55,600	63,400
1907	March	49,000	55,800
1916	January	109,000	164,000
1917	April	44,000	59,900
1920	February	111,000	155,000
1927	February	65,200	123,000

Table1. Comparison Of Significant Floods Of Record, Simulated Existing Versus Natural Runoff[1], Peak Discharge In Salt River At Granite Reef Diversion Dam

Water Year	Month	Existing Conditions	Natural[2]
1932	February	*No spill*	117,000
1938	March	*No spill*	115,000
1941	March	90,100	170000
1966	December-January	27,900	85,000
1978	March	72,900	260,000
1979	January	49,300	235,000
1980	February	130,000	241,000
1993	March	160,000	329,000

Notes:

1. Natural flow is the peak discharge that would have occurred in the absence of SRP reservoirs.
2. Results based on simulations reported in Table 4 of the May 1982 CAWCS Hydrology Report for the period from 1889 through 1980 only; results from 1980 to 1993 based upon simulations performed for the study of Modified Theodore Roosevelt Dam, reference a).

During most months of most years (please refer to Fig. 1, previous, and Table 2, following) there is no flow in the Salt River downstream of Granite Reef Diversion Dam. Almost the entire volume of runoff reaching the study area results from releases/spills from upstream SRP dams in excess of the delivery system capacity and user demand. These flows, typically lasting for a week or more, spill across Granite Reef Diversion Dam and continue downstream. During periods of sustained or high releases from the upstream SRP Dams, these spills reach Painted Rock Dam. Spills from the Salt River Dams occur almost always during the cold-weather months, and result from above normal precipitation, often accompanied by additional runoff from snowmelt or from snowmelt alone. The simulated flood history referred to above (1889-1993, Table 2) indicated spills would have occurred most frequently in the months of January through April, with the maximum spill threat in terms of volume occurring in January and February.

There is strong serial correlation between spills and *above normal* precipitation, both in the short-term (water year) and long-term (several water years). Moreover, the reservoirs tend to fill during the winter months, while the major demand is during the warm-to-hot-weather months. Typically reservoirs are "drawn-down" in the summer for hydropower, irrigation, and water supply, and "refilled" during the wet winter months. Hence, fewer spills occur early in the runoff season (November and December), and relatively more as the runoff season progresses (February through April). Refer to Table 2, and Figure 2, which follow. Similarly, above-normal runoff years result in high reservoir pools, such that even "normal" runoff during the following runoff season(s) may result in spills. Finally, as reservoirs begin to refill during the runoff season, severe storms, including melting snow, may produce spills and high discharges from the SRP dams. The majority of these types of storms occur during the months of January and February; as the runoff season progresses the likelihood of a storm intense enough to produce high peak discharges diminishes. During the warm-weather months the areal extent of

intense-precipitation storms diminishes, hence runoff from the large Salt River watershed is reduced; in addition, since the reservoirs are drawn-down due to increased demand, more space is available to store seasonal runoff. This disparity is seasonal spills is clearly shown in Table 2 and Figure 2.

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1889	0.0	0.0	116.8	118.4	0.0	208.5	35.9	0.0	0.0	0.0	0.0	0.0	479.6
1890	0.0	0.0	0.0	0.0	282.2	209.9	0.0	0.0	0.0	0.0	0.0	0.0	492.1
1891	0.0	67.8	162.2	123.7	1975.4	122.9	0.0	0.0	0.0	0.0	0.0	0.0	2452.0
1892	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1893	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1894	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1895	0.0	0.0	0.0	0.0	36.9	149.7	0.0	0.0	0.0	0.0	0.0	0.0	186.6
1896	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1897	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1898	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1899	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1901	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1902	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1903	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1904	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1905	0.0	0.0	0.0	0.0	277.5	480.7	847.9	112.4	0.0	0.0	0.0	0.0	1718.5
1906	0.0	122.3	87.3	84.1	54.2	652.0	168.0	0.0	0.0	0.0	0.0	0.0	1167.9
1907	0.0	0.0	0.0	208.3	196.6	296.0	0.0	0.0	0.0	0.0	0.0	0.0	700.9
1908	0.0	0.0	0.0	0.0	0.0	29.6	0.0	0.0	0.0	0.0	0.0	0.0	29.6
1909	0.0	0.0	0.0	80.2	157.1	134.9	100.5	0.0	0.0	0.0	0.0	0.0	472.7
1910	0.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.2
1911	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
1912	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1913	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1914	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1915	0.0	0.0	0.0	0.0	0.0	57.0	270.5	195.0	0.0	0.0	0.0	0.0	522.5
1916	0.0	0.0	0.0	1257.7	416.8	713.5	124.4	0.0	0.0	0.0	0.0	0.0	2512.4
1917	0.0	0.0	0.0	0.0	0.0	38.5	333.4	0.0	0.0	0.0	0.0	0.0	371.9
1918	0.0	0.0	0.0	0.0	0.0	44.9	0.0	0.0	0.0	0.0	0.0	0.0	44.9
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	21.4	302.3	284.9	1081.0	167.1	27.0	0.0	0.0	0.0	0.0	0.0	1883.7
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	21.5	55.1	0.0	0.0	0.0	0.0	0.0	0.0	76.6
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	38.1	33.4	0.0	0.0	42.4	0.0	0.0	0.0	0.0	0.0	113.9
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	97.1	63.8	0.0	0.0	0.0	0.0	0.0	0.0	160.9
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	107.1	199.5	70.4	0.0	0.0	0.0	0.0	0.0	377.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	45.1	121.3	17.8	0.0	0.0	0.0	0.0	0.0	184.2
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1941	0.0	0.0	0.0	0.0	146.2	386.0	532.5	190.0	0.0	0.0	0.0	0.0	1254.7
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	42.5	89.8	0.0	0.0	0.0	0.0	0.0	132.3
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	106.3	0.0	0.0	0.0	0.0	0.0	106.3
1966	0.0	0.0	59.4	41.2	0.0	83.9	0.0	0.0	0.0	0.0	0.0	0.0	184.5

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	13.1	54.6	11.7	48.8	170.1	642.3	275.7	0.0	0.0	0.0	0.0	1216.3
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	437.0	0.0	0.0	0.0	0.0	0.0	0.0	437.0
1979	0.0	0.0	244.3	432.5	238.4	529.2	361.6	3.8	0.0	0.0	0.0	0.0	1809.8
1980	0.0	0.0	0.0	0.0	1220.8	239.3	168.9	0.0	0.0	0.0	0.0	0.0	1629.0
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	93.7	568.1	240.7	33.8	0.0	0.0	0.0	0.0	936.3
1984	3.0	0.0	152.8	44.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200.0
1985	0.0	0.0	0.0	152.8	93.0	363.2	78.0	0.0	0.0	0.0	0.0	0.0	687.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0	24.6

Table 2. HYDROLOGY FOR AGRICULTURAL DAMAGE ASSESMENT: Simulated Monthly Spill History, Salt River below Granite Reef Diversion Dam, Existing Conditions, 1889 -1993

Monthly Spill Volume in 1000 Ac-ft: [Source: Section 7 Study for Modified Theodore Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam]

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total Volume (1000 Ac-Ft)
1993	0.0	0.0	0.0	684.7	870.2	381.0	178.1	0.0	0.0	0.0	0.0	0.0	3214.0
Total Monthly Volume (1000 Ac-ft)	3.0	224.0	1217.9	4618.0	7459.8	7019.8	6436.4	818.7	0.0	0.0	0.0	0.0	

Note: Values represent the greatest spill volume in each month during the simulation period.

1237

The simulated monthly spill history is displayed in the following graph (Fig. 2). Maximum spill volumes for each month are depicted along with the number of spills, as well as a summary of the largest spill and the largest number of monthly spills in any year.

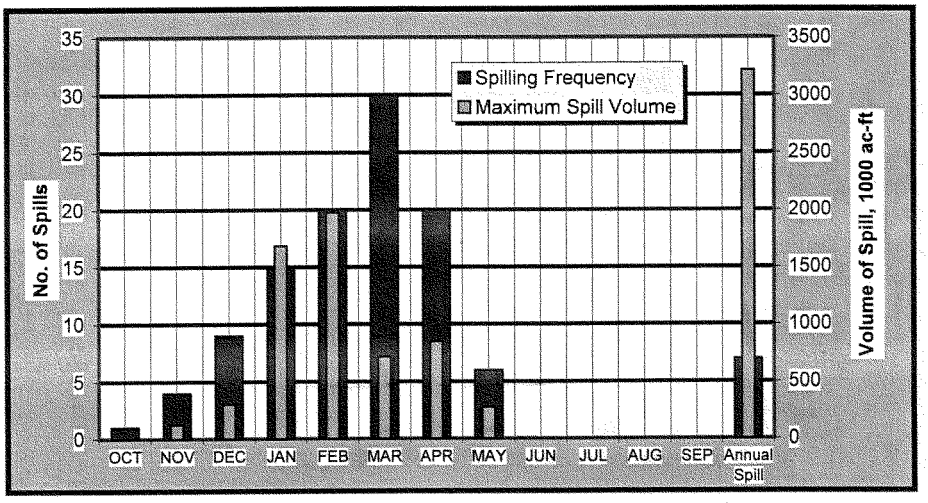

Figure 2. Monthly Summary of Spills: Salt River below Granite Reef Diversion Dam, *Existing Conditions*, 1889 - 1993

As shown in Figure 2, simulation of the POR did not result in any spill during the months of June through September; in addition there was only a single spill in October, of negligible volume (3000 ac-ft), and only four spills in November, with the greatest spill (122,000 ac-ft) being *less than half* of the greatest spill from any of the other months from December through May. The simulated POR (1889 –1993, 105 years) resulted in a total of 105 months during which some spill would have occurred (monthly spills for the entire POR were summarized in Table 2). The simulated spills ranged from 3000 ac-ft (October 1983) to nearly 2,000,000 ac-ft (February 1891), and *averaged about 250,000 ac-ft, per month, per spill event.* In other words, the "average" monthly spill was about a quarter-million ac-ft., while simulated spills *occurred on average* about once per year. However, there were only 34 years during which a simulated spill actually occurred (about a 32% chance of a spill occurring in a given year, or a 3-year recurrence interval). Many of the years in which spills would have occurred resulted from extended periods of above-normal runoff, and produced spills that occurred intermittently or continuously during a period of several months.

The foregoing Table 2 detailed the simulated spill volume over Granite Reef Diversion Dam for each month of the simulation period, as well as the relative frequency or infrequency of spills. On a monthly basis, spills occur only once every 12 months, or approximately 8% of the time. During the months of January through March (the 3 consecutive months with the greatest spill volumes) the frequency of spilling increases to approximately 62%, with greatest likelihood during February, nearly 29%. There is a late season flood threat in April and May, which

accounts for approximately a quarter of all monthly spill events (26 total spill months within the POR, with the greatest threat in April, 20 spill events, or approximately 19% of the time; the likelihood of a spill during May decreases to approximately 6% of the time, with 6 spill events in the POR). However, spills in these months are usually associated with continuing runoff from previous storms and floods, and late-season snowmelt. Of the 10 greatest simulated peak discharges at Granite Reef Diversion Dam, only one of those, April 1905, occurred during this late-season period. That event was the 10th largest in history (refer to Table 3, later in this report, for more details). Streamflow in the Salt River downstream of Granite Reef Diversion Dam is characterized in the following paragraphs.

a) *WARM WEATHER MONTHS.* During the "monsoon" season through the late-summer to early-autumn "hurricane" season (the months of June through October) there was only 1 simulated spill[3] (very minor) during the entire 105-year period; hence it is reasonable to conclude that the Salt River will be dry during this season. As a consequence, there will be no agricultural damages resulting from Salt River overflows during these months.

b) *COLD WEATHER MONTHS.* Most significant spills from the upstream SRP system occur during the cold-weather period (November through March), especially between the months of January and March[4].

c) *TRANSITION MONTHS.* Significant spills can also occur on a less frequent basis during the colder-weather transition months of November through December, and the warmer-weather transition months of April through May. However, the flood threat, that is flow *in excess of the conveyance capacity of the Salt River*, is very low during these months (refer to Table 3, which summarizes the simulated maximum annual peak resulting from the spills, and the months in which these occur).

Baseline information for *existing conditions* "spills" to the Salt River below Granite Reef Diversion Dam is portrayed in Figures 2 and 3. Figure 2 presented a summary of the simulated spilling frequency and volume on a monthly basis. Figure 3 includes the annual maxima and resulting discharge-frequency relationship.

[3] As previously mentioned, the volume was only 3000 ac-ft, in October 1983 (Water Year 1984).
[4] Of the 105 months in the POR during which spills occur, 78 are in the cold weather months (nearly 75%), and of these, 65 are in the months of January to March (62%).

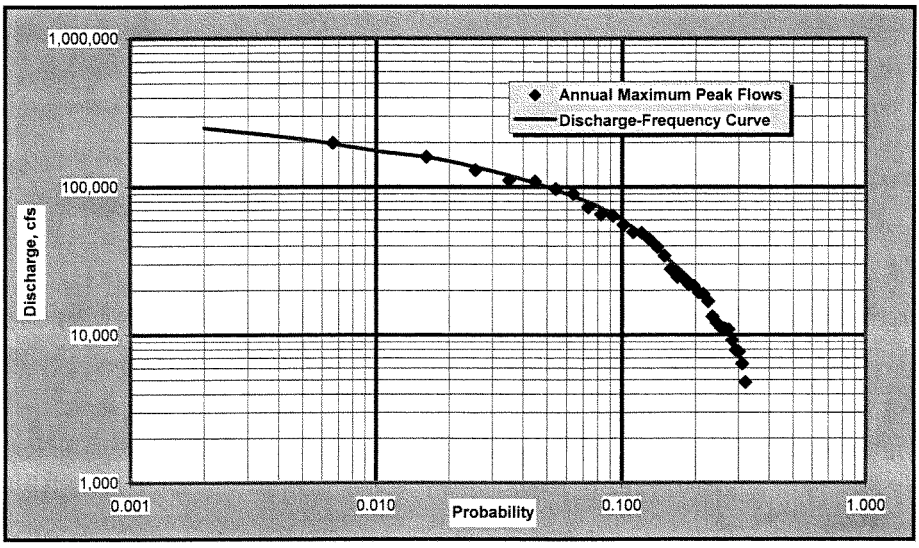

Figure 3. Annual Maximum Discharge-Frequency Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions.*

Table 3 (following page) includes the annual maxima in order of magnitude, as well as the months during which each simulated peak discharge occurred. **Note: none of the annual maxima occurred during the months of May through November.**

Table 3. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions*, 1889 - 1993														
RANK	PP	Discharge cfs	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.007	199,000		1891										
2	0.016	160,200	1993											
3	0.026	130,000		1980										
4	0.035	111,000		1920										
5	0.045	109,000	1916											
6	0.054	97,100		1890										
7	0.064	90,100			1941									
8	0.073	72,900			1978									
9	0.083	65,200		1927										
10	0.092	63,700				1905								
11	0.102	55,500			1906									
12	0.111	49,300	1979 (T)											1979 (T)
13	0.120	49,000			1907									
14	0.130	44,200				1917								
15	0.139	39,400			1918									
16	0.149	34,300			1937									
17	0.158	27,900	1966 (T)											1966 (T)
18	0.168	24,700												1983
19	0.177	24,500			1983									
20	0.187	22,000			1922									
21	0.196	21,400			1973 (T)	1973 (T)								
22	0.206	19,400			1911									
23	0.215	18,900			1985									
24	0.225	16,900			1889									
25	0.234	13,300			1924									
26	0.244	12,100			1966									
27	0.253	11,200			1908									
28	0.263	11,000			1895									

Table 3. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions,* 1889 - 1993														
RANK	**PP**	**Discharge cfs**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
29	0.272	10,900				1915								
30	0.282	9,200				1952								
31	0.291	7,900				1965								
32	0.301	7,700		1909 (T)	1909 (T)									
33	0.310	6,400			1932									
34	0.320	4,800			1992									

Note:
Cells highlighted in red indicate months during which the annual maximum NEVER occurred.
(T) Indicates year in which the annual maximum occurred over 2 consecutive months.

1242

6. Monthly and Seasonal Discharge-Frequency Analysis.

a) *GENERAL.* In order to conduct an adequate evaluation of the potential damages to agriculture along the overbank of the Salt River, LAD economists requested discharge-frequency relationships be differentiated on a monthly basis. The purpose of breaking the discharge-frequency relationships down to this level was to provide information on potential damages to a variety of crops and growth cycles. Separation of annual maximum streamflow data into smaller time intervals (e.g. monthly or seasonal) may provide real insight into flooding potential, especially when the data set is homogeneous from a hydro-meteorological viewpoint, or is easily differentiable from that viewpoint. In addition there must be sufficient data to adequately describe the resulting differentiated series. Finally, it is necessary that analysis of the differentiated samples and the annual maximum series be consistent. Thus, the integrated results of the monthly/seasonal discharge-frequency relationships must support the annual maximum results.[5] The risk of agricultural damage resulting from overflows from the Salt River below Granite Reef Dam is confined to the cold-weather months, especially January through March, as previously documented. Hence, the monthly analysis has been restricted to the relative risk during the cold weather months. **Note: April, a transition month, has been included in this analysis, while November has been dropped, because the April flood threat is much greater than in November, and in the upper Salt and Verde River watersheds retains characteristics of cold weather regimes, i.e. frontal event precipitation coupled with snowmelt.**

b) *MONTHLY DATA.* Sequential depictions of the monthly (cold-weather) contribution to the annual flooding potential are provided in Figures 4 and 5. Figure 4 includes all the cold weather months from December to April (refer also to Figure 2 and Table 3 which indicate these are the months with the most frequent and large spills); the differentiated[6] annual maxima are compared with the annual maximum discharge-frequency relationship. Similarly, Figure 5 limits the cold weather monthly spills to the most volatile of all the months, January to March (again re: Figure 2 and Table 3). It is apparent from the differentiated data that the annual maximum discharge-frequency relationship is almost entirely dependent upon the spills during the cold weather months, especially January through March.

[5] The exception would be if a "Mixed Population" analysis is appropriate and being conducted for the explicit purpose of modifying or more accurately defining the "Annual Maximum Series" results. In the case of a "Mixed Population" analysis, the annual maximum streamflow series is considered "non-homogeneous" because it represents several distinct meteorological causes. In such a case, the discharge-frequency relationship for each type of meteorological agent may be separated, a series developed, and separate analysis of each series performed. The integrated, combined-population discharge-frequency relationships are then considered more reflective of the true flood potential. Examples of this approach are documented in references c) and d).

[6] The annual maximum peak discharges are plotted according to annual rank, but "differentiated" as to their month of occurrence.

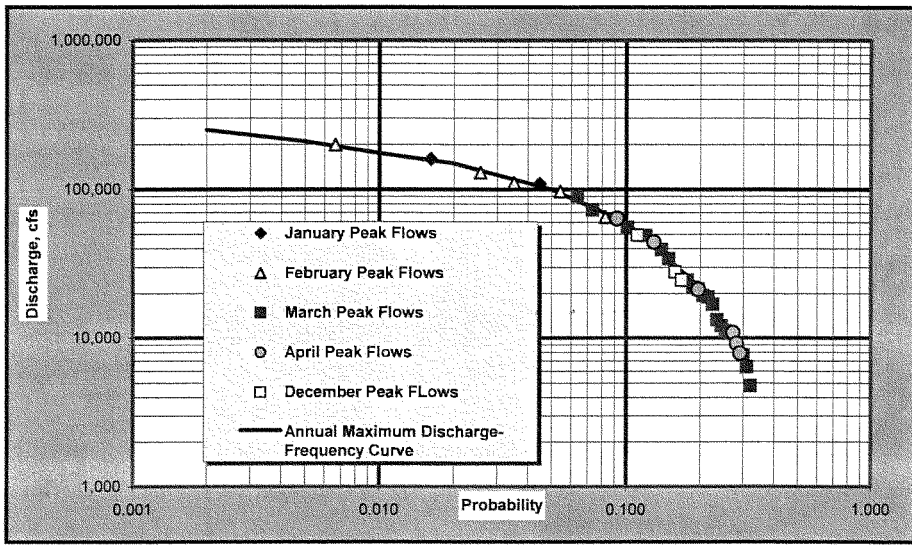

Figure 4. Annual Maximum Discharge-Frequency Curve with December – April Maxima, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

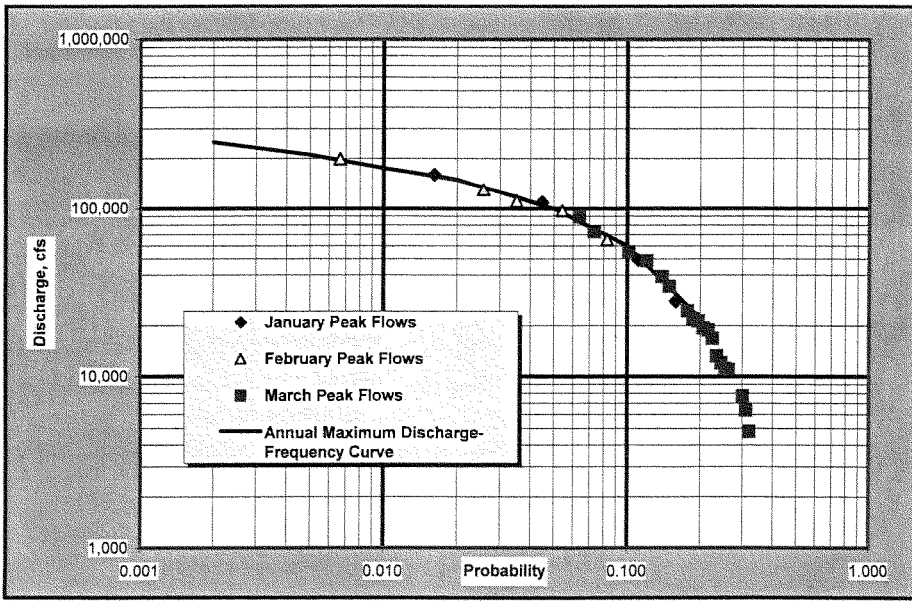

Figure 5. Annual Maximum Discharge-Frequency Curve with January – March Maxima only, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Monthly maxima were not available for each of the 105 months in the POR during which simulated spills would have occurred. However, this information is available for the largest of these events, which as previously emphasized occurred during the cold-weather months. The peak discharges presented in Table 3 were assigned "annual" plotting positions within each of the differentiated monthly samples. In other words, the largest peak discharge for each of the months in the POR is ranked as number 1, and assigned a plotting position associated with that ranking. Based upon the length of the simulation record (105 years), the median plotting position value assigned to each of the largest monthly discharges is 0.007.

Table 4. SALT RIVER BELOW GRANITE REEF DIVERSION DAM: Simulated Spill History, *Existing Conditions*, 1889 - 1993

RANK	Peak Q, cfs	Median Plotting Position				
		JAN	FEB	MAR	APR	DEC
1	199,000		0.007			
2	160,200	0.007				
3	130,000		0.016			
4	111,000		0.026			
5	109,000	0.016				
6	97,100		0.035			
7	90,100			0.007		
8	72,900			0.016		
9	65,200		0.045			
10	63,700				0.007	
11	55,500			0.026		
12	49,300	0.026				0.007
13	49,000			0.035		
14	44,200				0.016	
15	39,400			0.045		
16	34,300			0.054		
17	27,900	0.035				0.016
18	24,700					0.026
19	24,500			0.064		
20	22,000			0.073	0.026	
21	21,400			0.083	0.035	
22	19,400			0.092		
23	18,900			0.102		
24	16,900			0.111		
25	13,300			0.120		
26	12,100			0.130		
27	11,200			0.139		
28	11,000			0.149		
29	10,900				0.045	
30	9,200				0.054	
31	7,900				0.064	
32	7,700		0.054	0.158		
33	6,400			0.168		
34	4,800			0.177		

Table 4 above presents the POR, *Existing Conditions,* peak-discharges in the Salt River below Granite Reef Diversion Dam, originally displayed as a "differentiated"[7] annual series in Table 3, reassembled into multiple monthly series. As stated earlier, the annual maximum series was developed using graphical procedures, since the data did not fit the statistical requirements: i.e., *random, independent events.* Hence the monthly series were analyzed in a similar manner. In this case a graphical, curve-fitting procedure was utilized to generate consistent, smooth curves (please refer to Figure 6, below). To enhance the portrayal, the 0.002 probability event (500-year) was computed using the regressed equations for discharge (y) in Figure 6, and included in the plotted data. Months other than January to April and December were not included since the flood threat during those months is nearly non-existent.

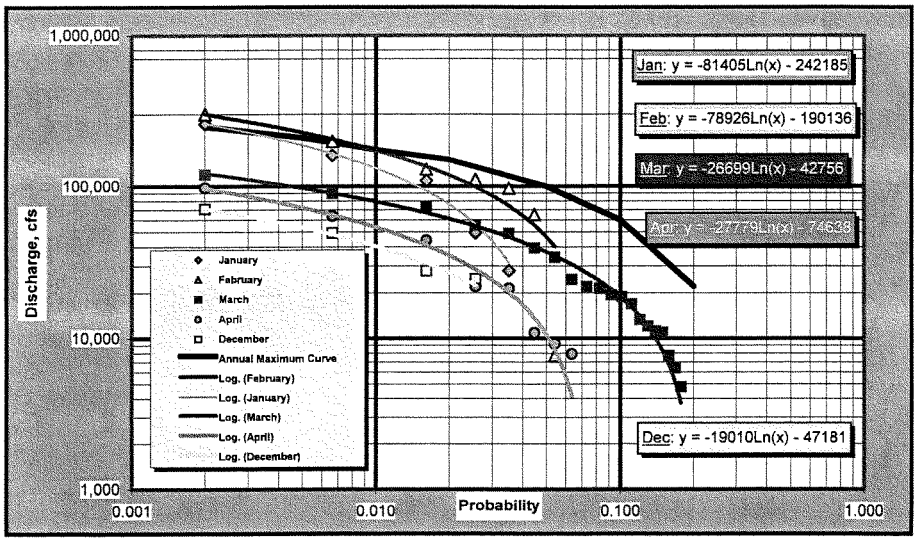

Figure 6. December – April Monthly Discharge-Frequency Curves (unadjusted) vs. Annual Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions.*

In Figure 6 above, the annual maximum discharge-frequency curve is compared to discharge-frequency curves developed from the data sets in Table 4 for each of the months in which significant spills have occurred during the simulation period (1889 – 1993). Each curve is a regressed best-fit curve, or "graphical" curve[8]. In is obvious from the graphs that two of the monthly curves, viz. January and February, are in conflict with the annual maximum curve, since for more rare frequency events the January and February curves equal or exceed the annual

[7] The data for the annual series in Table 3 was "differentiated" by indicating the month(s) in which the annual maxima occurred.

[8] Analytical curves for the Salt River below Granite Reef Diversion Dam are inappropriate since the data set is not composed of random independent events. A "best-fit" scheme based upon regression was selected for consistency across each data set. These "results" are intermediate, and only portrayed for comparison purposes.

maximum curve. It is also apparent that the December and April monthly discharge-frequency curves (and contributing data) have little impact on the annual maximum curve. To maintain consistency with the "parent" curve for the annual maximum series, adjustments were made to the January and February discharge-frequency curves[9], based upon the difference between the integrated monthly results and the annual maximum discharge-frequency curves. The adjustment procedure is shown in Table 5, following pages, and the adjusted January, February, and March values are highlighted on the last page of Table 5.

[9] The March discharge-frequency curve was also adjusted because the values for this month were also significant. In addition, the investigator wanted to develop a single-season curve for the months of January – March. It is apparent in Table 5, following, that the peak spills during March have much less contribution to the Combined Probability Function that the January and February data, especially for significant discharges (≥ 100,000 cfs).

Table 5. Salt River below Granite Reef Dam: Seasonal Discharge-Frequency Analysis Results, *Existing Conditions*, Based upon graphical curves, January - March, Computed Probability

INITIAL DEVELOPMENT OF ANNUAL SEASONAL CURVE (JAN-MAR) USING CULLED DATA FOR THOSE MONTHS

Q, cfs	Pr(Jan)	Pr(Feb)	Pr(Mar)	Pr(J)+Pr(F)+Pr(C)	Pr(J)xPr(F)	Pr(J)xPr(M)	Pr(F)xPr(M)	Pr(J)xPr(F)xPr(M)	Pr(CombAnn)	Pr, %	Pr(Annual Max), %
250,000	0.00237	0.00379	1.72957E-05	0.00617	8.960E-06	4.094E-08	6.5474E-08	1.54976E-10	0.00616	0.62	0.20
200,000	0.00437	0.00713	1.12526E-04	0.01162	3.120E-05	4.923E-07	8.0262E-07	3.51123E-09	0.01159	1.16	0.55
150,000	0.00809	0.01344	7.32098E-04	0.02226	1.087E-04	5.919E-06	9.8390E-06	7.95521E-08	0.02213	2.21	2.00
125,000	0.01099	0.01845	1.86736E-03	0.03131	2.028E-04	2.053E-05	3.4449E-05	3.78659E-07	0.03105	3.10	3.00
100,000	0.01494	0.02532	4.76305E-03	0.04503	3.784E-04	7.118E-05	1.2061E-04	1.80237E-06	0.04446	4.45	5.00
75,000	0.02032	0.03476	1.21491E-02	0.06722	7.062E-04	2.468E-04	4.2230E-04	8.57909E-06	0.06586	6.59	7.30
50,000	0.02762	0.04771	3.09885E-02	0.10632	1.318E-03	8.559E-04	1.4786E-03	4.08355E-05	0.10271	10.27	12.00
25,000	0.03755	0.06549	7.90422E-02	0.18208	2.459E-03	2.968E-03	5.1768E-03	1.94372E-04	0.17167	17.17	18.00
20,000	0.03993	0.06978	9.53215E-02	0.20502	2.786E-03	3.806E-03	6.6513E-03	2.65554E-04	0.19205	19.20	20.00
15,000	0.04245	0.07434	1.14954E-01	0.23175	3.156E-03	4.880E-03	8.5458E-03	3.62804E-04	0.21553	21.55	23.00
10,000	0.04514	0.07920	1.38629E-01	0.26298	3.576E-03	6.258E-03	1.0980E-02	4.95669E-04	0.24266	24.27	27.00
5,000	0.04800	0.08438	1.67180E-01	0.29957	4.051E-03	8.025E-03	1.4107E-02	6.77191E-04	0.27405	27.41	32.00

Notes:

Pr(J) = probability that a *January* event will be >, = the reference discharge, Q
Pr(F) = probability that a *February* event will >, = the reference discharge, Q
Pr(M) = probability that a *March* event will >, = the reference discharge, Q
Pr(Comb Ann) = probability that the combination of the seasonal events will be >, = the reference discharge, Q

Calculation of January - March Adjustment

Q, cfs	Pr(CombAnn)	Pr(Annual Max)	Adjustment Δ	Σ, Jan-Mar	Adj/Σ
250,000	0.00616	0.00200	0.00416	0.00617	0.67437
200,000	0.01159	0.00550	0.00609	0.01162	0.52388
150,000	0.02213	0.02000	0.00213	0.02226	0.09582
125,000	0.03105	0.03000	0.00105	0.03131	0.03353

ADJUSTMENT OF MONTHLY CURVES BASED UPON COMPARISON OF COMBINED RESULTS W/ ANNUAL MAXIMUM CURVE									
Unadjusted Probability				Incremental And Adjusted Monthly Probability					
Q	Pr(Jan)	Pr(Feb)	Pr(Mar)	Δ, Jan	Adj., Jan	Δ, Feb	Adj., Feb	Δ, Mar	Adj., Mar
250,000	0.00237	0.00379	1.7296E-05	0.00160	0.00077	0.00255	0.00123	1.16637E-05	5.63192E-06
200,000	0.00437	0.00713	1.1253E-04	0.00229	0.00208	0.00374	0.00340	5.89502E-05	5.35759E-05
150,000	0.00809	0.01344	7.3210E-04	0.00077	0.00731	0.00129	0.01215	7.01483E-05	6.61950E-04
125,000	0.01099	0.01845	1.8674E-03	0.00037	0.01062	0.00062	0.01783	6.26180E-05	1.80474E-03
100,000	0.01494	0.02532	4.7631E-03		0.01494		0.02532		4.76305E-03
75,000	0.02032	0.03476	1.2149E-02		0.02032		0.03476		1.21491E-02
50,000	0.02762	0.04771	3.0989E-02		0.02762		0.04771		3.09885E-02
25,000	0.03755	0.06549	7.9042E-02		0.03755		0.06549		7.90422E-02
20,000	0.03993	0.06978	9.5321E-02		0.03993		0.06978		9.53215E-02
15,000	0.04245	0.07434	1.1495E-01		0.04245		0.07434		1.14954E-01
10,000	0.04514	0.07920	1.3863E-01		0.04514		0.07920		1.38629E-01
5,000	0.04800	0.08438	1.6718E-01		0.04800		0.08438		1.67180E-01

Notes:

Adjustments calculated in previous table for discharges between 125,000 cfs and 250,000 cfs are applied proportionally to the probability of each monthly occurrence. That is the "adjustment/summation" is multiplied by the probability for each month to estimate the monthly adjustment to the probability (Δ). That (Δ) was then subtracted from the monthly probability to determine the "adjusted" monthly probability. Probabilities for discharges < 125,000 cfs did not require adjustments.

1249

Figure 7, below, depicts the January to March data, **adjusted monthly curves**, and the resulting integrated (Combined-Population), seasonal discharge-frequency curve.

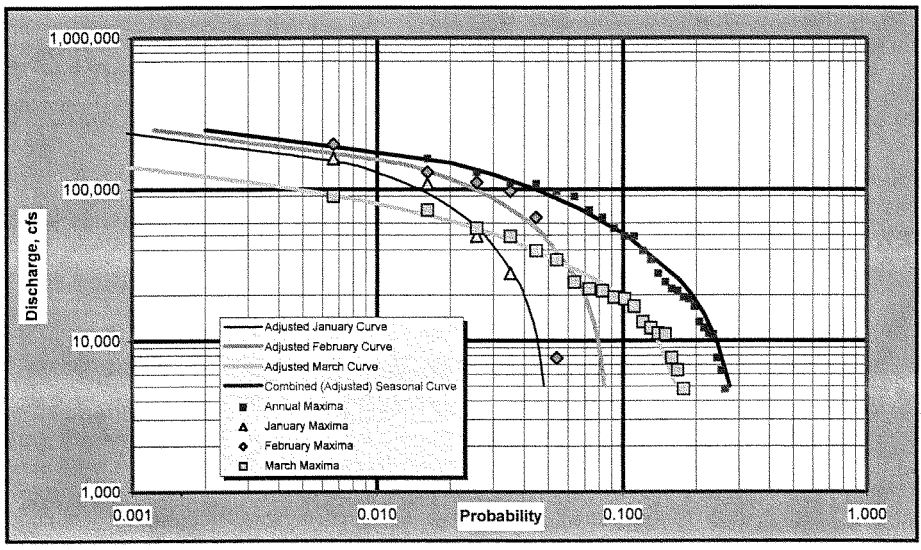

Figure 7. January – March Monthly Discharge-Frequency Curves (adjusted), and Combined Seasonal (Adjusted) Curve (Jan-Mar) w/ Simulated Monthly and Annual Maxima - FINAL RESULTS, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Annual maximum and monthly (viz. January to March) discharge-frequency values for two locations, one at the upstream end of the study area and the other near the downstream end are displayed in Table 6, which follows. Based upon hydraulic analysis of the Salt River in the study reach, discharges of approximately 160,000 ft^3/s may exceed the channel capacity. As indicated in Figure 6, a flood peak of this magnitude has less than a 0.2% chance of being equaled or exceeded in any year during the months of April and December (< 1 chance in 500, or a flood > 500-year return period). Hence, no discharge-frequency values are included for the remaining months because the flood threat is nearly non-existent.

Table 6. DISCHARGE FREQUENCY VALUES FOR THE SALT RIVER

LOCATION	RETURN PERIOD						
	500-YR	200-YR	100-YR	50-YR	20-YR	10-YR	5-YR
Annual Maximum Discharges (ft^3/s) in Salt River at:							
CP-40	250,000	210,000	**175,000**	**150,000**	100,000	60,000	22,000
CP-109	246,000	207,000	172,000	145,000	95,000	58,000	21,000
Annual Maximum Discharges (ft^3/s) in Salt River below Granite Reef Diversion Dam for Month of::							
Jan	200,000	160,000	130,000	79,000	~2500	< 1000	~0
Feb	220,000	190,000	160,000	110,000	46,000	< 1000	~0
Mar	120,000	99,000	80,000	62,000	37,000	19,000	~2500

NOTES:

Spill from Granite Reef Diversion Dam results in Flow in Salt River approximately once in three years. The flow may occur for continuous durations of several weeks, and sometimes months, or sporadically over those same durations. During other times the river is dry, except for locally wetted areas near side drains.

- *CP-40 is the upstream end of the study reach.*
- *CP-109 is above the downstream end of the study reach*
- *Discharges highlighted indicate flow might break out from channel. Note this happens at/around the 0.5 % annual chance in January and at/around the 1.0 % annual chance in February. For any other month the annual chance is < 0.2 %. The annual chance of a any flow exceeding the channel capacity is between 1% and 2 %, and the annual chance of a flow exceeding the channel capacity during the months of January through March is the same. The months of January through March are the most flood-prone months of the year from the perspective of "damaging discharges". Further information on the monthly flood threat is available in a series of tables/charts summarizing the frequency and volume of spills over Granite Reef Diversion Dam.*

DEFINITIONS:
CP-40, at Granite Reef Diversion Dam
CP-109, at Gilbert Road

c) *SEASONAL DATA* Separation of streamflow data and resulting discharge-frequency relationships across artificial boundaries, such as months, can be misleading. A flood event in January might just as likely occurred in February or December. If the agent causing the floods changes in the same temporal cycle, then the resulting runoff can be differentiated in a meaningful way. In the case of the Salt River watershed, spills result from accumulated antecedent effects during the runoff season and even prior runoff seasons. In addition spills are also the result of instantaneous response to intense rainfall and/or snowmelt. Based upon the preceding discussions, it is preferable from a hydrologic viewpoint to develop a seasonal discharge-frequency relationship; especially because in the case of the Salt River watershed, the flood threat (i.e., high peak discharges) is nearly completely reflective of the flood threat during the hydro-meteorologically similar months of January through March. Hence, the monthly discharge-frequency curves generated for January through March were integrated to provide a Combined-Population discharge-frequency relationship for the Salt River below Granite Reef Diversion Dam. This combined curve better characterizes the flood threat during the season than a differentiated monthly curve might. Whether this seasonal curve adequately describes damages to a variety of crops and crop cycles is an issue to be addressed within the economic framework of this or any other study.

Table 7, following page, summarizes the integration of the monthly discharge-frequency relationships into a Combined-Probability relationship.

Table 7. Salt River below Granite Reef Diversion Dam: Adjusted Seasonal Discharge-Frequency Analysis Results, based upon graphical curves, January - March										
				Computed Probability						
Q	Pr(Jan)	Pr(Feb)	Pr(Mar)	Pr(J)+Pr(F)+Pr(M)	Pr(J)xPr(F)	Pr(J)xPr(M)	Pr(F)xPr(M)	Pr(J)xPr(F)xPr(M)	Pr(CombAnn)	Pr, %
250,000	0.000771	0.00123267	5.63192E-06	0.002009	9.50097E-07	4.34087E-09	6.94232E-09	5.35087E-12	0.0020081	0.20
200,000	0.002083	0.00339603	5.35759E-05	0.005532	7.07355E-06	1.11592E-07	1.81945E-07	3.78971E-10	0.0055251	0.55
150,000	0.007311	0.01215177	0.00066195	0.020124	8.8837E-05	4.83927E-06	8.04386E-06	5.88056E-08	0.0200227	2.00
125,000	0.010623	0.01782931	0.001804738	0.030257	0.000189407	1.91723E-05	3.21772E-05	3.41829E-07	0.0300170	3.00
100,000	0.014943	0.02532278	0.004763051	0.045029	0.000378407	7.11759E-05	0.000120614	1.80237E-06	0.0444608	4.45
75,000	0.020315	0.03475963	0.012149075	0.067224	0.000706151	0.000246812	0.000422297	8.57909E-06	0.0658573	6.59
50,000	0.027618	0.04771325	0.030988547	0.10632	0.00131776	0.000855852	0.001478564	4.08355E-05	0.1027088	10.27
25,000	0.037547	0.06549419	0.079042235	0.182083	0.002459092	0.002967776	0.005176807	0.000194372	0.1716738	17.17
20,000	0.039925	0.06977753	0.095321488	0.205024	0.00278588	0.003805727	0.006651298	0.000265554	0.1920468	19.20
15,000	0.042454	0.07434099	0.114953557	0.231749	0.003156095	0.004880274	0.008545761	0.000362804	0.2155295	21.55
10,000	0.045144	0.0792029	0.138628976	0.262976	0.003575509	0.006258219	0.010979817	0.000495669	0.2426577	24.27
5,000	0.048003	0.08438279	0.167180498	0.299567	0.004050657	0.008025226	0.014107156	0.000677191	0.2740608	27.41
				Notes:						
Pr(J) = probability that a *January* event will be >, = the reference discharge, Q Pr(F) = probability that a *February* event will >, = the reference discharge, Q Pr(M) = probability that a *March* event will >, = the reference discharge, Q Pr(Annual) = probability that the combination of the seasonal events will be >, = the reference discharge, Q										

1253

Finally, Figure 8 compares the annual maxima, and annual maximum discharge-frequency curve to the integrated cold-weather curve for the months of January through March. The results indicate that the flood threat in the Salt River is almost entirely contained within the months of January through March. The flood threat from the remaining months only affects the discharge-frequency relationship at about the 5% annual chance or 20-year level (refer to Figure 8 below, and Table 8, which compares the annual maximum relationship to the integrated monthly relationship, Jan. to March). As indicated in Table 6, discharges associated with the 20-year event will not escape the Salt River channel and flood agricultural areas in the overbank.

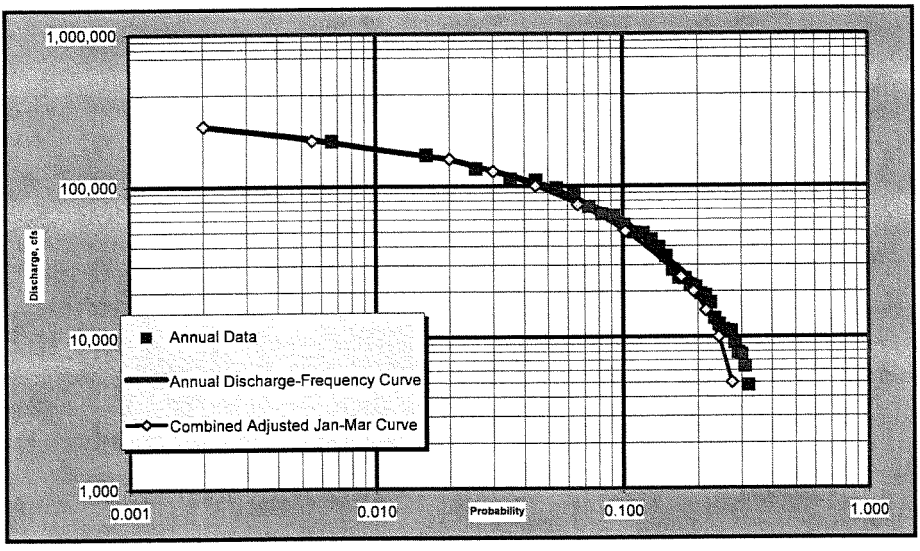

Figure 8. January – March Seasonal Discharge-Frequency Curve (adjusted) vs. Annual Curve, Salt River below Granite Reef Diversion Dam, *Existing Conditions*.

Consideration was given to inundation-duration frequency relationships[10], *since damage may be more the function of sustained rather than instantaneous flooding*, but since the recurrence interval associated with peak discharges is so infrequent (< 2% annual exceedance chance for the January to March season, and < 1% annual exceedance chance for the individual months, this aspect of the discharge-frequency relationships for agricultural damages was not considered critical to agricultural damage potential. In fact, as shown in Table 9, the chance of a damaging discharge being exceeded for even 1-day is between 0.5 and 0.2 % *in any given year*, or between a 200-year and 500-year event. The probability of this occurring during any month would be ≤ to the annual exceedance probability, or very remote.

[10] Defined as a reference discharge, exceeded for a specified duration, at a specified return period. For example, from Table 9, a discharge of 100,000 ft^3/s is exceeded for 1-day during a 100-year event, or has a 1% chance of being exceeded for a day during any given year (or a 0.2% chance of being exceeded for 3 consecutive days during any given year).

Table 8. Comparison of Annual Maximum Series Results to Combined January - March Results. Salt River below Granite Reef Diversion Dam		
Q	Pr E > Q, (Annual Max)	Pr E > Q, (Combined Monthly)
cfs	%	%
250,000	0.20	0.20
200,000	0.55	0.55
150,000	2.00	2.00
125,000	3.00	3.00
100,000	5.00	4.45
75,000	7.30	6.59
50,000	12.00	10.27
25,000	18.00	17.17
20,000	20.00	19.20
15,000	23.00	21.55
10,000	27.00	24.27
5,000	32.00	27.41

TABLE 9. INUNDATION-DURATION-FREQUENCY: SALT RIVER NEAR CENTRAL AVE.							
DURATION	FREQUENCY, years						
	500	200	100	50	20	10	5
DISCHARGE EXCEEDED FOR SPECIFIED DURATION, SALT RIVER AT CENTRAL AVENUE[1], ft³/s							
Peak[2]	240,000	202,000	166,000	135,000	87,000	53,000	20,200
1-Day	190,000	145,000	100,000	70,000	40,000	21,000	8000
3-Day	100,000	75,000	60,000	40,000	22,000	11,000	3500
5-Day	70,000	55,000	40,000	29,000	15,000	7000	2100
10-Day	46,000	33,000	25,000	18,000	10,000	5200	1500
30-Day	25,000	19,000	15,000	10,000	5300	2700	800
60-Day	14,000	9000	7000	5000	2800	1400	(0)[3]

Note:
Values highlighted in blue represent discharges that might break out of the channel in the VSA study area.

[1] Discharges exceeded for specified frequencies, with durations greater than or equal to 1-day, are approximately equal throughout *Río Salado* project reach. Central Avenue is used as a reference location.

[2] Values from Table 2-4, Reference a).

[3] During the 5-year event, the upstream release from the Salt River Project reservoirs does not last for 60-days. A flow rate of approximately 200 ft³/s is exceeded for 53-days during this event. Results are based upon simulation of Balanced Hydrographs. Please refer to previous note for the information source.

1255

REAL ESTATE

Real Estate Appendix
Va Shly'Ay Akimel Environmental Restoration Study
Date: April 12, 2004

Salt River, Phoenix, Arizona

1. Abstract of Project Data:

Project Name: Va Shly'ay Akimel, Salt River Restoration

The Native American names of this project signify "River People"

Location: Mesa and Salt River Pima-Maricopa Indian Community, Arizona

Project Purpose: Environmental Restoration

Acreage: all project acreage is to in fee simple and allocated to environmental restoration.

City of Mesa:	100	acres
SRPMIC	4003	acres
Total	4103	acres

Project Sponsors: City of Mesa and Salt River Pima-Maricopa Indian Community, Arizona
Two sponsors: each for their respective lands and project component.

2. Introduction:

This project is aimed as environmental restoration of the riparian area along this segment of the Salt River below Granite Reef Dam. This reach of the river has experienced extensive degradation compared to the natural river system due to human intervention and development. Granite Reef Dam immediately upstream of the study reach is the main diversion works for the Salt River Project that is the central reclamation project for municipal water supply and irrigation for Maricopa County. From Granite Reef Dam the stored waters of the river are diverted and delivered into three major canal systems providing irrigation water to the valley. The Salt River Project is a collaborative effort between the Bureau of Reclamation and a local organized municipal water and irrigation district (Salt River Project of Arizona- SRP)). The project was organized and undertaken in the early 1900's as a Federal Reclamation Project. The Salt River has been extensively modified including the construction of three major Bureau of Reclamation/SRP dam and reservoir projects. The project area is immediately downstream of last irrigation /water supply diversion dam on the system, Granite Reef Dam. Further development and urbanization of this area has resulted in subsequent degradation of the natural system. Current uses include sand and gravel extraction operations and other industrial uses. The land inside the study area generally is under the influence of the floodplain and river channel. This influence tends to limit development potential. In addition past uses have included several sites generating or utilizing potentially hazardous and toxic waste and previous landfill sites that have further contributed to the degradation of the area.

Overall project purposes or planning objectives.

With the new emphasis nationwide on environmental restoration and sustainable and beneficial environmental projects, this project is aimed at habitat restoration and prompting a balanced and harmoniously functioning riparian system. The purpose of the currently proposed project is to restore the riparian habitat and the holistic functioning of the riparian corridor and river system. The Federal interests would be aimed primarily at environmental, increasing habitat values and diversity with some potential for incidental benefits to floodplain management, better flood conveyance and improved functioning of the river system . Such benefits and improvements are now called Hydro-geomorphic system benefits. Incidental recreation and increased awareness or appreciation of natural and cultural resources may also be derivative benefits of such a project.

3. Authority:

The statutory authority for this project is contained in the following enacted laws:

Section 6, Public Law 761, Seventy-fifth Congress, dated June 28, 1938, which reads, " The Secretary of War is hereby authorized and directed to cause preliminary examination and surveys at the following locations..... Gila River and Tributaries, Arizona."

Additional authority was provided in the Energy and Water Development Appropriations Act of 2001 (P.L. 106-377 dated October 17, 2000), which provided $150,000 to the Corps of engineers to evaluate opportunities for environmental restoration on the Salt River.

Authority for project implementation will be sought in an upcoming Water Resources Development Project as a separately authorized civil works project.

4. Purpose of this Report:

This report is submitted as the Real Estate Plan to support the decision document that is a full feasibility report that will serve as the basis for eventual authorization in the next Water Resources Development Act.

5. Indian Community Lands:

The land principally upon the north or right bank of the study area is within a Reservation, now called a Community, established by Federal Treaty. This community is now designated the Salt River Pima-Maricopa Indian Community (SRPMIC). This is a self governing, sovereign entity created and governed through treaty obligations and responsibilities of the United States and the Tribe. Because they are a distinct sovereign entity, the Community will not subsume their sovereignty to a lesser sovereign. Due to the unique aspects of law that govern Native American peoples and their lands, and their unique treaty relationship with the Federal government, the Community (SRPMIC) must be contracted with as the official local sponsor for the project as situated on Community lands. Full project Sponsorship and participation by the SRPMIC is the only mechanism that will ensure that the tribal reservation lands can be made available for the construction, operation, maintenance, repair and replacement of the project.

As of this writing, the governing Tribal council is considering and reviewing input from the tribal Community including environmental reviews and public information meetings and forums before deciding to proceed with the actual implementation of the proposed environmental restoration

project. This is expected to coincide with the Corps public comment period and final approval of the feasibility report.

6. Estates:

The prescribed estate for environmental restoration projects is fee simple title: This is prescribed by ER-405-1-12, chapter 12. The recommended estate is fee simple.

The Non Federal Sponsors will need to issue a right-of-entry to the Corps of Engineers, its agents, contractors, etc. to enter upon the lands it owns or controls for purposes of constructing the Project. This is a standard Non-Federal Sponsor responsibility as included in a Model PCA.

7. Federal Lands, Interests or Reservations:

There are no Federally owned lands within the study area.

8. Navigational Servitude:

The riverbed is usually dry and is not considered a navigable waterway. The river has been harnessed and developed for irrigation, hydro-electric power, flood control and municipal water supply projects. Three major dams have been constructed under the auspices of the "Salt River Project" a project undertaken by the Bureau of Reclamation and the Salt River Project, a local municipal corporation organized for operating and maintaining irrigation, municipal water supply and electric generation and supply as a public utility concern. Although the river does not support navigation, there may be some Federal interests in the regulation and use of the water, flood control and regulations on the river and water resources of the Salt River, including environmental regulations relevant to water resources. This Federal interest is indicated by the prior Federal experience and authorities in participating in major projects for regional irrigation, flood control, and other purposes on the Salt River. Federal regulations and control is exercised through various programs and sections of the Clean Water Act and through the various programs of FEMA within the 100 year floodplain including the National Floodplain Insurance Program and the Floodplain Hazard Elimination Program.

The water to supply the proposed environmental restoration features in the riverbed will originate from Granite Reef Dam and is allocated to the SRPMIC as an adjudicated water right deriving from their historic use on the Salt River. This is a Federally assisted project constructed under authorization of the Bureau of Reclamation and operated locally by a municipal corporation, the Salt River Project. Irrigation is an authorized purpose of that project.

Given these considerations there are no outstanding water rights issues governing the use or allocation of the water to restore this portion of the Salt River. Further, there may be some modifications or measures that could be done in the natural river system, where the use or regulation of water or water resources would not result in a "taking" of property or property rights, such as regulations enforced through the Clean Water Act.

9. Description of Lands:

The study area includes the Salt River below Granite Reef Dam. The land includes the SRPMIC and some portions are within the City of Mesa . The study area runs from Granite Reef for approximately 14 miles to the Pima Freeway- Arizona Route 101. The land can be best described as the river corridor and floodplain. On some portions of the project terraces or banks

that are situated above floodplains influences may be incorporated into the project and used for ecosystem restoration. The lands are all undeveloped with the principle economic or industrial use being sand and gravel extraction. Typically these operations occupy leased land of the SRPMIC. Should any such areas be incorporated into the project it will the responsibility of the SRPMIC to extinguish or otherwise terminate the mineral extraction rights or leases.

Since the land is generally in a floodplain or if out of the actual floodplain inside the river corridor, there has been no development and the land lies mostly vacant and unimproved. There will be no residential or businesses to relocate.

10. Acquisition Authorities and PCA Responsibilities:

The Community (SRPMIC) is a sovereign self governing entity with the capability to hold title to lands and property within the bounds of its territorial reservation established by Federal treaty.

As to the City of Mesa that may be acquiring some of the lands along the left bank of the Salt River, the City of Mesa is a duly organized municipal corporation in the State of Arizona and is vested with sufficient power to acquire and hold title, and to condemn lands as needed for public purposes.

At this point in project formulation, it has been determined that the project will entail two components and two sponsors: the SRPMIC and the City of Mesa will sponsor their respective components of the project. Each sponsor will enter into its own PCA to implement its respective components as located within areas within their respective jurisdictional boundaries.

At this time in project formulation, we are aware of no unusual requirements or non-standard terms or articles for these prospective PCA's. The PCA for each sponsor will contain the standard responsibilities as set forth on the governing standard PCA for environmental restoration applicable at the time of project implementation and as negotiated with the Non Federal Sponsors.

11. Project Maps:

Project maps have been included in the main body of this feasibility report.

12. Land Value Estimate:

A gross appraisal, in four separate appraisal reports for 4 reaches or segments, has now been obtained and provided to Real Estate Division on April 12, 2004. The report carries a submittal date by the appraiser of Mach 26 and a date of valuation of February 27, 2004. Due to the limited time allowed between mandated project milestones, these appraisal reports have not yet been reviewed by the Corps of Engineers. Thus we are providing a disclaimer and caveat the no guarantee or representation should be made by these estimates as to the actual approved LERRD crediting that might be available to either Non-Federal sponsor. The actual crediting will be governed by separate appraisals after a PCA is signed and when the final crediting determinations as provided in those PCA's are accomplished and approved.

There is another source of uncertainty in the LERRD estimate as to the potential impact of any HTRW in the project area. A fuller discussion of the HTRW considerations is at paragraph 21 here and in the separate Geotechnical Appendix of this Feasibility Report.

For the SRPMIC component of the project there are 4003 acres to be contributed toward the project at fee simple value with a total gross appraisal estimate of $ 21, 750,000

This is an estimate of potential project costs only and is not a representation of actual credit that may be approved for this project component

For the City of Mesa component there are 100 acres to be contributed toward the project at fee simple value with a total gross appraisal estimate of $2, 260,000

This is an estimate of potential project costs only and is not a representation of actual credit that may be approved for this project component

Note: The gross appraisal reports submitted as of March 26, 2004 have not yet been reviewed by Corps reviewing appraisers as of the writing of this appendix. Any such estimates are preliminary in nature pending such review and approval and are subject to revision. Crediting appraisals will be used to approve any actual LERRD credits to be applied to an approved project.

13. Crediting for LERRD's:

Crediting will follow standard procedures as set out in a model Project Cooperation Agreement. Credit for Community lands and interests will be determined by an appraisal of such interests as if available and appraised for the "fair market value" and highest and best use, etc, by standard appraisal practices assuming such lands can be sold on the "open market". This issue has a precedent in the planning and development of the Tres Rios Environmental Restoration project, also in Maricopa County but involving the separate Gila River Indian Community. On that project this issue was resolved in the determination that tribal lands should be valued at "fair market value", as this term is applied in standard appraisal practices and in a Model PCA.

14. Facility Relocations:

Because the project lies in a vacated area , a wash and riverbed, no utilities or roads are likely to be affected or relocated. The principle aims of the project are to invest in environmental restoration benefits and so a guiding principle of the plan formulation and project design would be that the existing major utility installations and infrastructure would be are allowed to remain in place and that design work around these facilities.

Subsequent research of utilities or public facilities will be done in subsequent phases of the project and if approved for implementation, during project "PED" or Pre-Construction Engineering and Design.

Note: The following policy statement and disclaimer concerning any potential facility relocations prevails over any other statement, description or presentation in this report. Any conclusion or categorization contained in this report that an item is a utility or facility relocation to be performed by the Non Federal Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation and maintenance of the project after further analysis. A Final Attorney's Opinion of Compensability would be provided if necessary to address any such relocations added to the project as a result of this analysis.

15. Mineral Activity:

There is some sand and gravel extraction in the project area. However these operations are under leases with the sponsor, the SRPMIC. The continuance or discontinuance of these mineral extraction operations are under the control of the Non-Federal sponsor. Where there is a common variety mineral extraction potential (sand and gravel and the like) the project real estate estimate has considered the residual value attached to minerals for any and all required lands that are needed for project implementation.

16. Estates:

Acquisition of real estate environmental restoration purposes will be in fee simple title. This is the recommended estate needed to construct and implement the project, including operation, maintenance, repair, replacement and sustainability.

17. Construction Induced Flooding:

As this creek is a dry wash most of the time appropriate measures will be taken for the care and diversion of water, if any, during construction and there will be no construction induced flooding outside the project take areas.

18. Cost Estimate:

The revised cost estimate according to the recent gross appraisal reports for the respective components are:

City Of Mesa: LERRD's	$2,260,000	
Incidentals, Admin/Contigency 10%	$226,000	
		$2,486,000
SRPMIC LERRD's	$21,750,000	
Incidentals. Admin/Contigency 10%	$2,175,000	
		$23,925,000
Total both components:		**$26,411, 000**

Administrative and contingent costs are considered to be nominal part of total costs as the SRPMIC already owns all of their lands needed for the project and the City of Mesa only needs to acquire one additional parcel of 47 acres in the riverbed for the project. Thus, the 10 percent allocation to such expenses is deemed adequate.

19. Relocation Assistance (URA Relocations):

All property acquisitions will be accomplished in accordance with Public Law 91-646, as amended, and the Uniform Regulations as promulgated by the U.S. Department of Transportation. The property is unimproved and it does not appear that any displacements of businesses or residences will be required due to the design and configuration of the project. There appears to be only one additional tract needed to be acquired for the project of approximately 47 acres that would be acquired by the City of Mesa. The city of Mesa will be required to follow all applicable land acquisition and appraisal policies of Public Law 91-646, as amended, and the Uniform Regulations in their acquisition of this property. The plan would be to purchase this property after sand and gravel extractions have been "played out" and the business has already terminated operations at that specific location.

20. Other Matters:

No timber activity affects these lands. The sponsor is not using any zoning ordinances in lieu of acquisitions of lands or easements within the project areas.

21. Hazardous Waste Assessments:

The Geotechnical Appendix mentions several possible sources of hazardous waste that could affect the project area, however in reading the treatment on this subject in the Geotechnical appendix there was either insufficient testing or inconclusive results as to the presence or possible migration of hazardous and toxic waste into the project areas. For example on page 34 on the Geotechnical Appendix ,it reads":

"Available data are highly inconclusive regarding whether or not any released contaminants from Talley Defense Systems operations have impacted the currently (early 2004) planned environmental restoration features of the Va'Shly Akimel study area."

On Page 22 of the Geotechnical appendix it reads:

"The first stage inventory and site assessment identified "over 50 different sites of development and or utilization (sic: of potential HTRW)....in the study area. "

Table 4 of the Geotechnical Appendix on pages 51 and 52 lists 24 "Non_Hazardous Waste and Debris Sites Catalogue" , essentially solid waste sites , illegal dumping and past landfill sites that have been located within the project area.

It is apparent from the full discussion and recommendations contained in the Geotechnical Appendix that there is a risk of finding or uncovering HTRW substances or mixed substances in soil or substrates within the project area. It also expresses the concern of groundwater contact with any such substances or waste zones and the potential leaching or migration of any such contaminants. The study team has recommended additional testing and study in this area during Preconstruction Engineering and Design in the hopes of avoiding areas of HTRW or contaminated soils or substances. Any such areas that eliminated and not used as project lands would not be eligible as LERRD contributions. Such lands that are deemed surplus to project needs do not receive credit according to a PCA.

The potential presence of any HTRW substances in the project area, the required cost for remediation and clean up, and any impact on any market value of any of the project lands, are all unknown. The presence and number of potential sites where such substances were used, generated or dumped in the project area is yet one more factor underlying the uncertainty of the LERRD estimate.

The PCA conditions contain specific terms and conditions governing the sponsor's responsibility for environmental cleanup for CERCLA regulated substances.

In light of the possibilities for environmental contaminants in the study area as characterized in the Geotechnical Appendix, the Non Federal Sponsors must be fully informed of their responsibilities to address any remediation or removal of CERCLA regulated substances that might be discovered or unearthed during construction operations, and the possibly impact on continuance of project construction should such contamination be uncovered on the project lands.

The information contained here in the real estate appendix is provided as information and disclosure as to the known information and data as to HTRW sources and the possible impacts

on projects lands, land acquisition and valuation. The professional recommendations and findings to date on HTRW aspects are contained in the Geotechnical Appendix and the reader is referred there for the scientific data and findings and recommendations as to the handling and disposition of HTRW related matters.

The affects on acquisition of subject properties fall upon the City of Mesa as the SRPMIC lands are already owned by the Community and DO NOT require land acquisition. However the City of Mesa will be required to purchase a rock and gravel operation in the area designated for "annexation by the City of Mesa"

In light of the known potential for HTRW soils or substrates or waste that could be found in the project area, it is strongly recommended that the City Of Mesa require the present owner-operators to remediate and obtain all required certifications that contaminants have been remediated below applicable threshold levels for clean up. Further the City of Mesa, as Non Federal Sponsor will be responsible for any remediation or clean up of HTRW materials found on project lands that it owns or acquires and that such costs are not a cost share or project costs. The City of Mesa must be fully appraised of its responsibilities vis - a - vis the clean up, remediation and removal of hazardous waste materials as their sole responsibility; and that the clean up of such materials IS NOT an objective of the proposed Corps project.

Similarly, the SRPMIC must be advised that the Federal project for environmental restoration has as its objective the restoration of riparian habitat values, not the remediation of contaminants; and that the SRPMIC, as Non Federal Sponsor will be responsible for any remediation or clean up of HTRW materials found on project lands, as specified in the Project Cooperation Agreement, and that such costs are not a cost share or project costs.

22. Recreation:

There are no separable recreation lands. All of the land "blocked out" in the project footprint is required for environmental restoration features. The real estate requirements are based on designated floodplain and floodway limits and borders, parcel boundaries and considerations of avoiding uneconomic remnants or severance damages. The authorized Federal project will be for the purposes of environmental restoration.

To respond to another review comment on the use of recreation trails or features by members of the general public, it has now been determined that any recreation trails or facilities constructed with Federal assistance and funds will be available for use and enjoyment by the general public. This is consistent with policy on Corps-assisted projects in order that these benefits accrue to the public without restriction or discriminative affect.

23. Attitude of Landowners:

There is not expected to be a high degree of landowner opposition to the project. There appears to be only one ownership that needs to be acquired by the City of Mesa on its component. All other lands are already owned by City of Mesa or SRPMIC.

24. Report Content:

This report follows the requirements of ER-405-1-12, Chapter 12 and has been prepared using the information on the project formulation that has been provided. Revisions and amendments stemming from Independent Technical Review and HQ policy review have been incorporated and addressed.

RECREATION

Va Shly'ay Akimel
Salt River Restoration Project
Recreation Analysis
April 6, 2004

1.0 Introduction

The goal of the recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge, and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of the Salt River on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the study area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle, or on horseback.

Recreational components that were considered for this project have been limited to trails and a Cultural Center. More aggressive recreational components, such as recreational lakes, sporting centers, sports fields, etc., were rejected as out-of-harmony with the character of this project. The following section (Section 1.1) discusses the general nature of the planned trails. Section 1.2 discusses the Cultural Center. Later sections discuss how various trail alignments were combined with the Cultural Center to create recreation plan alternatives, referred to herein as "Recreation Options". Three options are then presented for consideration.

2.0 Trails

2.1 Description of Trail Amenities

The trails are proposed as multi-use trails, available for access by pedestrians, bicyclists, wheelchairs, and equestrians. Motorized vehicles would be prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

Access to the trails would be available to both SRPMIC Community members and also to non-Community members. Use of the trails would be limited to daylight hours and after dark lighting will not be available along the trails or at the rest stops.

The following design elements are currently anticipated for the trails:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar
- Trail lined with boulders or curbing to define the trail location. (Curbing along both sides of the trail assumed for costing purposes)

- Parking lot and trailhead with appropriate signage at major access points. For costing purposes, one such parking lot is assumed for every four trail miles.

- Mileage markers every 1/4 mile

- Plaques or similar markers or signs at significant project feature locations to educate the public relative to cultural, biological or environmental aspects of the project.

- Concrete benches approximately every quarter mile

- Rest stops spaced at approximately one per mile, each perhaps overlooking a significant project feature. Each rest stop is currently envisioned as including a 12'x12' shade structure constructed on a concrete pad, one metal picnic table, two trash receptacles, a bike stand, low height masonry wall, and a stand alone plaque or other signage to discuss a nearby project feature or to present other historical, cultural or educational material.

- As appropriate, incorporate art that highlights the cultural, historical or environmental aspects of the project into the design of such things as bike racks, rest stations, shade structures, signage, etc.

- Gates at the major access points, so that the trails can be closed at night and/or during maintenance activities.

- Guard posts or other barriers at access points to prevent unauthorized vehicular access.

- No fencing is currently contemplated.

- Signage at major street crossings, both to identify the street and to identify the trail

- At bridged crossings, the trail will cross under the bridge to avoid conflict with vehicular traffic on the roadways. At unbridged crossings (e.g., McKellips Road), the project will include construction of a refuge island in the middle of the roadway as a zone of protection for pedestrians. The project will not include pedestrian overpass bridges or traffic signals for pedestrian access.

Potable water is not available within the project boundaries. Therefore, drinking fountains and restrooms are not included.

Where possible, the trails have been designed to connect with the City of Mesa's existing trail system along the canals within the City of Mesa. Refer to Figure 1 (attached) for the City of Mesa's existing trail system.

2.2 Construction Costs for the Trails

The estimated construction cost of the trails, including the amenities described in the foregoing section and including a 15% design contingency, is approximately $420,000 per trail mile. The U.S. Army Corps of Engineers will verify the costs of the trails in the text of the main feasibility study report.

2.3 Operation and Maintenance Costs for the Trails

Based on City of Mesa experience with their trails, the operation and maintenance costs for the trails are anticipated to be approximately $50,000 per year per trail mile.

2.4 Trail Visitation Rates

The City of Mesa has several trails that are similar in design and use to the trails proposed for the project. There currently are no recorded data available for usage rates on the existing City of Mesa trails. Visitation estimates provided herein are based on City of Mesa Parks and Recreation staffers personal observations and estimates of trail use.

The City of Mesa Parks and Recreation staffers estimate that approximately 30 people per day will use each project trail mile in the summer (for the purposes of this section, "summer" is defined as June through September) and 45 people per day per trail mile in the winter (i.e., the rest of the year). This equates to an average usage rate for the entire year of approximately 40 people per day per trail mile.

The City of Mesa Parks and Recreation staffers also provided the following additional information about anticipated, estimated peak usage rates on the trail system. Peak days for trail usage are Saturday and Sunday. Peak hours for trail usage are estimated to be between 6 am and 9 am and again between 3 pm and 6 pm. The table below summarizes estimated usage during different peak and non-peak periods:

Trail Usage Period	**Visitors**
Average Winter Month Usage	45 users per day
Average Summer Month Usage	30 users per day
Usage Averaged Year-Round	40 users per day
Winter Peak Days (Sat & Sun)	70 users per day
Winter Non-Peak Days (weekdays)	35 users per day
Peak Hour on Peak Day in Winter	7.8 users per hour
Non-Peak Hour on Peak Day in Winter	3.9 users per hour
Peak Hour on Non-Peak Day in Winter	3.9 users per hour
Non-Peak Hour on Non-Peak Day in Winter	1.9 users per hour
Summer Peak Days (Sat & Sun)	46.7 users per day
Summer Non-Peak Days (weekdays)	23.4 users per day
Peak Hour on Peak Day in Summer	5.2 users per hour
Non-Peak Hour on Peak Day in Summer	2.6 users per hour
Peak Hour on Non-Peak Day in Summer	2.6 users per hour
Non-Peak Hour on Non-Peak Day in Summer	1.3 users per hour

3.0 Cultural Center

3.1 Description of Cultural Center

The concept for the Cultural Center comes from a programming document for a "Museum and Cultural Center", as provided to the project team by SRPMIC staff ("Museum and Cultural Center Conceptual Design 20% Submittal" by David N. Sloan and Associates, StastnyBrun Architects, Inc., and Native American Design Collaborative). The programming

document discusses a complex of several buildings that, taken together, comprise the Museum and Cultural Center (hereafter referred to only as the "Cultural Center"). The attached figure labeled "Schematic Design" shows the proposed layout of the Cultural Center. The individual buildings listed in the programming document are shown below with their estimated square footages:

Buildings included in the Programming Document	**Estimated Square Footage**
Museum	19,200
Cultural Education Center	10,200
Performing Arts Center	18,200
Food Services	7,900
Traditional Habitat Interpretive Center	4,000
Restored Environmental/Botanical Center	4,800
Total Square Footage	**64,300**

The project trail system will have ties and connections to the Cultural Center. Refer to the attached recreation option plans.

3.2 Costs and Eligibility for Cost-Sharing

Not all elements within the Museum and Cultural Center complex are eligible for cost-sharing by the USACE. It has not yet been determined which elements of the Cultural Center are cost-sharable and which are not. A preliminary list of cost-sharable items (subject to final determination) was obtained from Mike Hallisy, USACE Los Angeles District office, and is given below with the estimated costs of each element:

Design Element	**Additional Comments**	**Estimated Costs**
Museum: • Restrooms (only) in the Museum or as a stand alone building	Restrooms are a support feature for the trail system	• 615SF x $150/SF = $92,250
Habitat Interpretive Center: • Outdoor demonstration area only	Exact character of the outdoor demonstration area not yet determined	• 1050 SF x $15/SF for hardscape = $15,750
Ramadas and Outdoor Shelters	None	• 1 each x $15,000/ea = $15,000 (other ramadas are already built into the cost of the project trails)
Access Road and Parking	Limit cost to a small parking lot to support the trailhead, not the full cost of the parking lot for the Cultural Center	• Estimate $50,000 for a small parking lot
Utilities	Portion of the overall utility installation costs for the Cultural Center to support the restrooms	• Per programming document, "Site Utilities" for the Cultural Center are $207,000. Assume that approx. 20% of this could be related back to the restrooms = $41,000
Electrical lighting	For the parking lot, restrooms and ramadas	• $15,000

Miscellaneous: • Picnic Tables • Trash Receptacles • Benches • Signs	None	• Estimated at $35,000 for planning purposes.

Total Estimated Construction Cost of Cost-Sharable Improvements = $264,000

As shown in the foregoing table, the construction cost for cost-sharable items at the Cultural Center are anticipated to be in the range of $200,000 - $300,000 (costs to be verified by the U.S. Army Corps of Engineers in the main feasibility study report.) For reference only, according to the programming document, the total construction cost of the entire Cultural Center complex is estimated to be $10,978,600.

For the purposes of this report, it is assumed that USACE participation in the Cultural Center will be limited to the elements listed in the table above and that the non-federal sponsor will provide other funding to allow the remainder of the Cultural Center to be added to the project during the PED phase as a "betterment". The "betterment" will be entirely locally funded. The portion of the Cultural Center included in the project during the feasibility phase is limited to the cost-sharable items. The cost-sharable items (taken alone) are referred to hereafter as the "restroom/ramada facility", but it shall be understood that such term includes the parking lot and other associated improvements listed in the table above. Furthermore, where the recreation plans show a "Cultural Center", it shall be understood to mean a cost-sharable "restroom/ramada" facility that will be upgraded during PED to a Cultural Center (via a locally funded "betterment").

3.3 Operation and Maintenance Costs for the Cultural Center

The operation and maintenance costs discussed previously for the trail system ($50,000 per trail mile per year) are adequate to cover the minimal O&M costs for the restroom/ramada facility. The O&M costs for the upgraded Cultural Center are immaterial, since the upgrade to a full Cultural Center will be a "betterment" fully funded by the local sponsor. Economic justification for said "betterment" is not required in the feasibility study.

3.4 Visitation Rates for the Cultural Center

For the purposes of the feasibility study, visitation numbers will not be credited to the restroom/ramada facility as a stand-alone feature. (By itself, the restroom/ramada facility has little very "draw".) For the purposes of the feasibility study, the restroom/ramada facility is viewed as being part of the trail system, and will be justified based on the visitation numbers for the trail system.

Visitations for the upgraded Cultural Center are immaterial since economic justification of said "betterment" is not required in the feasibility study.

3.5 Location for the Cultural Center

In past iterations of this report, the Cultural Center has been shown at the southeast corner of the intersection of Dobson Road and McKellips Road, with an alternative location at the

southwest corner of Gilbert Road and the Beeline Highway. The USACE has since ruled that the Cultural Center must be within the limits of the river restoration project to be eligible for cost-sharing by the USACE. Therefore, the location at Dobson Road and McKellips Road has been discarded in favor of the location at the intersection of Gilbert Road and the Beeline Highway.

4.0 Recreational Options

Three recreation options are presented herein for consideration. Each option includes the Cultural Center location at the southwest corner of Gilbert Road and Beeline Highway and varies the trail alignments.

4.1 Option A

In Option A (figure attached), a trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. The City of Mesa's existing trail system is shown in Figure 1 (attached) for reference.

In Option A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete.

Option A also includes placement of a Cultural Center at the southwest corner of the intersection of Beeline Highway and Gilbert Road. A trail is included along Gilbert Road from the Cultural Center to Thomas Road. This connector trail would allow residents living south of the river to more easily access the Cultural Center and would also provide a tie between the Cultural Center and the trail along the south side of the river discussed above.

4.2 Option B

Option B is the same as Option A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive. This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly.

4.3 Option C

Option C includes all of the features of Option A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (Loop 101 Freeway) and Val Vista Drive. Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

5.0 Cost/Benefit Analysis

The USACE will perform the cost/benefit analysis that will be presented in the feasibility study report. The cost/benefit analysis is not presented here. However, based on preliminary calculations by the USACE, it appears as though all of the recreation options are economically justifiable.

6.0 Conclusion

It is anticipated that the SRPMIC Tribal Council and/or the SRPMIC voters (if the matter is referred to them by the SRPMIC Tribal Council) will make the final selection of the Recreation Option that will be incorporated into the restoration project.

As an additional outstanding issue, a final determination must be made relative to which aspects of the Cultural Center are eligible for cost-sharing, and which other/additional features the local sponsor would like to add to the Cultural Center as a "betterment".

Volume 4 of 4 - Final Environmental Impact Statement

Va Shly'ay Akimel
FINAL Salt River Ecosystem Restoration Study

Prepared by:

U.S. Army Corps of Engineers
South Pacific Division
Los Angeles District

In cooperation with:

Salt River Pima-Maricopa Indian Community

and the

City of Mesa

Va Shly'ay Akimel Salt River Ecosystem Restoration Feasibility Study

Final Environmental Impact Statement

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September 2004

Jones & Stokes. 2004. *Va Shly'ay Akimel Salt River Ecosystem Restoration Feasibility Study, Final Environmental Impact Statement.* September. (J&S 03048) Phoenix, AZ. Prepared for U.S. Army Corps of Engineers, Los Angeles District, Phoenix Field Office.

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Contents

ABSTRACT ..... **xiii**

EXECUTIVE SUMMARY **ES-1**

ES.1 INTRODUCTION ES-1
ES.2 MAJOR CONCLUSIONS ES-1
ES.2.1 Formulation and Screening of Alternatives ES-1
ES.2.2 Areas of Controversy and Unresolved Issues ES-2
ES.2.3 Summary of Potential Environmental Effects ES-2

Chapter 1. INTRODUCTION **1-1**

Chapter 2. NEED FOR AND OBJECTIVES OF THE PROPOSED ACTION **2-1**

2.1 DESCRIPTION OF PROPOSED ACTION 2-1
2.2 PURPOSE AND NEED 2-1
2.2.1 Background 2-1
2.2.2 Purpose and Need 2-2
2.3 PROJECT LOCATION 2-2
2.4 PROJECT OBJECTIVES 2-2
2.4.1 Study Objectives 2-2
2.4.2 Relationship to other Projects 2-3
2.5 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT 2-3
2.6 PUBLIC INVOLVEMENT 2-4
2.7 APPLICABLE REGULATORY COMPLIANCE AND COORDINATION 2-4

Chapter 3. DESCRIPTION OF ALTERNATIVES CONSIDERED, INCLUDING THE PREFERRED ALTERNATIVE **3-1**

3.1 FORMULATION AND SCREENING OF ALTERNATIVES 3-1
3.1.1 Choosing the Preferred Alternative 3-3
3.2 DESCRIPTION OF THE PROJECT ALTERNATIVES 3-5
3.2.1 Components Common to all Construction Alternatives 3-97
3.2.2 No-Action Alternative (Future Without Project) 3-15
3.2.3 Alternative F 3-15
3.2.4 Alternative N 3-20
3.2.5 Alternative O (Preferred Alternative) 3-23
3.2.6 Alternative E 3-26

4.5 AESTHETIC RESOURCES 4-67
4.5.1 Introduction 4-67
4.5.2 General Project Setting 4-67
4.5.3 General Description Of The Project Area At Photo Locations 4-67
4.5.4 Regulatory Setting 4-69
4.5.5 Salt River Pima-Maricopa Indian Community 4-72
4.6 AIR QUALITY 4-73
4.6.1 Introduction 4-73
4.6.2 Climate and Meteorology 4-73
4.6.3 Existing Air Quality 4-75
4.6.4 Regulatory Setting 4-79
4.7 NOISE 4-82
4.7.1 Introduction 4-82
4.7.2 General Noise Setting 4-82
4.7.3 Regulatory Setting 4-84
4.8 SOCIAL AND ECONOMIC RESOURCES (INCLUDING ENVIRONMENTAL JUSTICE) 4-86
4.8.1 Introduction 4-86
4.8.2 General Socioeconomic Setting 4-86
4.8.3 Environmental Justice 4-94
4.9 TRANSPORTATION 4-95
4.9.1 Introduction 4-95
4.9.2 Transportation Setting 4-95
4.9.3 Regulatory Setting 4-102
4.10 LAND USE 4-104
4.10.1 Introduction 4-104
4.10.2 Land Uses In The Project Study Area 4-104
4.10.3 Regulatory Setting 4-105
4.11 Recreation 4-113
4.11.1 Introduction 4-113
4.11.2 Existing Recreation Environment 4-113
4.11.3 Regulatory Environment 4-116
4.12 PUBLIC HEALTH AND SAFETY 4-120
4.12.1 Introduction 4-120
4.12.2 General Project Setting 4-120
4.12.3 Regulatory Setting 4-121

Chapter 5. ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION AND ALTERNATIVES 5-1

5.1 GEOLOGY AND TOPOGRAPHY 5-1
5.1.1 Approach and Methodology 5-1
5.1.2 Environmental Impacts 5-2
5.2 HYDROLOGY AND WATER RESOURCES 5-5
5.2.1 Approach and Methodology 5-5
5.2.2 Environmental Impacts 5-6
5.3 BIOLOGICAL RESOURCES 5-18

5.3.1 Approach and Methodology 5-18
5.3.2 Environmental Impacts 5-36
5.4 CULTURAL RESOURCES 5-53
5.4.1 Approach and Methodology 5-53
5.4.2 Environmental Impacts 5-54
5.4.3 Commitments 5-56
5.5 AESTHETIC RESOURCES 5-57
5.5.1 Approach and Methodology 5-57
5.5.2 Environmental Impacts 5-57
5.6 AIR QUALITY 5-60
5.6.1 Approach and methodology 5-60
5.6.2 Environmental Impacts 5-61
5.7 NOISE 5-67
5.7.1 Approach and Methodology 5-67
5.7.2 Environmental Impacts 5-67
5.8 SOCIAL AND ECONOMIC RESOURCES 5-72
5.8.1 Approach and Methodology 5-72
5.8.2 Environmental Impacts 5-72
5.8.3 Environmental Justice 5-73
5.9 TRANSPORTATION 5-74
5.9.1 Approach and Methodology 5-74
5.9.2 Environmental Impacts 5-75
5.10 LAND USE 5-83
5.10.1 Approach and Methodology 5-83
5.10.2 Environmental Impacts 5-83
5.11 RECREATION 5-90
5.11.1 Approach and Methodology 5-90
5.11.2 Environmental Impacts 5-90
5.12 PUBLIC HEALTH AND SAFETY 5-96
5.12.1 Approach and Methodology 5-96
5.12.2 Environmental Impacts 5-96

Chapter 6. UNAVOIDABLE SIGNIFICANT IMPACTS 6-1

Chapter 7. CUMULATIVE IMPACT ANALYSIS 7-1

7.1 POTENTIAL CUMULATIVE IMPACT ZONE 7-1
7.2 SUMMARY OF CUMULATIVE IMPACTS BY RESOURCE AREA 7-1
7.3 CONCLUSIONS REGARDING CUMULATIVE IMPACTS OF THE VA SHLY'AY AKIMEL PROJECT 7-5

Chapter 8. MITIGATION MEASURES/ENVIRONMENTAL COMMITMENTS 8-1

8.1 GEOLOGY AND TOPOGRAPHY 8-1
8.2 HYDROLOGY AND WATER RESOURCES 8-1

8.3 BIOLOGICAL RESOURCES 8-3
8.4 CULTURAL RESOURCES 8-3
8.5 AESTHETIC RESOURCES 8-3
8.6 AIR QUALITY 8-3
8.7 NOISE 8-4
8.8 SOCIAL AND ECONOMIC RESOURCES 8-5
8.9 TRANSPORTATION 8-5
8.10 LAND USE 8-5
8.11 RECREATION 8-5
8.12 PUBLIC HEALTH AND SAFETY 8-5

Chapter 9. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY 9-1

Chapter 10. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES 10-1

10.1 WATER RESOURCES 10-1
10.2 IRRIGATION TECHNIQUES 10-1
10.3 VEGETATION 10-1
10.4 RESHAPING 10-2
10.5 RIVER CHANNELIZATION 10-2
10.6 GRADE CONTROL STRUCTURE 10-2
10.7 BANK STABILIZATION 10-2

Chapter 11. PUBLIC INVOLVEMENT AND INTERAGENCY COORDINATION 11-1

11.1 SCOPING 11-1
11.2 HGM MODEL PREPARATION 11-3
11.3 AGENCY COORDINATION 11-3
11.4 DRAFT EIS REVIEW 11-4

Chapter 12. LIST OF PREPARERS AND REVIEWERS 12-1

12.1 U.S. ARMY CORPS OF ENGINEERs 12-1
12.2 SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY 12-1
12.3 CITY OF MESA 12-1
12.4 JONES & STOKES 12-3
12.5 OTHER CONTRIBUTORS 12-4

Chapter 13. REFERENCES 13-1

PRINTED REFERENCES 13-1
PERSONAL COMMUNICATIONS 13-9

Chapter 14. GLOSSARY OF TERMS AND ACRONYMS 14-1

14.1 ACRONYMS AND ABBREVIATIONS 14-1
14.2 GLOSSARY 14-5

Index ..... I-i

Tables

Table		Page
2-1	Summary of Applicable Regulations	2-5
3-1	Cost-Effective Alternatives	3-4
3-2	Incrementally Cost-Effective Alternatives	3-4
3-3	Comparison of Alternatives	3-6
3-4	Vegetated Area and Evapotranspiration Rate for Alternative F	3-17
3-5	Vegetated Area and Evapotranspiration Rate for Alternative N	3-20
3-6	Vegetated Area and Evapotranspiration Rate for Alternative O	3-24
3-7	Vegetated Area and Evapotranspiration Rate for Alternative E	3-27
3-8	Vegetated Area and Evapotranspiration Rate for Alternative A	3-28
3-9	Estimated Trail Usage	3-44
3-10	Square Footage of Cultural Center Buildings	3-44
3-11	Cultural Center: Preliminary Estimate of Cost-Sharable Elements	3-45
4.2-1	Major Dams and Reservoirs in the Gila River Basin	4-7
4.2-2	Inundation-Duration Frequency Values for the Salt River	4-10
4.2-3	General Depths (Feet) to Groundwater near the Lower Salt River	4-12
4.2-4	Types of Water Contaminants in the Lower Salt River	4-14
4.2-5	Relationships Between Pollutants of Concern and Stressors	4-18
4.3-1	Cover Types Present within the Va Shly'ay Akimel Project Study Area	4-29
4.3-2	PWAA Descriptions	4-42
4.3-3	Special-Status Species That Could Occur or Are Known to Occur in the Va Shly'ay Akimel Study Area	4-43

4.4-1	Hohokam Chronology	4-54
4.4-2	Salt River Terraces within the Project Area	4-59
4.4-3	Archaeological Sites Evaluated for NRHP Eligibility in the Va Shly'ay Akimel Ecosystem Restoration Project Class III Cultural Resources Project Area	4-61
4.4-4	Areas of Potential Research for the Prehistoric and Protohistoric Sites Located in the SRRP Study Area	4-64
4.6-1	Meteorological Summary for Survey Area, 2001–2002	4-74
4.6-2	State and Federal Ambient Air Quality Standards	4-76
4.6-3	Health and Welfare Effects of Criteria Air Pollutants	4-77
4.6-4	Ambient Air Quality Monitoring Data from Mesa Monitoring Station	4-78
4.8-1	Population and Household Characteristics in the Vicinity of the Study Area	4-87
4.8-2	Ethnic Population Characteristics in the Vicinity of the Study Area	4-87
4.8-3	Occupancy Rates in the Vicinity of the Study Area	4-88
4.8-4	Housing-Unit Type and Housing-Unit Median Value in the Vicinity of the Study Area	4-89
4.8-5	Industry Employment in Maricopa County, January 2002	4-89
4.8-6	Occupational Employment in the Vicinity of the Study Area	4-90
4.8-7	Median Income in Maricopa County and in the Vicinity of the Study Area	4-94
4.9-1	Roadway Segment Level of Service	4-96
4.9-2	City of Mesa ADT Volumes	4-97
4.9-3	Salt River Pima-Maricopa Indian Community ADT Volumes	4-100
4.9-4	Mesa Arterial Intersection LOS	4-100
4.11-1	City of Mesa Park Standards	4-117
4.12-1	CERCLIS Sites	4-122

4.12-2 Landfills 4-122

4.12-3 LUST Sites 4-126

4.12-4 RCRA Sites 4-127

4.12-5 Recycle Facilities 4-128

5.3-1 Comparison of Habitat Types (Acres): No-Action Alternative and Alternative F 5-19

5.3-2 Comparison of Habitat Types (Acres): No-Action Alternative and Alternative N 5-23

5.3-3 Comparison of Habitat Types (Acres): No-Action Alternative and Alternative O 5-27

5.3-4 Comparison of Habitat Types (Acres): No-Action Alternative and Alternative E 5-30

5.3-5 Comparison of Habitat Types (Acres): No-Action Alternative and Alternative A 5-33

5.6-1 Estimated Annual Air Pollutant Emissions (tpy) Associated With Alternatives F, N, O, E, A 5-65

5.7-1 Noise Emission Levels Typical for Construction Equipment 5-67

5.7-2 Estimated Construction Noise in the Vicinity of Active Construction Sites 5-69

5.9-1 Estimated Traffic Associated with Recreational Use 5-75

Figures

Figure		Follows Page
1-1	Regional Location Map	1-1
1-2	Project Study Area	1-1
2-1	Location of other Corps Projects	2-3
3-1	Project Area Reaches	3-5
3-2	Surface Braided Irrigation Network (SBIN) Diagram	3-7
3-3	Alternative F	3-14
3-4	Bank Stabilization Locations	3-15
3-5	Longitudinal Profile of Salt River	3-16
3-6	Alternative N	3-18
3-7	Alternative O	3-21
3-8	Alternative E	3-24
3-9	Alternative A	3-27
3-10	City of Mesa Multi-Use Path System	3-43
3-11	Concept for Cultural Center	3-44
3-12	Proposed Recreation Option A	3-48
3-13	Proposed Recreation Option B	3-48
3-14	Proposed Recreation Option C	3-48
4.2-1	Gila River Basin	4-6
4.2-2	Proportional Natural Mean Monthly Discharge of the Salt River	4-8
4.2-3	100-Year Floodplain	4-9

4.2-4	Annual Peak Flow of the Salt River for Major Releases from Granite Reef Dam, 1891–1993	4-9
4.2-5	Groundwater Elevations in the Salt River Valley	4-13
4.3-1	Biological Communities	4-28
4.5-1	Photo Location Key	4-68
4.5-2	Views of the Vicinity of the Pima Freeway	4-68
4.5-3	Views of the Vicinity of Beeline Highway	4-68
4.5-4	Views of the Vicinity of the Arizona Canal	4-69
4.5-5	Views of the Vicinity of Granite Reef Dam	4-69
4.5-6	Views of the Vicinity of the City of Mesa	4-69
4.6-1	Monthly Total Precipitation, Phoenix, Arizona 1960–1996	4-73
4.6-2	Monthly Mean Temperature, Phoenix, Arizona 1960–1996	4-74
4.8-1	Census Tracts, Minority/Hispanic Origin (2000)	4-94
4.8-2	Census Tracts, Poverty Level (2000)	4-94
4.9-1	Local Transportation Network	4-97
4.11-1	Recreational Facilities within the Vicinity of Study Area	4-113
5.3-1	Trend in Average Annual Functional Capacity Units (AAFCUs) for the Va Shly'ay Akimel Alternatives	5-18

Appendices

Appendix A. **Section 404(b)(1) Evaluation and ADEQ Support Letter**

Appendix B. **Monitoring and Adaptive Management Plan**

Appendix C. **List of Plant and Animal Species Mentioned in the Text**

Appendix D. **Fish and Wildlife Coordination Act Documentation**

Appendix E. **Biological Assessment and USFWS Section 7 Letter**

Appendix F. **Background Information on Acoustics**

Appendix G. **Air Quality Assumptions and Calculations**

Appendix H. **Va Shly'ay Akimel Phase I Environmental Site Assessment**

Appendix I. **Yuma Clapper Rail Survey Report**

Appendix J. **Response To Comments Received on the Public Draft EIS**

**FINAL ENVIRONMENTAL IMPACT STATEMENT
FOR THE VA SHLY'AY AKIMEL ECOSYSTEM RESTORATION
FEASIBILITY STUDY,
MARICOPA COUNTY, ARIZONA**

The responsible federal lead agency is the Department of the Army, U.S. Army Corps of Engineers, Los Angeles District.

ABSTRACT

This final environmental impact statement (FEIS) analyzes the potential environmental impacts associated with the proposed Va Shly'ay Akimel restoration project in Maricopa County, Arizona. Ecosystem restoration is the primary purpose of the proposed action. The project study area, located east of Phoenix, extends from the Granite Reef Dam at its easternmost boundary to the Pima Freeway (State Route 101), a distance of approximately 14 miles. The project area includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. This document addresses the no action, the preferred action and five alternative plans developed to improve and increase native vegetation and overall wildlife habitat values in the project area, and to provide a greater diversity of habitat for threatened and endangered species such as the Yuma clapper rail and southwestern willow flycatcher. Incidental benefits would include both passive and active recreational opportunities, general improvement in the aesthetic quality of the project area and a slight reduction in the potential for flood damage. Each of the alternatives has been designed to minimize adverse impacts to the maximum extent practicable. The anticipated cumulative effects of implementation of the proposed action have been considered and addressed. Analyses and documentation are consistent with the National Environmental Policy Act and other applicable laws, regulations, and policies, and have been conducted in coordination with the U.S. Army Corps of Engineers, the SRPMIC, the City of Mesa, and concerned resource agencies and members of the public. Information referred to in this document, as well as in the accompanying feasibility report and appendices, is incorporated by reference.

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

This final environmental impact statement (FEIS) has been prepared by the U.S. Army Corps of Engineers (Corps), Los Angeles District, to analyze potential environmental impacts associated with the implementation of restoration alternatives for the Va Shly'ay Akimel project study area, located along the Salt River approximately 11 miles east of downtown Phoenix, Maricopa County, Arizona. The approximately 14-mile-long, 2-mile-wide study area extends from Granite Reef Dam to the Pima Freeway (State Route 101) and includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa.

This FEIS provides a description of restoration alternatives, including the No-Action Alternative; provides an analysis of the existing and future conditions of the area without the project; and analyzes the impacts associated with five alternatives that have been determined to be the most feasible, including the preferred alternative (proposed action). Alternative O has been identified as the recommended plan based on its achievement of project objectives, and its meeting of completeness, efficiency, effectiveness, and preliminary public acceptability criteria.

ES.2 MAJOR CONCLUSIONS

ES.2.1 FORMULATION AND SCREENING OF ALTERNATIVES

The purpose of the project alternatives associated with the study is to provide for increasing and improving native vegetation in the project area, wildlife habitat values, and habitat diversity for threatened and endangered species. Incidental benefits would include passive and active recreation, as well as improvement in the aesthetics of the project area.

Specific planning objectives were to create a complete and diverse riparian system similar to the natural riparian habitat typical of this area. The restored areas should incorporate a diverse mix of riparian habitat types, including velvet mesquite, cottonwood-willow, Sonoran desertscrub uplands, wetland marsh, and open water.

The project team developed a set of ecorestoration components that could be combined in various ways under each alternative to provide different approaches to accomplishing the project objectives. These components are listed below.

- Vegetation Planting Palettes. These palettes include cottonwood-willow, mesquite, wetland, Sonoran Desert scrub-shrub, and river bottom.
- Saltcedar Eradication. In order to improve habitat values, saltcedar would be replaced with one or several of the vegetation types listed above.

- Water Distribution System for Irrigation. The water distribution system is the infrastructure needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, well, or effluent line) to the vegetated areas, exclusive of the irrigation system. Surface water from the SRPMIC would be the primary source of water for all construction alternatives.
- Channelization. Channelization may be constructed that would entail confining flows of the Salt River to a narrower and deeper channel than the current main channel. This would be done to offset the reduction in the capacity of the channel to convey water in certain areas due to planting of vegetation within the main channel.
- Grade Control Structure. A grade control structure may be constructed to help reduce upstream migration ("headcutting") and thus stabilize the river system, improving the likelihood of success of vegetation established upstream and downstream.

Relatively little fill material will need to be acquired for any of the construction alternatives, as most materials can be gained during reshaping prior to planting. Any waste materials will be transported to either a recycling facility if appropriate or to the nearest appropriate landfill. Vector control and environmental monitoring would be incorporated into all restoration features.

Five primary design alternatives have been studied in detail for this site: Alternatives F, N, O, E, and A. These alternatives, considered during the plan formulation process, each contain all of the above-referenced components, with the exception of channelization, which is only included in Alternatives F and E, and the grade control structure, which is only included in Alternatives F, N, and O.

Operations and maintenance (O&M) activities have also been identified for the project and have been evaluated in this EIS. These activities include maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features, and periodic removal of sediment, surface reshaping, or replanting of project features damaged by flood events.

ES2.2 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

The National Environmental Policy Act ensures public involvement and notification of a proposed project. An initial public meeting was held on January 24, 2002 and a final public meeting was held on June 3, 2004. Multiple public workshops, information sessions, and meetings were also held as part of the scoping process. Public concerns expressed at the public meetings included the following (those items in bold were expressed repeatedly):

1. **Where will the water come from and how will future droughts be addressed?**
2. Who will maintain the aquifer in the future and what are the risks of aquifer contamination?
3. Concern was expressed about the City of Mesa's involvement.

4. **Concern was expressed about future rights to the land surrounding the river and future possession by federal government.**
5. Concern was expressed about future property loss of project site.
6. Where does project fit in with Sand and Gravel mining?
7. Concern was expressed about the protection of burial grounds.
8. Concern was expressed that preservation of this land would encourage the FAA to cement their flight plans over Community land due to lack of human establishment.
9. **Concern was expressed about future restrictions of Community land use due to project.**

Additional information regarding the public involvement and scoping process is provided in Chapter 11.

Endangered Species Act, Section 7 informal consultation was completed during the production of the study's FEIS. The U.S. Fish and Wildlife Service concurred with a determination of "may affect, not likely to adversely affect" for the Yuma clapper rail, southwestern willow flycatcher, cactus ferruginous pygmy owl, California brown pelican and bald eagle. This concurrence ends the Section 7 consultation process. Details of the Section 7 informal consultation are provided in Appendix F. The Clean Water Act Section 404(b)(1) Compliance Evaluation can be found in Appendix A of this document.

Initiation and completion of activities associated with Va Shly'ay Akimel restoration project depends on the resolution of the following issues:

- Water Quality Certification under Section 401 of the Clean Water Act.
- Further evaluations of cultural resources in the project area will need to be conducted in accordance with Section 106 of the NHPA. If resources were determined to be NRHP eligible and avoidance is not feasible, further mitigation measures would be detailed in a Memorandum of Agreement between the Corps, the SRPMIC, the City of Mesa, and the SHPO. These would include field surveys, testing, and data recovery. These would include field surveys, testing, and data recovery. Mitigation measures would also contain provisions that if cultural or paleontological resources are encountered during construction or other activities, work in the area will stop until a qualified archaeologist can evaluate the finds and determine whether further investigation is necessary. The Corps, SRPMIC, City of Mesa, and the SHPO will be notified if buried cultural resources are encountered.
- Future operational activities associated with sand and gravel mining in the project area will need to be defined.

It is expected that these issues will be resolved during the preliminary engineering design phase of the project after the Final EIS has been published.

ES2.3 SUMMARY OF POTENTIAL ENVIRONMENTAL EFFECTS

Each of the alternatives has been analyzed to determine the environmental effects that would result if that alternative were implemented. Mitigation measures have been developed to avoid, minimize, or reduce the effects of any substantial adverse impacts. A cumulative analysis has also been prepared for each resource area. Table ES-1 provides a summary of the impacts and mitigation measures for each resource area by alternative. These impacts include unavoidable significant impacts on prehistoric and historic cultural resources. Unavoidable significant impacts are impacts that remain following the implementation of mitigation measures, or impacts for which there are no mitigation measures. These significant impacts could occur as a result of implementing any of the analyzed construction alternatives [F, N, O, E, and A]. More detailed information on unavoidable significant impacts is provided in Section 6 of the FEIS.

Based on the HGM and ICA analyses, Alternative O was determined to be the environmentally preferable alternative. Alternative O is also the non-federal sponsor(s) preferred alternative.

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
5.1 GEOLOGY AND TOPOGRAPHY						
Impact: Minor Geomorphologic Changes in River Channel						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant
5.2 HYDROLOGY AND WATER RESOURCES						
Impact: Temporary Adverse Effects on Water Quality during Project Construction						
Level of Significance	Significant	Significant	Significant	Significant	Significant	N/A
Mitigation Measure(s)	Implement erosion control measures	Implement erosion control measures	Implement erosion control measures	Implement erosion control measures	Implement erosion control measures	N/A
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	N/A
Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials During Project Construction						
Level of Significance	Significant	Significant	Significant	Significant	Significant	N/A
Mitigation Measure(s)	Implement SWPPP	Implement SWPPP	Implement SWPPP	Implement SWPPP	Implement SWPPP	N/A
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	N/A
Impact: Changes in 100-year Water Surface Elevations						
Level of Significance	Significant	Significant	No Impact	Significant	No Impact	Less than significant

1292

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Mitigation Measure(s)	Identify possible changes to the water surface elevation and redesign alternative	Identify possible changes to the water surface elevation and redesign alternative	No Mitigation	Identify possible changes to the water surface elevation and redesign alternative	No Mitigation	No Mitigation
Residual Significance	Less than significant	Less than significant	No Impact	Less than significant	No Impact	Less than significant
Impact: Changes in Groundwater Hydrology (from installation of new well)						
Level of Significance	Significant	Significant	Significant	Significant	N/A	N/A
Mitigation Measure(s)	Develop institutional agreements for groundwater use	Develop institutional agreements for groundwater use	Develop institutional agreements for groundwater use	Develop institutional agreements for groundwater use	N/A	N/A
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	N/A	N/A
Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water						
Level of Significance	Significant	Significant	Significant	Significant	Significant	Less than significant
Mitigation Measure(s)	Conduct additional stormwater quality sampling and analysis	Conduct additional stormwater quality sampling and analysis	Conduct additional stormwater quality sampling and analysis	Conduct additional stormwater quality sampling and analysis	Conduct additional stormwater quality sampling and analysis	No Mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant
5.3 BIOLOGICAL RESOURCES						
Impact: Long-Term Increase in Saltcedar and Decrease in Cottonwood-Willow Vegetation						

1293

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Level of Significance	N/A	N/A	N/A	N/A	N/A	Less than significant
Mitigation Measure(s)	N/A	N/A	N/A	N/A	N/A	No mitigation
Residual Significance	N/A	N/A	N/A	N/A	N/A	Less than significant
Impact: Long-Term Decrease in Wildlife Habitat						
Level of Significance	N/A	N/A	N/A	N/A	N/A	Less than significant
Mitigation Measure(s)	N/A	N/A	N/A	N/A	N/A	No mitigation
Residual Significance	N/A	N/A	N/A	N/A	N/A	Less than significant
Impact: Substantial Short-Term Impacts on Vegetation						
Level of Significance	Significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	Project construction phasing & area restrictions	Project construction phasing & area restrictions	Project construction phasing & area restrictions	Project construction phasing & area restrictions	Project construction phasing & area restrictions	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Short-Term Impacts on Common Wildlife Species						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation

1294

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Potential Impacts on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	Maintenance activities on rotating basis & only during non-nesting periods	Maintenance activities on rotating basis & only during non-nesting periods	Maintenance activities on rotating basis & only during non-nesting periods	Maintenance activities on rotating basis & only during non-nesting periods	Maintenance activities on rotating basis & only during non-nesting periods	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Short-Term Impacts on Waters of the United States						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Short-Term Impacts on Waters of the United States During O&M Activities						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Short-Term Impacts on Habitat for Listed Wildlife Species						
Level of Significance	No impact	Significant	Significant	Significant	No impact	No impact

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Mitigation Measure(s)	No mitigation	Conduct surveys for the presence of Yuma Clapper Rails (Section 7 Consultation if necessary)	Conduct surveys for the presence of Yuma Clapper Rails (Section 7 Consultation if necessary)	Conduct surveys for the presence of Yuma Clapper Rails (Section 7 Consultation if necessary)	No mitigation	No mitigation
Residual Significance	No impact	Less than significant	Less than significant	Less than significant	No impact	No impact
5.4 CULTURAL RESOURCES						
Impact: Potential Disturbance of Loss of Properties Listed or Eligible for Listing on the National Register						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	Develop MOA between the Corps, SRPMIC, City of Mesa and SHPO	Develop MOA between the Corps, SRPMIC, City of Mesa and SHPO	Develop MOA between the Corps, SRPMIC, City of Mesa and SHPO	Develop MOA between the Corps, SRPMIC, City of Mesa and SHPO	Develop MOA between the Corps, SRPMIC, City of Mesa and SHPO	No mitigation
Residual Significance	Significant and unavoidable	Significant and unavoidable	Significant and unavoidable	Significant and unavoidable	Significant and unavoidable	No impact
5.5 AESTHETIC RESOURCES						
Impact: Potential Short-Term Adverse Aesthetic Effects						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Potential Long-Term Adverse Aesthetic Effects						

1296

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant
5.6 AIR QUALITY						
Impact: Generation of Construction-Related and Operational Tailpipe Emissions						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Generation of Construction-Related and Operational Fugitive Dust Emissions						
Level of Significance	Significant	Significant	Significant	Significant	Less than significant	No impact
Mitigation Measure(s)	Implementation of PM-10 reducing Measure(s)s	Implementation of PM-10 reducing Measure(s)s	Implementation of PM-10 reducing Measure(s)s	Implementation of PM-10 reducing Measure(s)s	Implementation of PM-10 reducing Measure(s)s	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
5.7 NOISE						
Impact: Exposure of Sensitive Land Uses to Construction Noise						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact

1297

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Mitigation Measure(s)	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Increase Traffic Noise in the Project Vicinity from Recreational Users						
Level of Significance	Less than significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	No mitigation	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Increase Traffic Noise from O&M Activities						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	Employ noise-reducing construction Measure(s)s	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
5.8 SOCIAL AND ECONOMIC RESOURCES						
Impact: No Direct Impacts Associated with Social and Economic Resources						
Level of Significance	No impact	No impact	No impact	No impact	No impact	No impact

1298

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	No impact	No impact	No impact	No impact	No impact	No impact
5.9 TRANSPORTATION						
Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Potential Damage to Roadway Surfaces during Project Construction						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	Repair damaged roadways	Repair damaged roadways	Repair damaged roadways	Repair damaged roadways	Repair damaged roadways	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Generation of Additional Vehicle Trips by Recreationists						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact

1299

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
5.10 LAND USE						
Impact: Temporary Adverse Effects on Land Use during Project Construction						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Temporary Adverse Effects on Land Use during Project Construction						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance:	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
5.11 RECREATION						
Impact: Temporary Adverse Effects on Recreation during Project Construction						
Level of Significance	Less than significant	Less than significant	Less than significant	Less than significant	No impact	No impact
Mitigation Measure(s)	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	No impact	No impact

1300

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
5.12 PUBLIC HEALTH AND SAFETY						
Impact: Potential for Breach and/or Damage to Landfill Closure Caps						
Level of Significance	Significant	No impact	No impact	Significant	No impact	No impact
Mitigation Measure(s)	Redesign vegetation pallet for landfill closure caps	No mitigation	No mitigation	Redesign vegetation pallet for landfill closure caps	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Addition of Cover Materials on Tri-City Landfill May Cause Exceedance of Minimum Ground Clearance for Overhead Power Transmission Lines						
Level of Significance	Significant	No impact	No impact	Significant	No impact	No impact
Mitigation Measure(s)	Concrete encasements at bases of towers or poles	No mitigation	No mitigation	Concrete encasements at bases of towers or poles	No mitigation	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Temporary Construction-Related Water Quality Impacts						
Level of Significance	Significant	Significant	Significant	Significant	Significant	No impact
Mitigation Measure(s)	Construction management	Construction management	Construction management	Construction management	Construction management	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	No impact
Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities						

1301

Table ES-1. Environmental Impact Summary Matrix

Environmental Element	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Level of Significance	Significant	Significant	Significant	Significant	Significant	Less than significant
Mitigation Measure(s)	Initiate vector control Measure(s)s	Initiate vector control Measure(s)s	Initiate vector control Measure(s)s	Initiate vector control Measure(s)s	Initiate vector control Measure(s)s	No mitigation
Residual Significance	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant

1302

CHAPTER 1. INTRODUCTION

This environmental impact statement (EIS) has been prepared by the U.S. Army Corps of Engineers (Corps) to analyze the potential environmental effects associated with the implementation of a range of ecosystem restoration alternatives for the Va Shly'ay Akimel study area. This study area is located within the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa in Maricopa County, Arizona. Figure 1-1 shows the regional location for the study area. The study area focuses on the Salt River between State Route 101 (Pima Freeway) and Granite Reef Dam (Figure 1-2).

The Corps is investigating potential alternatives to restore riparian habitat within the Va Shly'ay Akimel study area to more closely resemble the conditions that existed in the study area before extensive modifications occurred within the Salt River channel and adjacent floodplain. This EIS investigates those feasible restoration alternatives that most closely meet the purpose and need for the proposed action and are consistent with the study authority given by Congress.

This study has been conducted under two separate authorities provide by Congress. The first and most recent authority is provided by House Resolution 2425 (HR 2425), dated May 17, 1994. HR 2425 states:

> The Secretary of the Army is requested to review reports of the Chief of Engineers on the State of Arizona...in the interest of flood damage reduction, environmental protection and restoration and related purposes.

The second authority is given in Public Law 761, 75th Congress, known as Section 6 of the Flood Control Act of 1938. This authority, dated June 28, 1938, states:

> The Secretary of War (now Secretary of the Army) is hereby authorized and directed to cause preliminary examinations and surveys . . . at the following localities: . . . Gila River and tributaries, Arizona.

This EIS provides a description of restoration alternatives, including the No-Action Alternative; provides an analysis of the existing and future conditions of the area without the project; and analyzes the impacts associated with the alternatives that have been determined to be most feasible, including the recommended or preferred alternative. The Corps, together with the local sponsors, the SRPMIC and the City of Mesa, will then use this EIS to make a decision regarding which alternative to implement.

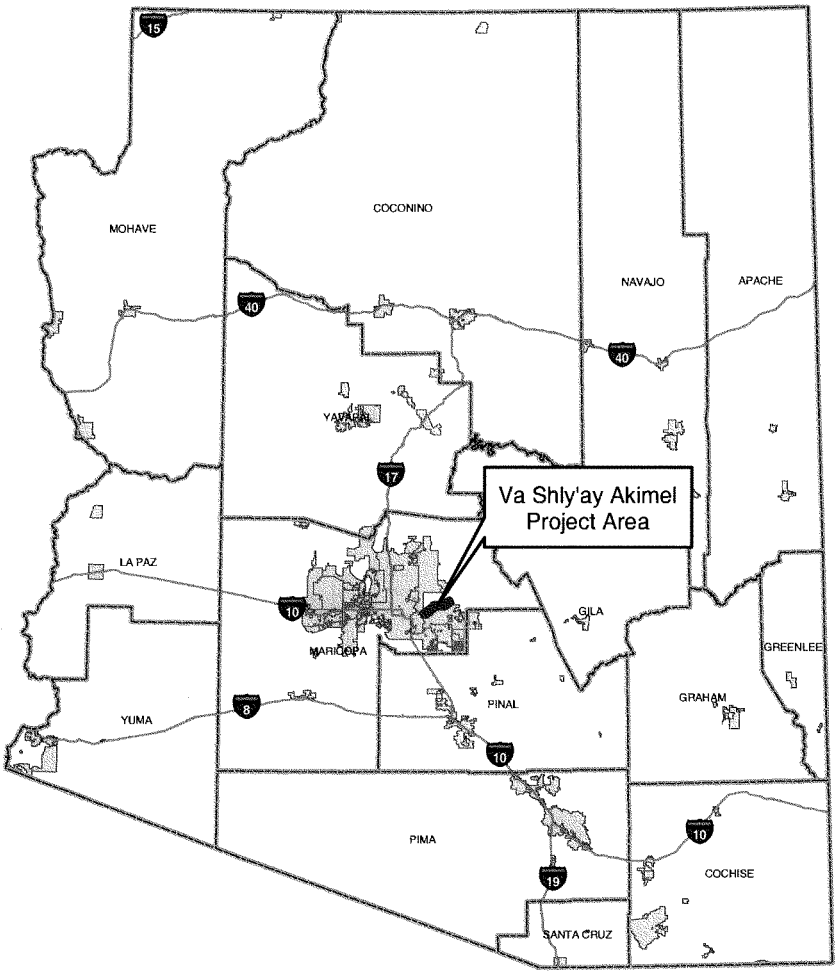
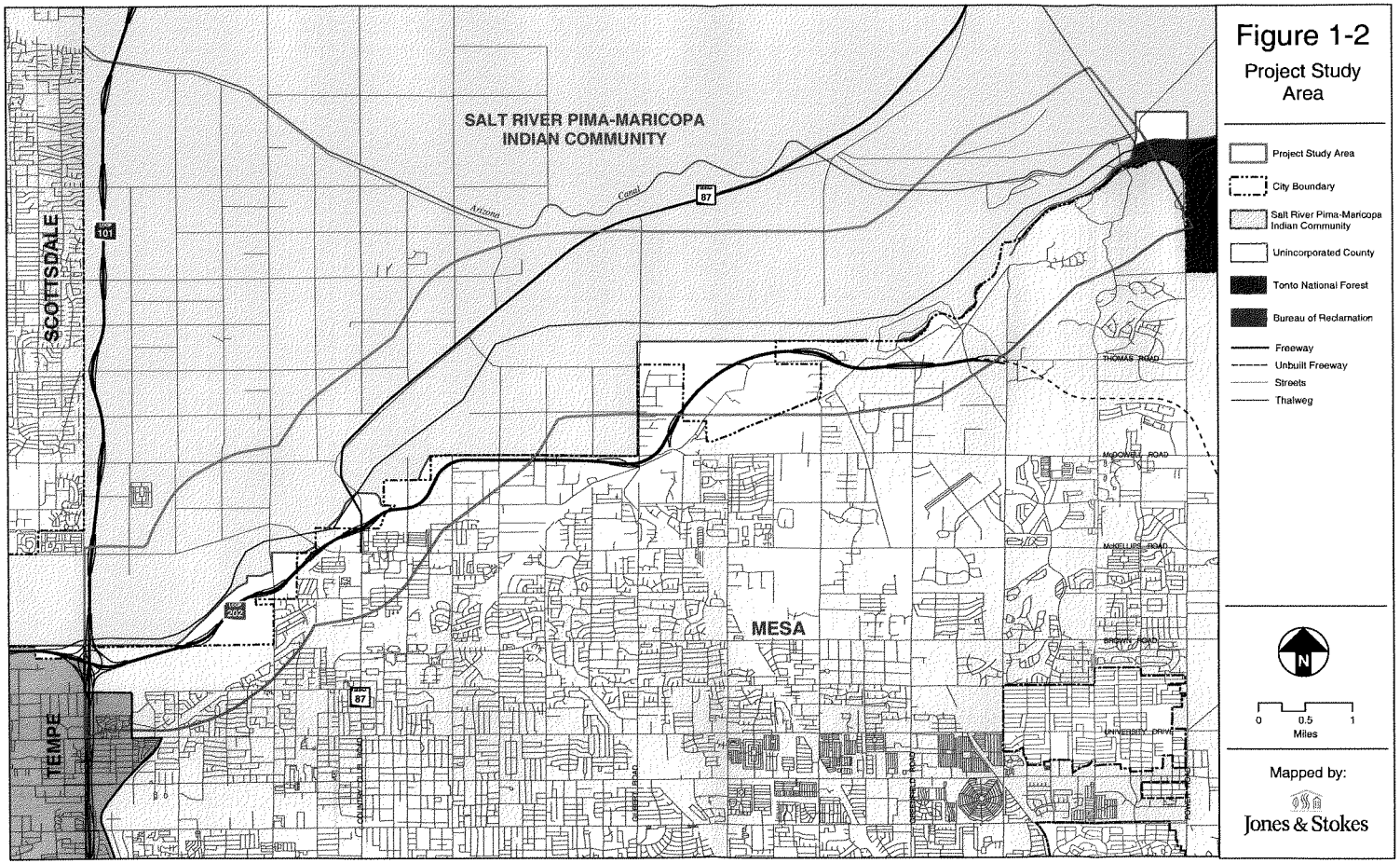


Figure 1-1
Regional Location Map


SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY
Arizona
Canal
SCOTTSDALE
TEMPE
MESA
Loop 101
Loop 202
87
THOMAS ROAD
McDOWELL ROAD
McKELLIPS ROAD
BROWN ROAD
UNIVERSITY DRIVE
COUNTRY CLUB DRIVE
POWER ROAD
GILBERT ROAD
Figure 1-2
Project Study Area
Project Study Area
City Boundary
Salt River Pima-Maricopa Indian Community
Unincorporated County
Tonto National Forest
Bureau of Reclamation
Freeway
Unbuilt Freeway
Streets
Thalweg
N
0
0.5
1
Miles
Mapped by:
Jones & Stokes

CHAPTER 2. NEED FOR AND OBJECTIVES OF THE PROPOSED ACTION

2.1 DESCRIPTION OF PROPOSED ACTION

The proposed action involves the creation of a complete and diverse riparian system similar to the natural habitat historically characteristic of this portion of the Salt River. The restored areas will incorporate a diverse mix of typically riparian habitat types, including velvet mesquite, cottonwood/willow, wetland marsh, open water, and Sonoran desertscrub. Southwestern arid riparian systems are often ephemeral or intermittent. Because these systems cannot rely on a perennial source of water, they often include vegetative species that can also be found in upland areas. This vegetative series (Sonoran desert scrub shrub) is often found along dry channel beds and includes triangle bursage, rabbit brush, and desert broom.

2.2 PURPOSE AND NEED

2.2.1 BACKGROUND

The Salt River is a major tributary to the Gila River in Arizona. The river originates in eastern Arizona and flows westward to its confluence with the Gila River west of downtown Phoenix. Before agricultural development and urbanization of the Phoenix metropolitan area, the Salt River was a perennial stream fed by snowmelt from mountains in eastern Arizona. In the early part of the 20th century, major modifications to the river system occurred as part of the Salt River Project, which placed several dams along the Salt River to allow diversions of water for agricultural and urban uses. Sand and gravel mining operations and other activities along the river induced additional changes to the river channel and hydrology.

As diversions of water increased, the perennial flows in the river ceased, causing the groundwater table to drop. These changes in hydrological conditions caused the natural riparian ecosystem to decline to the point at which only small, isolated fragments of this former habitat remain. The changes in hydrology have also allowed saltcedar, an invasive nonnative plant species with minimal habitat value, to become established in the region. The study area now consists of a highly disturbed riverbed with minimal extant native vegetation.

2.2.2 PURPOSE AND NEED

The purpose of the proposed action is to produce a viable riparian ecosystem that will support native wildlife and vegetation and thereby improve the overall ecological health of the river and return the project area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species, and produce a viable riparian ecosystem that would require a minimal level of annual

maintenance. The proposed action would also provide a number of incidental benefits including passive and active recreation and general improvements to the aesthetic appeal of the project area.

Flood control and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological regime. This alteration and increased agricultural development and urbanization of the metropolitan Phoenix area have resulted in the substantial alteration of the native cottonwood/willow, mesquite bosque, freshwater marsh, and willow woodland habitat types. Without restoration, habitat values in the study area are expected to further decline within the next 50 years. Continued degradation will decrease the overall habitat value for wildlife and reduce habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, and other sensitive species.

This project is also needed to provide an ecological connection between other riparian restoration projects that are currently underway along the Salt River. (See Section 2.4.2, "Relationship to Other Projects," below.)

2.3 PROJECT LOCATION

The study area is located in Maricopa County, Arizona, and includes portions of the SRPMIC and the City of Mesa. The study area is approximately 14 miles long, extending along the Salt River between the Pima Freeway and Granite Reef Dam. The study area is approximately 2 miles wide and encompasses approximately 17,435 acres.

2.4 PROJECT OBJECTIVES

2.4.1 STUDY OBJECTIVES

This feasibility study has planning objectives that are similar to, and compatible with, the objectives established for other proposed restoration projects located along the Salt River. Specific planning objectives developed for the Va Shly'ay Akimel project include the following:

- Identify water sources within and outside the project boundary that can be committed for the life of the project to sustain the riparian restoration features
- Restore the riparian ecosystem to the degree that it supports native vegetation and wildlife through the Salt River from immediately downstream of the Granite Reef Dam to the Pima Freeway (SR 101).
- Establish a functional floodplain in unconstrained river reaches of the study area that is ongoing and mimics the natural processes found in other naturalized riparian corridors in Arizona.
- Provide passive recreation opportunities for visitors of all ages, abilities, and backgrounds that are in harmony with the SRPMIC's management of its culture and native ecology.

- Create awareness through ongoing educational opportunities of the significance of the cultural resources relating to the Salt River.
- Create awareness through ongoing education opportunities of the significance of the Salt River ecosystem.
- Maintain or improve the existing level of flood protection in the study area for as long as the project remains authorized.
- Create awareness through ongoing educational opportunities of the ecological connection between other ongoing riparian restoration projects along the Salt River.

2.4.2 RELATIONSHIP TO OTHER PROJECTS

The Va Shly'ay Akimel project is one of four ecosystem restoration projects in various stages of development by the Corps and local sponsors along the Salt River downstream from Granite Reef Dam. Figure 2-1 shows the location of the Va Shly'ay Akimel project relative to these other projects.

The Rio Salado project, just downstream from Va Shly'ay Akimel, was the first of this series of projects to be proposed. This project is currently under construction. The Rio Salado Oeste project is immediately downstream of the Rio Salado project and is currently on a parallel feasibility study schedule with Va Shly'ay Akimel. The Tres Rios project, just downstream from Rio Salado Oeste, is currently in the design stage.

2.5 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

This EIS contains the following major elements:

- Chapter 1, Introduction.
- Chapter 2, Need for and Objectives of the Proposed Action. This section describes the overall authority, purpose, and need for the study.
- Chapter 3, Alternatives. This section describes the alternatives considered in detail, provides a summarized analysis of the environmental impacts of each alternative, and compares the impacts of each project alternative. Descriptions of alternatives considered, but subsequently eliminated from further evaluation, are also provided.
- Chapter 4, Affected Environment. This section describes the existing environmental baseline conditions of the study area and estimates the conditions of the site in the future without the project.
- Chapter 5, Environmental Consequences of the Proposed Action and Alternatives. This section describes the impacts of each alternative analyzed in detail and identifies mitigation measures for significant impacts.

The EIS focuses on major issue areas, including:

- geology and topography;
- hydrology and water resources;
- biological resources (e.g., wildlife, vegetation, and endangered species);
- cultural resources;
- aesthetic resources;
- air quality;
- noise;
- social and economic resources (including environmental justice);
- transportation;
- land use;
- recreation; and
- public health and safety (hazardous materials and waste).

2.6 PUBLIC INVOLVEMENT

The National Environmental Policy Act ensures public involvement and notification of a proposed project. An initial public meeting was held on January 24, 2002 and a final public meeting was held on June 3, 2004. Multiple public workshops, information sessions, and meetings were also held as part of the scoping process. Details of the public involvement and scoping process are provided in Chapter 11.

2.7 APPLICABLE REGULATORY COMPLIANCE AND COORDINATION

Table 2-1, which is included in the text after the following page, provides a summary of the applicable regulatory compliance and coordination for the study. The Clean Water Act Section 404(b)(1) Compliance Evaluation can be found in Appendix A of this document. The Clean Water Act Section 401 Water Quality Certification can be found in Appendix B. Endangered Species Act, Section 7 informal consultation was completed during the production of the study's FEIS. The U.S. Fish and Wildlife Service concurred with a determination of "may affect, not likely to adversely affect" for the Yuma clapper rail, southwestern willow flycatcher, cactus ferruginous pygmy owl, California brown pelican and bald eagle. This concurrence ends the Section 7 consultation process. Details of the Section 7 informal consultation are provided in Appendix F.

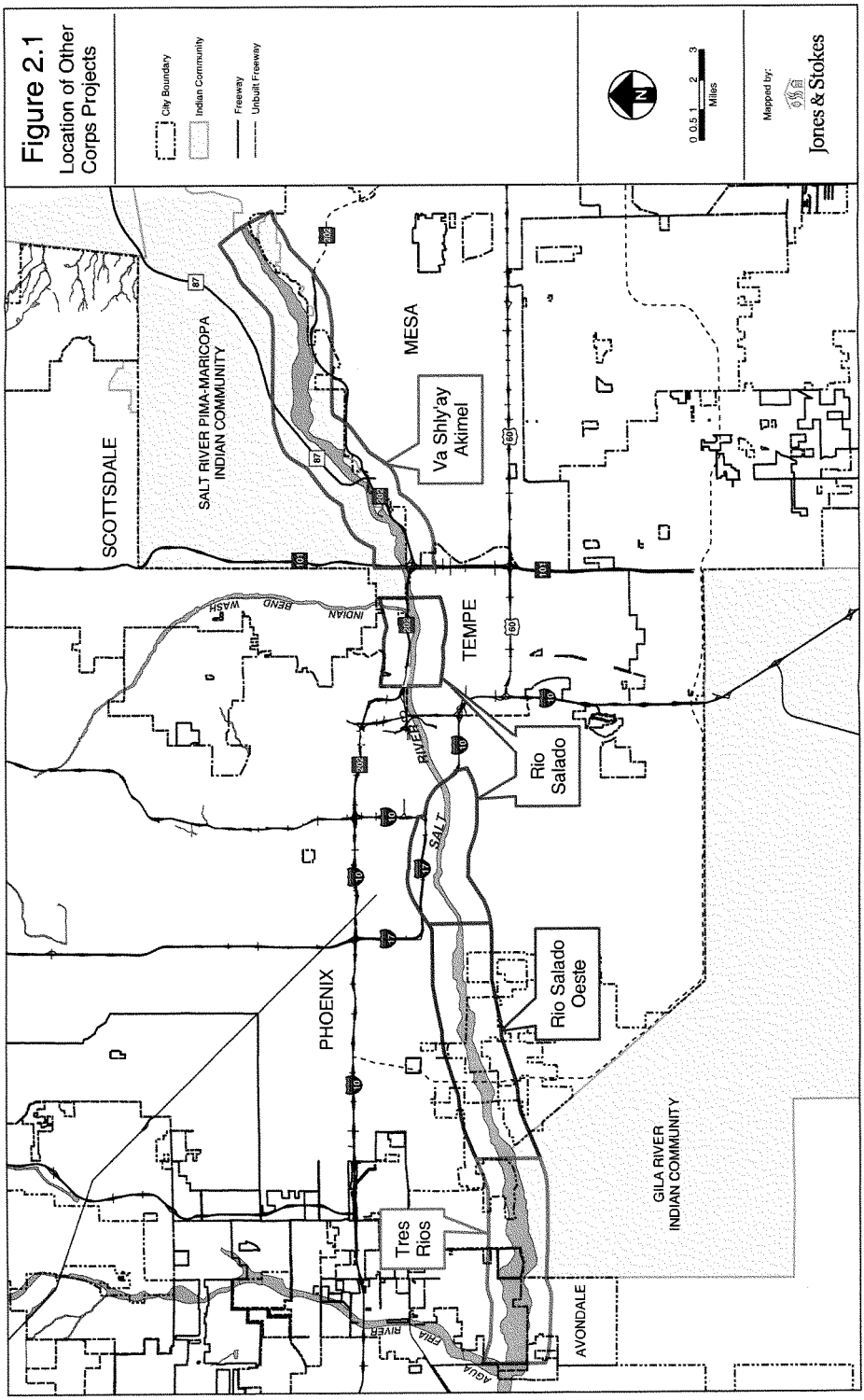


Figure 2.1
Location of Other Corps Projects
City Boundary
Indian Community
Freeway
Unbuilt Freeway
N
0 0.5 1 2 3
Miles
Mapped by:
Jones & Stokes
SCOTTSDALE
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
MESA
Va Shly'ay Akimel
TEMPE
PHOENIX
Rio Salado
Rio Salado Oeste
Tres Rios
GILA RIVER INDIAN COMMUNITY
AVONDALE
SALT RIVER
INDIAN BEND WASH

Table 2-1. Summary of Applicable Regulations

Statute	Status
National Environmental Policy Act and the Council on Environmental Quality Implementing Regulations	This EIS has been prepared in accordance with the requirements of NEPA, the Council on Environmental Quality regulations for implementing the procedural provisions of NEPA, and Corps of Engineers Engineering Regulation 200-2-2, "Procedures for Implementing NEPA."
ER-200-2-2, "Environmental Quality, Procedures for Implementing NEPA," CECW-RE (now CECW-A), March 4, 1998.	This engineering regulation provides guidance on implementing NEPA within the context of the Corps' civil works program.
Fish and Wildlife Coordination Act	Coordination efforts have been initiated and continue with U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department in accordance with the Fish and Wildlife Coordination Act. This consultation is ongoing with both agencies, and both agencies are involved in the habitat evaluation analysis.
Federal Endangered Species Act, as amended	As required by Section 7 of the federal Endangered Species Act, the Corps requested from USFWS a list of species that are listed under the act as threatened or endangered, proposed for listing, or candidates for listing. Section 7 consultation will be conducted as part of this action.
National Historic Preservation Act of 1966: Public Law 89-665; 16 U.S.C. 470-470m, as amended, 16 U.S.C. 460b, 4701-470n.	The National Historic Preservation Act provides for an expanded National Register of Historic Places, including district, sites, buildings, structures, and objects significant in American history, architecture, archeology, and culture. It authorizes a program matching grants-in-aid to the states and development projects. It also established the Advisory Council on Historic Preservation, appointed by the President, to advise the President and the Congress on matters relating to historic preservation. The Advisory Council is authorized to secure information it may need from federal agencies in order to carry out its responsibilities. The most recent changes in the Act require that a plan be developed for public and Native American involvement in the process. Section 106 of the Act required federal agencies to identify and protect significant properties which are located on federal lands and or which would be affected by federal actions.
American Indian Religious Freedom Act of 1978: Public Law 95-341; 42 U.S.C. 1966	The American Indian Religious Freedom Act makes it policy of the federal government to protect and preserve the inherent rights of American Indians, Eskimo, Aleut, and Native Hawaiian to believe, express and exercise their traditional religions. This includes, but is not limited to access to religious sites, use and possession of sacred objects, and freedom to worship through ceremonials and

Statute	Status
	traditional rites. It directs federal agencies to evaluate their policies and procedures to determine if changes are needed to ensure that such rights and freedoms are not disrupted by agency practices. The act also requires that the views of Native American leaders are to be obtained and considered where a proposed land use might conflict with traditional Indian religious beliefs or practices.
Native American Graves Protection and Repatriation Act of 1990: Public Law 101-601	The Native American Grave Protection and Repatriation Act (NAGPRA) addresses the recovery, treatment and repatriation of Native American and Native Hawaiian remains, including human remains, associated funerary objects, sacred objects, and objects of cultural patrimony.
Executive Order 13084 of May 14, 1999: Consultation and Coordination with Indian Tribal Governments	President Clinton established this order to establish regular and meaningful consultation and collaboration with Indian Tribal governments in the development of regulatory practices on Federal matters that significantly or uniquely affect their communities.
Clean Water Act, as amended	Each of the alternatives may require the discharge of fill material into waters of the United States. A Section 404(b)(1) evaluation will be prepared to address practicable alternatives. An NPDES permit will also be required for construction. A Section 404(r) exemption is applicable to the project. The Corps is requesting that this project be declared exempt under the 404(r) exemption because it is a Congressionally authorized project. The Corps will work with the local sponsors to help them obtain the necessary Section 404 permit and Section 401 water quality certification that will be required for post-construction operations and maintenance activities that take place after construction is complete. This EIS will be used for the purpose of issuing a Section 404 permit for subsequent operations and maintenance. Because each of the alternatives may result in the discharge of fill material into waters of the United States, a Section 404(b)(1) evaluation was prepared to analyze the practicable alternatives (Appendix A). Based on this evaluation, the project as proposed is in compliance with Section 404(b)(1) Guidelines with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem. A Section 404(r) exemption is applicable for this project, and the Corps will be requesting that this project be declared exempt under Section 404(r) exemption because it is a congressionally authorized project. Section 404(r) of the Clean Water Act waives the requirement to obtain either the State water quality certificate or the 404 permit if: 1) information on the effects of the discharge of dredged or

Statute	Status
	fill material into waters of the United States, including the application of the Section 404(b)(1) Guidelines, are included in an EIS on the proposed project; *and* 2) The EIS is submitted to Congress before the actual discharge takes place and prior to either authorization of the proposed project or appropriation of funds for its construction. A NPDES permit will also be required for construction. The Corps will work with the local sponsors to help them obtain the necessary Section 404 permit and Section 401 water quality certification for post-construction operations and maintenance activities that take place after construction is complete. The EIS will be used for the purpose of issuing a Section 404 permit for subsequent operations and maintenance.
Clean Air Act	The project site is in an air quality nonattainment area for carbon monoxide, ozone, and PM10. Maricopa County is the agency with jurisdiction to enforce the Clean Air Act in this area. Significant impacts may occur during construction. Feasible measures for reduction of emissions have been proposed.
Migratory Bird Treaty Act	The Migratory Bird Treaty Act prohibits the taking, killing, or possession of migratory birds. Coordination with USFWS has been ongoing. Mitigation measures proposed for the alternatives would ensure compliance with this act by ensuring that active nests of migratory species would not be disturbed.
Bald and Golden Eagle Protection Act	The Bald and Golden Eagle Protection Act prohibits any form of possession or taking of bald and golden eagles, alive or dead, including eagle body parts, feathers, nests, or eggs. The statute imposes criminal and civil sanctions as well as an enhanced penalty provision for subsequent offenses. The statute exempts from its prohibitions on possession the use of eagles or eagle parts for exhibition, scientific, and Indian religious uses.
Executive Order 11990, Protection of Wetlands	The Corps considered the effect of the alternatives on wetlands. This project will increase the acreage of wetlands in the project study area and improve the quality of existing wetlands.
Executive Order 12898, Environmental Justice	The purpose of this order is to avoid the disproportionate placement of any adverse environmental, economic, social, or health impacts resulting from federal actions and policies on minority and low-income populations. An analysis of environmental justice impacts has been included in this EIS.
Executive Order 11988, Floodplain Management	The alternatives will affect floodplains in the project area in a beneficial manner with regard to the natural

Statute	Status
Management	environment and flood protection.
Resource Conservation and Recovery Act of 1976 (PL 94-580)	Chemical and pesticide use will be in conformance with this law.
Farmland Protection Policy Act	This law is intended to minimize the extent to which federal activities contribute to the conversion of agricultural land to nonagricultural uses. Appropriate coordination between the Corps and the Natural Resources Conservation Service will occur as required under this statute.
Arizona Executive Order 91-6 Protection of Riparian Areas	Under this executive order, the Governor of Arizona has established state policy: ■ To recognize that the protection and restoration of riparian areas are of critical importance to the State; ■ To actively encourage and develop management practices that will result in maintenance of existing riparian areas and restoration of degraded riparian areas; ■ To promote public awareness through the development of educational programs of the benefits and values of riparian areas and the need for their protection and careful management; ■ To seek and support cooperative efforts and local group and citizen involvement in the protection, maintenance and restoration of riparian areas; ■ To actively encourage the preservation, maintenance, and restoration of instream flows throughout the State; and ■ that any loss or degradation of riparian areas will be balanced by restoration or enhancement of other riparian areas of equal values and functions.
Executive Order 13045, Environmental Health and Safety Risks to Children	Under this executive order, each federal agency: (a) shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and (b) shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

CHAPTER 3. DESCRIPTION OF ALTERNATIVES CONSIDERED, INCLUDING THE PREFERRED ALTERNATIVE

This section provides:

- an overview of the alternative formulation and screening process conducted for the Va Shly'ay Akimel Ecosystem Restoration Project;
- descriptions of the biologically and incrementally cost effective alternatives (including the No-Action Alternative) selected for evaluation in this document;
- brief descriptions of the alternatives that were evaluated and eliminated from consideration during the screening process; and
- preliminary recreation options that could be implemented with any of the alternatives selected for evaluation.

3.1 FORMULATION AND SCREENING OF ALTERNATIVES

The Corps' six-step planning process is used to develop, evaluate, and compare the array of candidate plans that are considered. The plan formulation process includes the following steps:

10. The specific problems and opportunities to be addressed in the study are identified, and the causes of the problems are discussed and documented. Planning goals are set, objectives are established, and constraints identified.
11. Existing and future without-project conditions are identified, analyzed, and forecasted. The existing condition resources, problems, and opportunities critical to plan formulation, impact assessment, and evaluation are characterized and documented.
12. The study team formulates alternative plans that address the planning objectives. An initial set of alternatives is developed and is evaluated at a preliminary level of detail.
13. Alternative project plans are evaluated for effectiveness, efficiency, completeness, and acceptability.
14. Alternative plans are compared. Cost-effectiveness and incremental cost analysis is used to prioritize and rank ecosystem restoration alternatives. A public involvement program obtains public input to the alternative identification and evaluation process.
15. The plan with the greatest net benefits is selected for recommendation if at least one plan exists demonstrating federal interest.

The Va Shly'ay Akimel feasibility study process involves successive iterations of solutions to the defined ecosystem degradation problem. These alternatives were based upon the study objectives and constraints and address problems and opportunities, which are outlined in

Chapter 2. Once the planning goals and objectives were defined, the existing condition of the study area was characterized. This, in essence, involved taking a "snapshot" in time to document what currently exists in terms of resources, problems, and opportunities for the area. Next, projections are developed to ascertain what the future may potentially look like in the same area if conditions and impacts remain unchanged. Once the study area's existing and future conditions are characterized, there is an opportunity to develop alternative solutions. The existing and future without-project conditions assessment can be found in detail in the Feasibility Study.

The alternative formulation begins initially by developing measures based on public input and suggestions, Corps and other federal and state agencies experiences with similar restoration opportunities, technical considerations based upon the characteristics of the area, and flood damage reduction considerations for improving or maintaining the existing level of protection. Preliminary management measures addressed such categories as ecosystem restoration, channel stabilization, public education, and recreation.

A combination of these measures formed the first array of five preliminary alternative plans developed by the Corps and the local non-federal sponsor(s) (SRPMIC and the City of Mesa) during the alternatives formulation process. These five preliminary alternatives indicated that a range of potential alternatives exist for ecosystem restoration in the study area. The alternatives vary with respect to habitat focus and the ability to restore function to the river, water requirements and total scale. This initial screening of alternatives relied on informed judgment of experts, empirical data, and acceptability by the stakeholders. Based on this screening process, a second array of alternatives was developed and compared.

The second array of alternatives examined a total of 31 alternatives. The initial array of five alternatives was expanded to 15 alternatives and were alphabetically coded Alternative A through Alternative O. The "No-Action Alternative" was coded Alternative P. Each of the initial 15 alternatives have a numeric subset, identifying the alternative with a "1" representing that it utilizes drip irrigation or with a "2" indicating that it utilizes surface braided network (SBIN) irrigation. Therefore, 30 alternatives were alphanumerically numbered "A1, A2, B1, B2 ..." and so forth through Alternative O, and the 31st alternative is the "No-Action" Alternative P.

These alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water source, infrastructure). The alternatives were ranked and screened based on associated habitat benefits and implementation costs. The Hydrogeomorphic (HGM) method assesses and quantifies the capacity to restore river function (e.g., plant community characteristics, channel dynamics, water storage, connectivity) and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives. Results of the HGM assessment were then incorporated into the Corps' standard cost evaluation analysis to identify the alternatives that provided the highest habitat benefits per unit cost. Following formulation and refinement of the project alternatives, the alternatives were ranked and screened based on associated habitat benefits and implementation costs. Additional formulation, engineering, design, cost estimating, incremental evaluation, benefit-to-cost analyses, and project impacts were completed during this

secondary screening in order to more accurately compare the features of each of the remaining alternatives.

Furthermore, as part of federal guidelines for water resources projects, the alternatives are compared against the general feasibility criteria that are required to be met as follows:

- *Technical Feasibility*: Alternatives must be technically capable of performing the intended function, have a reasonable certainty of addressing the problem, and conform to Corps technical standards, regulations, and policies;
- *Environmental Feasibility*: Alternatives must comply with all applicable environmental laws, including NEPA;
- *Economic Feasibility*: Alternatives must be economically justifiable in that the economic benefits or, in the case of National Ecosystem Restoration (NER) Plan (non-monetary) benefits, must exceed the economic costs, in accordance with applicable regulations, policies, and procedures; and
- *Public Feasibility*: Alternatives must be publicly acceptable as evidenced by a cost-sharing, non-federal sponsor and further documented through an open public involvement process that incorporates the public's input into the formulation of the alternatives.

3.1.1 CHOOSING THE PREFERRED ALTERNATIVE

Once the 31 study alternatives were determined, two techniques were used to determine the most cost-effective alternatives. The first method, which compares alternatives respective of their cost effectiveness, is termed the Cost Effectiveness Analysis (CEA). Using this method, alternatives that produced increased levels of output, measured by the HGM method as Average Annual Functional Capacity Units (AAFCUs), for the same or lesser costs were considered "effective" alternatives and were retained. Those alternatives that provided lesser return for higher associated cost were dropped from consideration.

The second technique measuring cost-effectiveness involves conducting an Incremental Cost Analysis (ICA) using those alternatives that were deemed "cost-effective." In short, the ICA explores the costs associated with a given incremental increase in output of a given alternative. The results of this two-part analysis identified alternatives that are both cost- and incrementally effective. Annualized costs and outputs for all alternatives, as well as the results of the CEA and ICA evaluations are discussed in depth in the feasibility study economic appendices.

3.1.1.1 Cost-Effective Alternatives

The cost analysis indicates that the six most cost-effective alternatives are Alternatives A2, B2, L2, E2, O2 and F2. The AAFCUs for the cost-effective alternatives are provided in Table 3-1.

Table 3-1. Cost-Effective Alternatives

Alternative	AAFCU	AA COST	AAC/AAFCU*
A2	389	2,522	$6.5
B2	619	6,276	$10.1
L2	792	8,935	$11.3
E2	966	9,304	$9.6
O2	1006	10,127	$10.1
F2	1084	16,632	$15.3

* AAC/AAFCU dollar figures are in thousands.

3.1.1.2 Incrementally Effective Alternatives

Results of the ICA indicate that the four incrementally cost-effective alternatives are Alternatives A2, E2, O2, and F2. Alternative A2 is included as an ICA alternative as it is the least expensive plan. On the other end of the spectrum, Alternative F2 provides the highest number of functional capacity units, but at a substantially higher cost per AAFCU than the other three incrementally cost effective alternatives. Alternatives E2 and O2 are both incrementally cost effective, producing a similar level of outputs. While alternative E2 is slightly more cost effective compared to Alternative O2, the study team elected Alternative O2 as the environmentally preferred alternative and the Tentatively Recommended Plan. The incremental costs of these alternatives are show in Table 3-2.

Table 3-2. Incrementally Cost-Effective Alternatives

Alternative	AAFCU	Incremental AA Cost	Incremental AAC/AAFCU*
A2	389	$2,522	$6.5
E2	966	$9,304	$11.8
O2	1,006	$10,127	$20.6
F2	1,084	$16,632	$83.4

* AAC/AAFCU dollar figures are in thousands.

Further explanation is warranted and provided here as to why Alternative O2 is recommended over Alternative E2 and the NER Plan. While Alternative O2 only provides an extra 40 AAFCUs and 70 acres of habitat, relative to Alternative E2, the additional cost is justified due to the type of vegetation planted. In the HGM model, all four vegetation types (cottonwood-willow, mesquite, Sonoran desert scrub shrub and wetlands) were assigned the same value. In other words, the FCU value of an acre of cottonwood-willow vegetation was equal to the FCU value of an acre of Sonoran desert scrub shrub. While it can be said that it is not possible to value one habitat type over another, the study team held that there are inherent differences.

Given the historical presence and current rarity of cottonwood-willow and wetland vegetation in the arid Southwest relative to the desert scrub shrub, it can be argued that there would be more environmental gain if the rare habitat were reestablished. For example, in the arid Southwest, roughly 70% of the listed threatened and endangered vertebrate species are considered riparian obligates (Johnson 1989). Alternative O establishes approximately 883 acres of cottonwood-willow and 200 acres of wetlands. Alternative E establishes only 287 acres of cottonwood-willow and 52 acres of wetland, a difference of 596 acres and 148 acres respectively. Alternative O would reestablish considerably more riparian habitat and therefore provide a larger benefit for those listed obligate species. Thus, Alternative O is considered the least environmentally damaging practicable alternative that meets the objective of the purpose and need for this project. It is the rarity of riparian vegetation, and its inherent value, that the project delivery team determined justifies the additional cost of Alternative O.

Based on the HGM and ICA analyses, Alternative O2 is the environmentally preferable alternative and therefore is the Tentatively Recommended NER Plan. Alternative O2 is also the non-federal sponsor(s) preferred alternative. Alternative O2 ranked as the second biological alternative and as an incrementally cost effective alternative. The strong functional capacity output, the incremental cost effectiveness, and the non-federal sponsor(s) strong preferences for this alternative moves Alternative O2 forward as the Tentatively Recommended Plan.

3.2 DESCRIPTION OF THE PROJECT ALTERNATIVES

Following the HGM and ICA screening processes, the four incrementally cost effective alternatives (A2, E2, O2, F2) as well as the No-Action Alternative (P) remained under consideration for this project. The alternatives vary with respect to the amounts and types of vegetation to be established, water sources, methods for distributing water, irrigation techniques, and where or whether river channelization, surface reshaping, and bank stabilization would occur. For ease of comparison, the river in the project area was divided into nine reaches (Figure 3-1).

This section begins by discussing components that are common to all of the alternatives. The No-Action Alternative, Alternative F, Alternative O (the Tentatively Recommended Plan), Alternative E, and Alternative A are then described. The descriptions of the four alternatives are ordered from the alternative that entails the greatest amount of work effort to the alternative that would require the least work effort. In a previous iteration, Alternative N was an incrementally cost-effective plan as well. However, with recent modifications to the cost estimates, Alternative N is no longer cost effective. Nevertheless, the analysis previously completed on Alternative N remains in the document for information purposes only. Finally, all incrementally cost-effective plans used the SBIN method; therefore, all discussions throughout the following sections will refer to the alternative simply by its alphabetical name, and not the alphanumeric name (e.g., "Alternative A" instead of "Alternative A2"). Table 3-3 presents a comparison of the salient characteristics of each of these alternatives.

Table 3-3. Comparison of Alternatives

Feature	Alternative F	Alternative N	Alternative O	Alternative E	Alternative A	No Action
Channelization	Yes: Reaches 2, 3, 4, 6	No	Yes: Reaches 2,3	Yes: Reach 2, 5	No	No
Bank stabilization	Yes: Reaches 2, 5, 6	No	No	Yes: Reaches 2, 5, 6	No	No
Installation of grade control structure	Yes: Reach 5	Yes: Reach 5	Yes: Reach 5	No	No	No
Removal of invasive plant species (e.g., saltcedar)	Yes: Reaches 8, 9	Yes: Reaches 8, 9	Yes: Reaches 8, 9	Yes: Reaches 8, 9	Yes: Reaches 8, 9	No
Irrigation via SBIN	Yes: Reaches 2, 3, 4, 5, 6	Yes: Reaches 2, 3, 4, 5, 6	Yes: Reaches 1, 2, 3, 4, 5, 6	Yes: Reaches 4, 5, 6	Yes: Reaches 5, 6	No
Irrigation from new groundwater well	Yes: Reaches 5, 6	Yes: Reaches 5, 6	Yes: Reaches 5, 6	Yes: Reaches 5, 6	Yes: Reach 5	No
Flood irrigation	Yes: Reach 6	Yes: Reach 6	No	Yes: Reach 6	No	No
Irrigation via effluent	Yes: Reach 1	Yes: Reach 1	Yes: Reach 1	Yes: Reach 1	No	No
Creation of wetland features	Yes: Reaches 2, 3, 4, 5, 6	Yes: Reaches 2, 4, 5, 6	Yes: Reaches 1,2, 4, 5, 6	Yes: Reaches 2, 5, 6	No	No
Establishment of new cottonwood	Yes: Reaches 2, 3, 4, 5, 6	Yes: Reaches 1, 2, 3, 4, 5, 6	Yes: Reaches 1, 2, 3, 4, 5, 6	Yes: Reaches 1, 2, 5, 6	No	No
Establishment of new mesquite	Yes: Reaches 2, 4, 5, 6	Yes: Reaches 2, 4, 5, 6	Yes: Reaches 2, 4, 5, 6	Yes: Reaches 2, 4, 5, 6	No	No
Establishment of new Sonoran Desert vegetation	Yes: Reaches 4, 5	Yes: Reach 5	Yes: Reach 5	Yes: Reaches 2, 5	Yes: Reaches 5, 6	No
Total irrigated area (acres)	1,711	1,387	1,486	1,416	496	0
Total annual water demand (acre-feet)	8,304	7,736	8,550	4,540	992	0
Total new habitat (acres)	2,119	1,589	1,712	1,733	652	0

1320

Figure 3-1
Project Area
Reaches
Project Study Area
City Boundary
SRP-MIC
Reach
Thalweg
Canal
Highway
Proposed Highway
Local Road
Miles
0
0.5
1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY (SRP-MIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
202
101

3.2.1 COMPONENTS COMMON TO ALL CONSTRUCTION ALTERNATIVES

3.2.1.1 Water Sources

The alternatives rely primarily on surface water and groundwater from the SRPMIC and effluent from the City of Mesa Wastewater Treatment Facility. According to SRPMIC staff, 30,000 acre-feet/year of water can be allocated to the project. Groundwater is considered a secondary source of water.

3.2.1.2 Water Distribution System

The water distribution system is the infrastructure needed to deliver water (surface water, groundwater, or wastewater) from the source (irrigation canal, or well) to the vegetated areas, exclusive of the irrigation system. Surface water from the SRPMIC would be the primary source of water for all construction alternatives. No modifications will be made to existing stormwater drainage infrastructure; however, the project will utilize stormwater runoff as available.

Surface water would enter the project area through irrigation canals controlled by SRPMIC. It is assumed that the SRPMIC will distribute the water to satisfy water demands for the project areas. A flow diversion structure would be used to store and divert surface water from the irrigation channels. During the Preliminary Engineering Design phase of the project, the Corps will coordinate with the Salt River Project to assess the feasibility of using the Hennessey Drain to transport SRPMIC surface water from the south canal.

Effluent will be used as a water source to irrigate vegetation established in the existing recharge basins only. Groundwater would be pumped to the drainage ditches and channels through a buried pipeline.

3.2.1.3 Irrigation Techniques

Surface water from stormwater sources, irrigation canals, and ditches would be conveyed to various vegetated areas through a network of lined irrigation channels and buried pipes. The size of the channel and pipe would depend on site-specific conditions, such as flow requirements and terrain. Pumps may be needed to distribute water. To irrigate the vegetated areas it is recommended that either a surface braided irrigation network (SBIN), flood irrigation, or drip irrigation be used. These methods differ as follows:

- SBIN distributes water through a network of shallow ditches, 6 inches deep and 2 to 3 feet wide. Maintenance of these lined channels may be necessary after larger flow events. Water distribution would need to be manually controlled for the life of the project. Figure 3-2 depicts the layout of the SBIN irrigation method.

- Flood irrigation consists of inundating an area by overland flow. This method has a low irrigation efficiency but also low maintenance requirements and construction costs. Water distribution would need to be manually controlled for the life of the project.
- Drip irrigation distributes water to individual plants through a network of small-diameter tubes.
- Granite Reef Underground Storage Project (GRUSP): Because the vegetation surrounds the GRUSP site, it may affect or be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction.

3.2.1.4 Surface, Vegetation, and Irrigation Reshaping

Surface reshaping is defined as moving material to alter significant features such as large mounds, filling quarry pits, and reducing the side slopes of quarry walls. Although the extent of surface reshaping varies greatly among some alternatives, all construction alternatives involve at least the reshaping of the old Gilbert quarry to create new river bottom.

Vegetation reshaping is minor reshaping required for planting purposes and to ensure that gravity irrigation systems will be feasible. It is assumed that for vegetation reshaping, 2 feet of material would be moved per acre of vegetated area.

Irrigation reshaping is the construction of irrigation ditches needed in the flood irrigation and SBIN irrigation methods (2 to 3 feet wide and 6 inches deep) and the construction of drainage ditches (15 feet wide and 3 feet deep).

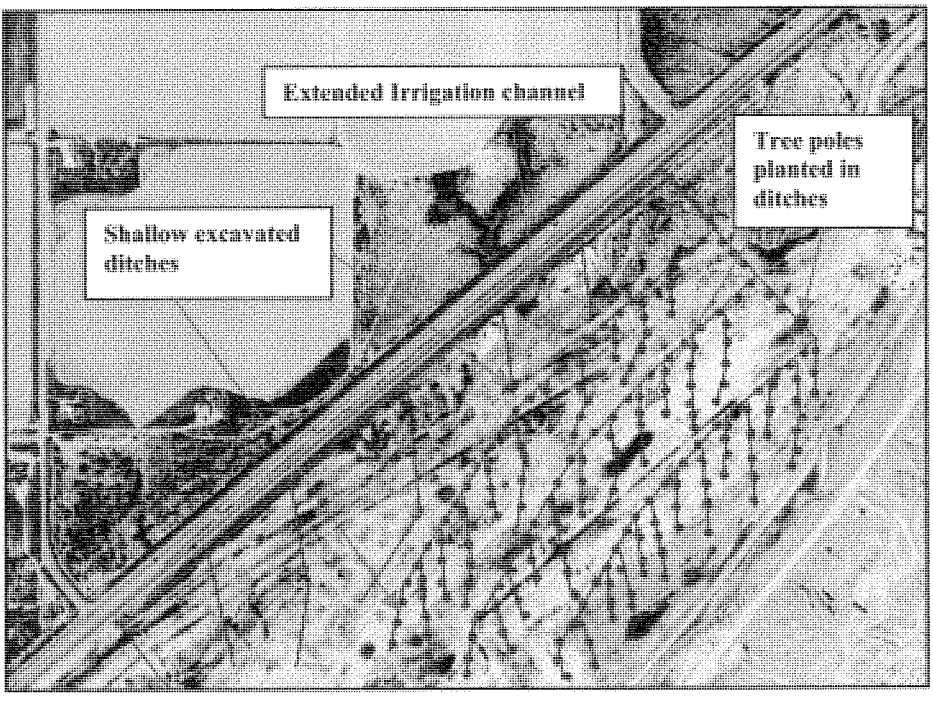
3.2.1.5 Operation and Maintenance

Operation and maintenance activities (O&M) would occur after the project is constructed in order to keep project features functioning as designed. These activities may include:

- maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features,
- vector control,
- environmental monitoring, and
- periodic removal of sediment, surface reshaping, or replanting of project features damaged by flood events.

The types of O&M activities necessary would generally be the same for each construction alternative, although the level of effort would be proportional to the amount of new habitat created and the extent of structural features built for that alternative. Alternative A would require the least amount of O&M and Alternative F would require the greatest amount of effort

Figure 3-2. Surface Braided Irrigation Network (SBIN) Diagram



and cost. A table comparing O&M costs for each alternative is available in Chapter V of the Feasibility Study.

Drainage Maintenance

This maintenance activity consists of clearing debris from drainage structures, including outfalls and channels, and general earthwork maintenance. This is expected to occur on an as-needed basis (inspections would occur more frequently). Excess soil materials would be disposed of locally in areas that are not environmentally sensitive or subject to Clean Water Act permitting.

Maintenance and Replacement of Water Distribution System and Irrigation Infrastructure

Preventive maintenance and routine repairs would be performed on an as-needed basis on pumps and pipelines, diversion structures, irrigation canals and ditches, the SBIN, and drip irrigation equipment (inspections would occur more frequently).

Vector Control

Depending upon the duration and frequency of surface water flow in wetland and riparian habitat areas, the implementation of vector control management activities may be required to protect public health. Management activities that may be implemented to reduce potential habitat and inhibit the development of mosquito larvae include:

- providing pulse flows/periodic flushes;
- removing vegetation to increase wind-driven circulation;
- scheduling irrigation to avoid creating shallow ponded areas;
- stocking mosquito fish in areas where a regular source of standing water is available;
- applying larvicides such as *Bacillus thuringiensis israeliensis* and *Bacillus sphaericus* would be applied by spraying at a frequency of every 2 to 4 weeks during the mosquito season; and
- applying a broad spectrum adulticide such as Malathion in the event of an imminent public health threat.

Environmental Monitoring

Monitoring of habitat and wildlife would occur periodically. This would include monitoring water quality and water supplies as well as vegetation monitoring and management. During the first 5 years following construction of the project, the Corps would share responsibility for monitoring water quality and the success of the restoration components with the project sponsors. In the succeeding years, monitoring would be accomplished by the project sponsors

only. Appendix C contains a Monitoring and Adaptive Management Plan prepared by the Corps for this project.

Sediment Removal

After periods of high flows in the river, substantial quantities of sediment may be deposited in channelized portions of the Salt River or in newly established habitat areas. To maintain the flow conveyance capacity of the river, channelized portions would need to be excavated and reshaped to restore design specifications if conveyance is significantly affected. Sediment removal would occur on an as-needed basis (inspections would occur more frequently).

Sediments may also need to be removed to maintain the viability of areas vegetated for the project. This is anticipated to occur once each year on a rotating basis so that no more than 25% of the marsh area would be affected in any one year. The work would be performed outside the nesting season for birds.

An estimated average of 50 cubic yards of sediment would be removed during each sediment removal event. This material would be provided to commercial sand and gravel operators for reuse or would be used in project repairs.

Maintenance Activities in Specific Areas

Maintenance activities in constructed wetlands would include performing work on outlets and berms to ensure proper functioning and to correct damage from beavers or other rodents that may colonize these areas. Saltcedar and other potentially invasive plant species would be removed on a periodic basis for the life of the project, since local seed sources would continue to be available. Vegetation removal would be done either by mechanical means or by burning in place. A burn permit would be required in the latter case.

Maintenance of cottonwood/willow areas would be limited to debris removal, minor saltcedar removal, minor grade adjustments, and replacement of plants if necessary. Work would not be performed during the nesting season for birds.

Maintenance in mesquite and Sonoran desert areas would consist of monitoring the success of vegetation establishment and replacing plants where necessary. Irrigation systems would need to be periodically inspected during the establishment period but may not be needed after establishment, except perhaps under excessive drought conditions.

3.2.1.6 Vegetation

Varying amounts and locations of five vegetation types are considered in the five construction alternatives:

- Cottonwood/Willow (CW),

- Mesquite (MS),
- Wetland (WT),
- Sonoran Desert Scrub-Shrub (SD), and
- River Bottom (RB).

While all construction alternatives include establishing native vegetation, only some alternatives entail establishing all five vegetation types. The requirements for implementing each vegetation type are as follows.

Cottonwood/Willow (CW)

CW forests would be dominated by Fremont cottonwood and Gooding's willow. Other understory species would be planted, depending upon individual site conditions, but may include arrow weed, elderberry, and/or burro brush.

Under natural conditions, CW stands are restricted to near overbank areas of streams and rivers or areas with saturated soil conditions. They require a water table or saturated soil conditions 1 to 25 feet below the ground surface and have an average annual water demand range from 4 to 8.5 feet. Because the groundwater table for the majority of the study site is 60 feet below the surface, cottonwood/willow stands would rely upon soil saturated by irrigation. It is assumed that the average annual water demand is 6.3 feet. In areas where grading may be required, uneven grading is most beneficial, allowing for depressions where sediment can collect and shelter seeds for establishment. Due to the relative high water demands of CW, a drip irrigation system may be used to help ensure establishment. Once established, CW stands would rely on flood irrigation or SBIN for water needs.

The CW areas would be planted at a density of approximately 20 cottonwood trees, 40 willows, and 5 understory brush species per acre. Understory forbs would also be planted using a native seed mixture.

Mesquite (MS)

Mesquite bosques would be dominated by honey mesquite with scattered velvet mesquite and some understory shrubs, such as desert thorn, blue paloverde, and brittlebush, as well as forbs.

MS areas are commonly found 5 to 20 feet above the river channel where there is adequate water. They require a water table or semi-saturated soil conditions 10 to 30 feet below surface elevation and rely on occasional saturated conditions 1 to 3 feet below surface. It was assumed that the average annual water demand average is 3.0 feet. A drip irrigation system may be necessary to establish the MS. However, once established, the MS would rely on flood irrigation or SBIN. Previous restoration efforts have shown that MS can survive on natural precipitation alone, even when groundwater is not available. However, this cannot be assumed for all

locations. Therefore, a site-specific evaluation would need to be performed to determine if or how much supplemental water is required.

The mesquite bosques would be planted with a density of approximately 100 honey mesquite, 10 velvet mesquite, and 40 understory shrubs per acre. Understory forbs would also be planted using a seed mix.

Wetland (WT)

WT areas for this project would consist of areas of open water, emergent vegetation, or muddy shorelines, all requiring a water table at or near the surface. Wetland vegetation would be primarily cattails, tule, and sedges.

It was assumed that the average annual water demand is 9.0 feet. Because project area soils are porous, the surface of WT areas would be lined to maintain surface water or saturated soils. Excavation and layering of a silt clay soil substrate overlain by a mixed gravel layer and then a cobble layer is recommended. This soil structure would reduce disturbance of the soil-clay layer by reducing piping of fine material and turbulent forces acting on the layer.

WT areas proposed near storm drain outlets would require erosion control measures at the outlets to prevent scouring during high flows. To distribute water from the WT laterally, a series of drainage ditches would be constructed from the WT to convey water to other areas that require irrigation. The ditches would be semi-elliptical in shape with a top width of 4 feet and maximum depth of 2 feet. The drains would increase lateral dispersion of runoff to maximize the stormwater benefit.

Some WT areas would also include an outlet channel leading to the main channel of the Salt River. The preliminary design of the outlet channel proposes a 20-foot bottom width, 3-foot maximum depth, 2:1 side slopes, 300-foot length, and large cobble bottom. The Design Q (volume) equals 400 cubic feet per second (cfs). Not all proposed WT would require an outlet channel.

Sonoran Desert (SD)

The specific SD scrub-shrub species that would be planted would vary depending upon soil conditions. Likely species include rabbit brush, triangle bursage, blue paloverde, ironwood, and possibly some cactus species.

The proposed vegetation types would not require saturated soil conditions and it is assumed that the average annual water demand is 2.0 feet. The SD may need to be periodically inundated the first 1 to 5 years to establish the vegetation. However, once established, SD should be sustained by annual precipitation or with periodic inundation, via flood irrigation, during extreme drought periods.

Densities of plantings could range from 5 ironwoods per acre to 25 to 30 stems of triangle bursage or brittlebush per acre.

River Bottom (RB)

RB is found in the active river channel. It is expected to remain mostly unvegetated because of the cobble substrate and relatively high disturbance level found in these locations. However, some areas, where smaller aggregate soils have accumulated, may support scrub-shrub species such as burro brush or rabbit brush. Also, areas of standing water that has collected in natural depressions may support small pockets of emergent vegetation such as cattails or bulrush. RB would require only surface reshaping, including partially filling large depressions and excavating large mounds to reduce possible impacts to restoration efforts. RB areas may also require hydroseeding with a variety of native shrubs. These plants would be sustained with natural precipitation and any tailwater that may enter the river from other irrigation systems. Irrigation would not be required. In addition to planting, some reshaping may be necessary to provide the proper landscape to maintain and encourage the future propagation of this vegetation type.

3.2.2 NO-ACTION ALTERNATIVE (FUTURE WITHOUT PROJECT)

Under the No-Action Alternative, the Corps would take no action to restore the ecosystem and wildlife habitat within the study area. Plans with potential incidental benefits to reduce flood damage and improve water quality and water supply also would not be provided by the Corps. Although it is possible that local agencies would implement limited improvements, restoration efforts would not occur on the scale of the proposed project.

3.2.3 ALTERNATIVE F

As indicated earlier in this chapter, Alternative F is the alternative with the greatest number of project features. It is also one of two construction alternatives that include channelization of portions of the Salt River (the other is Alternative O) and bank stabilization features in certain reaches (the other is Alternative E).

Channelization would entail confining flows of the Salt River to a narrower and deeper channel than the current main channel. It would be done in order to offset the reduction in the capacity of the channel to convey water in certain areas due to planting vegetation within the main channel. A total of 16,500 linear feet would be channelized under this alternative.

The river bottom would be excavated to form a low-flow channel with a bottom width of 200 feet, 1V:3H side slopes, and a depth of 4 to 8 feet. The channel would be free to migrate. The excavated material would be used to create benches along the channel, to fill quarry pits, and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. Maintenance of the channel may be necessary after flow events. A

200-foot buffer on both sides of the low-flow channel would be incorporated into the design to allow for the migration of the channel.

Portions of the low-flow channel would be designed with a semi-impervious soil substrate to support wetland areas. It is recommended that Sonoran vegetation be planted along the low-flow channel to increase stability of the overbank area.

The purpose of bank stabilization (also called armoring) is to stabilize the river, reduce erosion, and provide protection for newly established vegetation. The preferred method of bank stabilization is soil cement.

A layout of the proposed restoration for Alternative F is shown in Figure 3-3. Activities proposed for each reach are described below.

Reaches 9 and 8: Invasive plant species, primarily saltcedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes are proposed in Reach 7 due to the presence of the active Higley Quarry. It is assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual removal of materials from the Higley Quarry would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the affects from mining operations at the Higley Quarry, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material will continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reach 6: Relatively large areas of CW and MS would be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and would be irrigated using surface water from the North Canal. In both areas the water will be distributed by flood irrigation or by a SBIN. Because the vegetation surrounds the GRUSP site, it may affect or be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction. On the south bank of the river, CW would be planted in an unnamed abandoned quarry depression directly east of Gilbert Road, between a larger quarry and the channel, and within the 5-year floodplain. The area would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation.

A larger abandoned quarry further upstream along the south bank would be reconnected to the Salt River with two spillways. No reshaping of this quarry is recommended because of the extremely large volume of material that would be required to fill the quarry to the channel invert

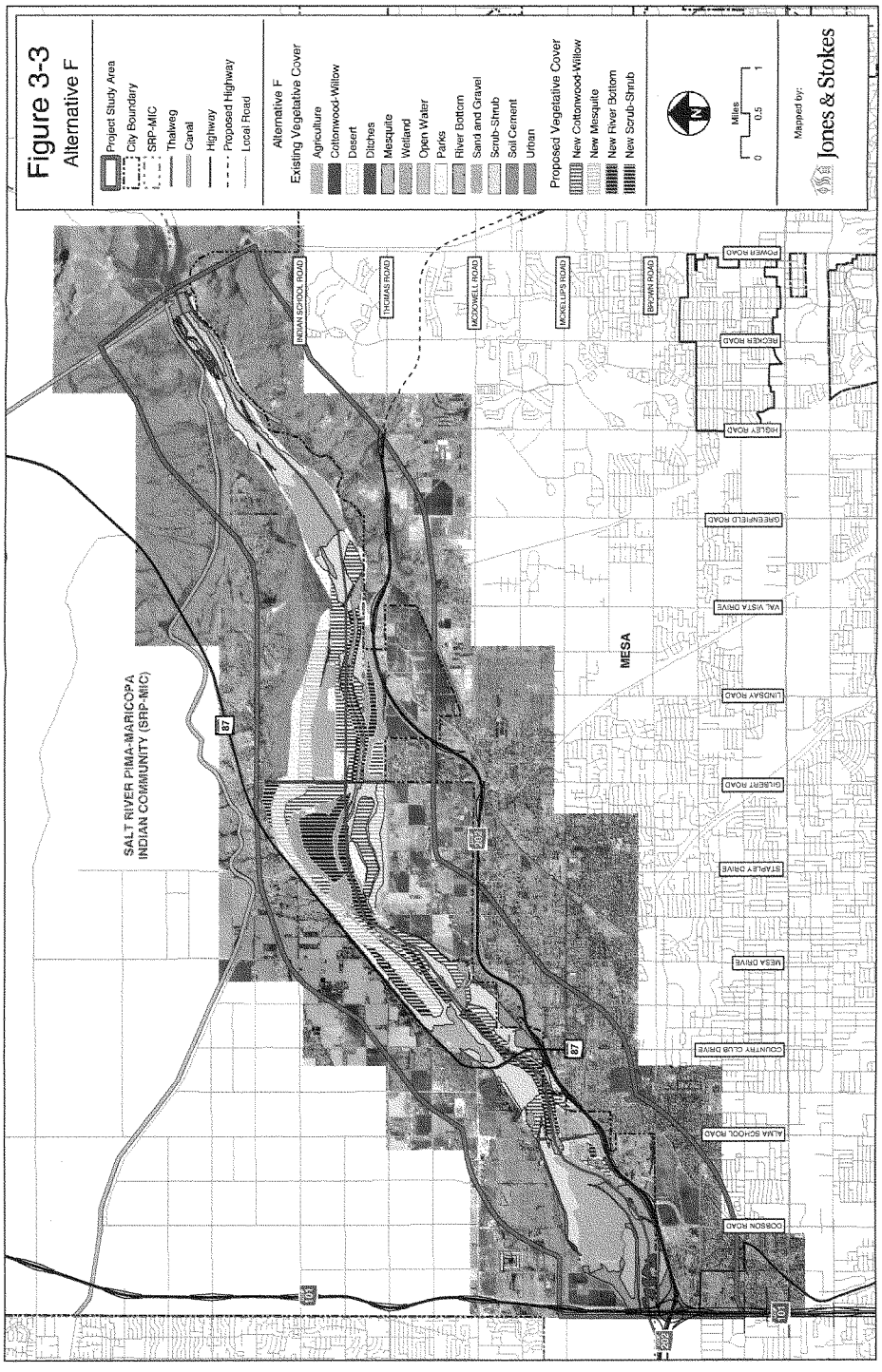


Figure 3-3
Alternative F
Project Study Area
City Boundary
SRP-MIC
Thalweg
Canal
Highway
Proposed Highway
Local Road
Alternative F
Existing Vegetative Cover
Agriculture
Cottonwood-Willow
Desert
Ditches
Mesquite
Wetland
Open Water
Parks
River Bottom
Sand and Gravel
Scrub-Shrub
Soil Cement
Urban
Proposed Vegetative Cover
New Cottonwood-Willow
New Mesquite
New River Bottom
New Scrub-Shrub
Miles
0
0.5
1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY (SRP-MIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
MILEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
60
101

level. The quarry pit would be partially filled with material. This quarry is oriented such that during high flows, the river could be redirected south into the quarry pit, causing bank erosion along the south bank and a headcut migration upstream and downstream of the quarry (Va Shly'ay Akimel Hydraulic Sediment Analysis). Headcutting would adversely affect vegetation establishment within Reach 6 and might damage the Gilbert Road Bridge at the west end of Reach 6. To ensure that the quarry does not affect the current channel layout, the south bank of the river would be reestablished north of the quarry and hard-banked. Approximately 6,000 linear feet of the south river bank would armored (Figure 3-4).

A wetland (WT) would be constructed in the riverbed near the existing Hennessey Drain outlet near the east end of Reach 6. A berm of coarse rock would be constructed on the upstream side of the WT to provide some protection from scour during flow events and help force flows away from the south bank. The WT would be lined with a low-permeability liner system to help maintain surface water level and the saturated soil conditions necessary for vegetation growth. The WT would be adjacent to a new CW stand at its upper (east) end, taking advantage of the saturated soil conditions, and would be irrigated using surface water from the Hennessy Drain and either SBIN or flood irrigation.

The WT would also serve as the upstream starting point of the low-flow channel for the portion of the Salt River that would be channelized. The larger wetland feature would narrow to fit within the channelized portion of the river. This section of channelization would continue downstream to approximately Gilbert Road (the western limit of Reach 6), with a total of two WT features within the channel, one at the eastern end and one at the western end. SD would be established on the benches.

Reach 5: The north bank of the Salt River in the vicinity of the Gilbert Quarry pit would be armored to prevent the river from potentially moving north into the Gilbert Quarry pit during high flows. If the river channel were to break through into the quarry pit, headcutting could occur both upstream and downstream of this area. Soil cement is the recommended bank stabilization material.

The Gilbert Quarry pit would be reshaped and converted to river bottom. Two spillways would be constructed as part of the bank stabilization to allow water flow into and out of the pit from the river. CW, MS, and SD would be planted on the overbank area. The SD and MS would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from the drainage distribution channel via the SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to river bottom. WT and MS would be established at Evergreen Drain, on the north side of the channel. The MS would be irrigated using groundwater from the new well, and the WT would be supported by runoff from Evergreen Drain.

The south bank would be vegetated with CW and MS. Surface water and stormwater would be used to irrigate these areas. The south bank CW and MS would continue eastward, ending at Gilbert Road. Irrigation of the CW and MS would be done by SBIN.

A grade control structure is proposed to protect the channel and the newly-restored upstream riparian area from headcutting associated with extensive mining that has occurred downstream of the Gilbert Road Bridge. Mining operations have altered the channel system, creating a nickpoint, or area where an abrupt change in elevation and slope occurs. Water flowing over a nickpoint generally results in headcutting, causing erosion and downcutting, which allows the channel to migrate upstream. Results from the Va Shly'ay Akimel Hydraulic Sediment Analysis indicate that the headcut could undermine the bridge and damage features directly upstream of the quarry.

The grade control structure would help reduce the upstream migration and stabilize the river system, improving the likelihood of success of vegetation established upstream and downstream. The grade control structure would be placed in the main channel at the center point of the former Gilbert Quarry. It would be designed to the estimated scour depth, would span the entire width of the riverbed, and would stand 10 feet tall with a 20-foot toe depth (total height 30 feet). The depth of the structure would be 8 feet and the length 1,100 feet. Riprap would be placed on the downstream end to prevent erosion.

Figure 3-5 shows the longitudinal profile of the Salt River with the structure. The future main channel was assumed to have been lowered 20 feet due to mining.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. MS, SD, and a small stand of CW could be established in this area if there are no water quality issues (e.g., potential leachate and methane production) and the soil layer over the landfill cap is sufficiently deep to allow trees and shrubs to root. The area would be irrigated using surface water and stormwater by way of the SBIN.

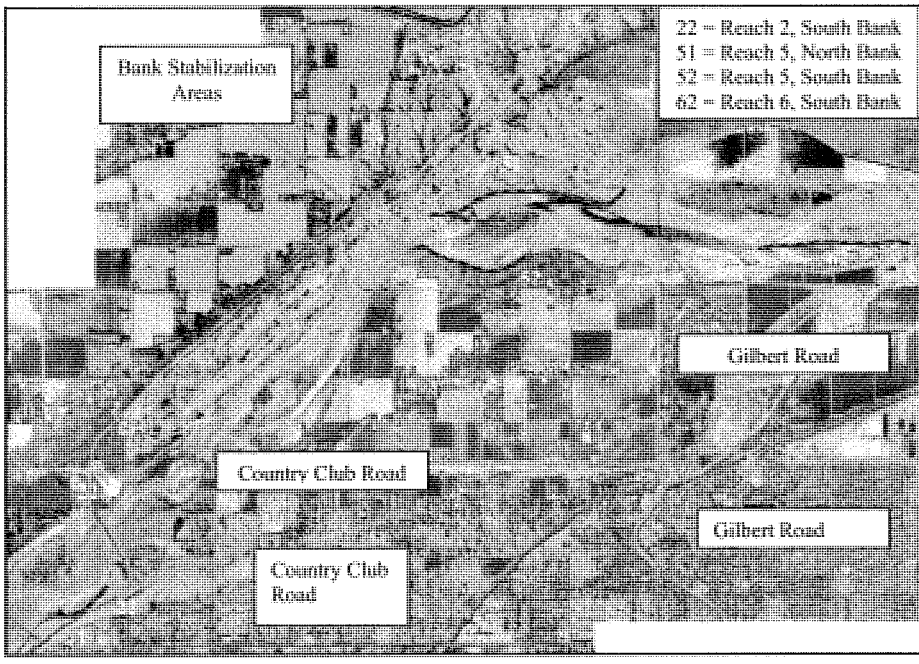
The area along the south bank would support CW, MS, and WT. Two surface water outlets on the south bank would supply water to the SBIN to irrigate the vegetation. The western outlet would support the WT as well as surrounding CW and MS. Since this southern area is relatively protected from the main channel, damage to the channel and the irrigation system has the potential to occur less frequently.

The western wetland feature would be the upstream starting point for the second section of channelized river bottom. In Reach 4, this channelized area would support two WT features within the channel and SD on the benches. Channelization would extend from this point in Reach 4 downstream through all of Reach 3 and Reach 2.

Reach 3: As indicated in the previous paragraph, the river would be channelized for the entire length of Reach 3, thus reshaping and creating new river bottom along this entire reach.

A channel would be constructed to drain the southern portion of Reach 4 to supply water to a portion of the WT and CW vegetation to be established within the river channel in Reach 3. Water would be conveyed to the CW using the SBIN.

Figure 3-4. Bank Stabilization Locations



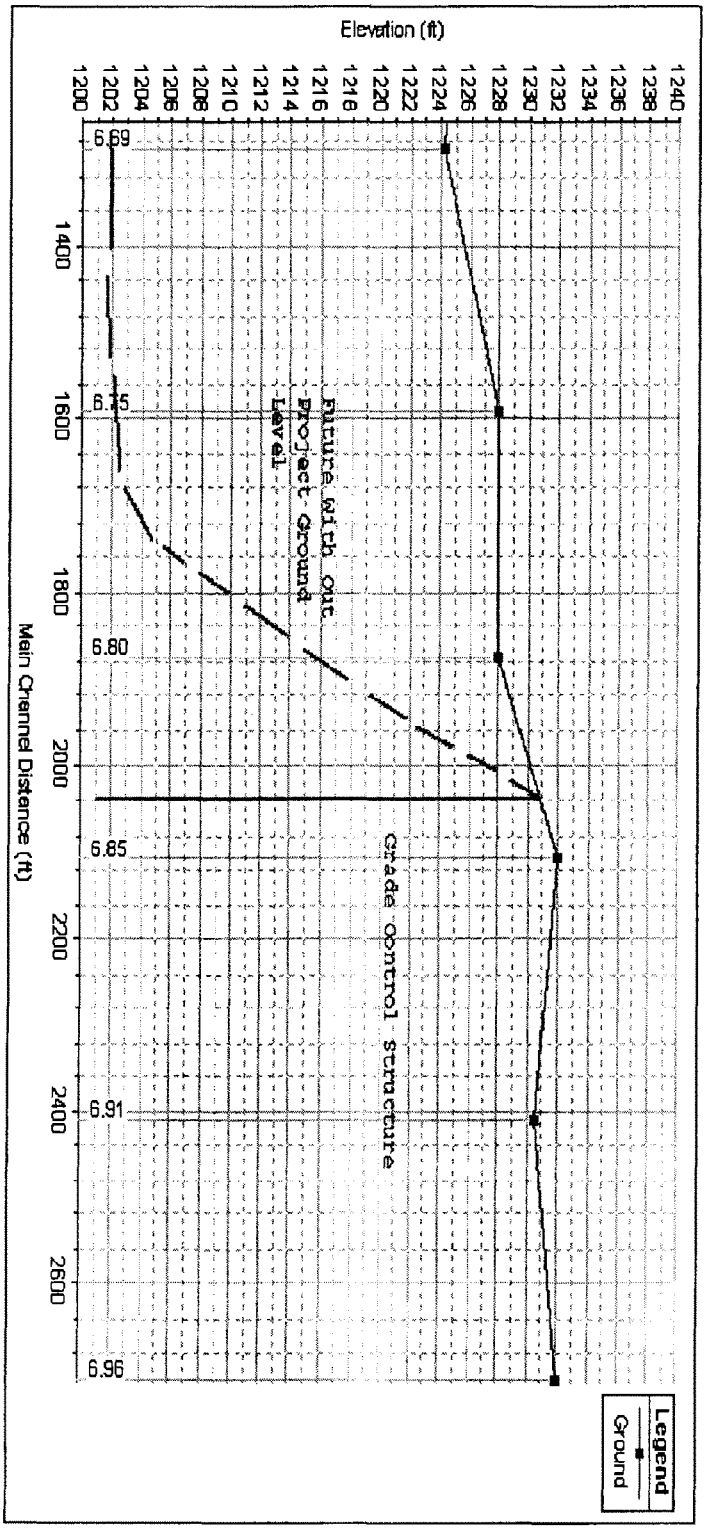


Figure 3-5. Longitudinal Profile of Salt River Main Channel with Grade Control Structure

Reach 2: The river would be channelized for the entire length of Reach 2. It would support an in-channel WT that terminates in a larger wetland immediately downstream of Alma School Road.

Bank stabilization with soil cement is recommended for the south bank between Country Club Road and Alma School Road (Figure 3-4) to prevent a southerly migration of the river resulting in damage to project features and Highway 202. Soil cement bank protection in this area would be 3,000 feet long, 40 feet tall, and 6 feet deep.

The northern portion would support a WT feature surrounded by CW to the west, south, and east, and MS to the north. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River, if the water is of sufficient quality.

The south bank would include a small WT and small areas of CW and MS. One stand of CW would surround the wetland; the second stand would be downstream of the first, with the stand of MS located between the two CW areas. The WT would be constructed near the Country Club Storm Drain on the existing river bottom and will need to withstand stormwater runoff.

The WT would be surrounded by CW and irrigated using SBIN.

Reach 1: No work is proposed for Reach 1. The SRPMIC has expressed an interest in developing this area for commercial purposes.

3.2.3.1 Water Sources Related Structures

Eleven new irrigation diversion structures and one new groundwater well are proposed for this alternative.

3.2.3.2 Water Demand

The total annual evapotranspiration demand for Alternative F is 8,960 acre-feet (Table 3-4).

Table 3-4. Vegetated Area and Evapotranspiration Rate for Alternative F

Reach	Area (acres)	Evapotranspiration (acre-ft)
1	0	0
2	233	1,298
3	29	181
4	344	1,668
5	495	2,204

Reach	Area (acres)	Evapotranspiration (acre-ft)
6	610	2,952
Total	1,711	8,304

3.2.4 ALTERNATIVE N

A layout of the proposed restoration for Alternative N is shown in Figure 3-6. As noted earlier, Alternative N would include most of Alternative F's vegetation features but lacks most of its structural features. Most notably, it does not include either channelization or bank stabilization. Activities proposed for each reach are described below.

Reaches 9 and 8: Invasive plant species, primarily saltcedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes are proposed in Reach 7 due to the presence of the active Higley Quarry. It is assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the effect of the Higley mining operations, the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bedload material to Reach 6. By reducing the deposition, bedload material will continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reach 6: Relatively large areas of CW and MS will be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and would be irrigated using groundwater from a new well. In both areas the water will be distributed by flood irrigation or by a SBIN. Because the vegetation surrounds the GRUSP site, it may affect or be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction.

On the south bank of the river, two areas of CW will be planted. One CW would be located in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain. The second CW would be a relatively narrow strip along the southern edge of the main channel. Both areas will be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation.

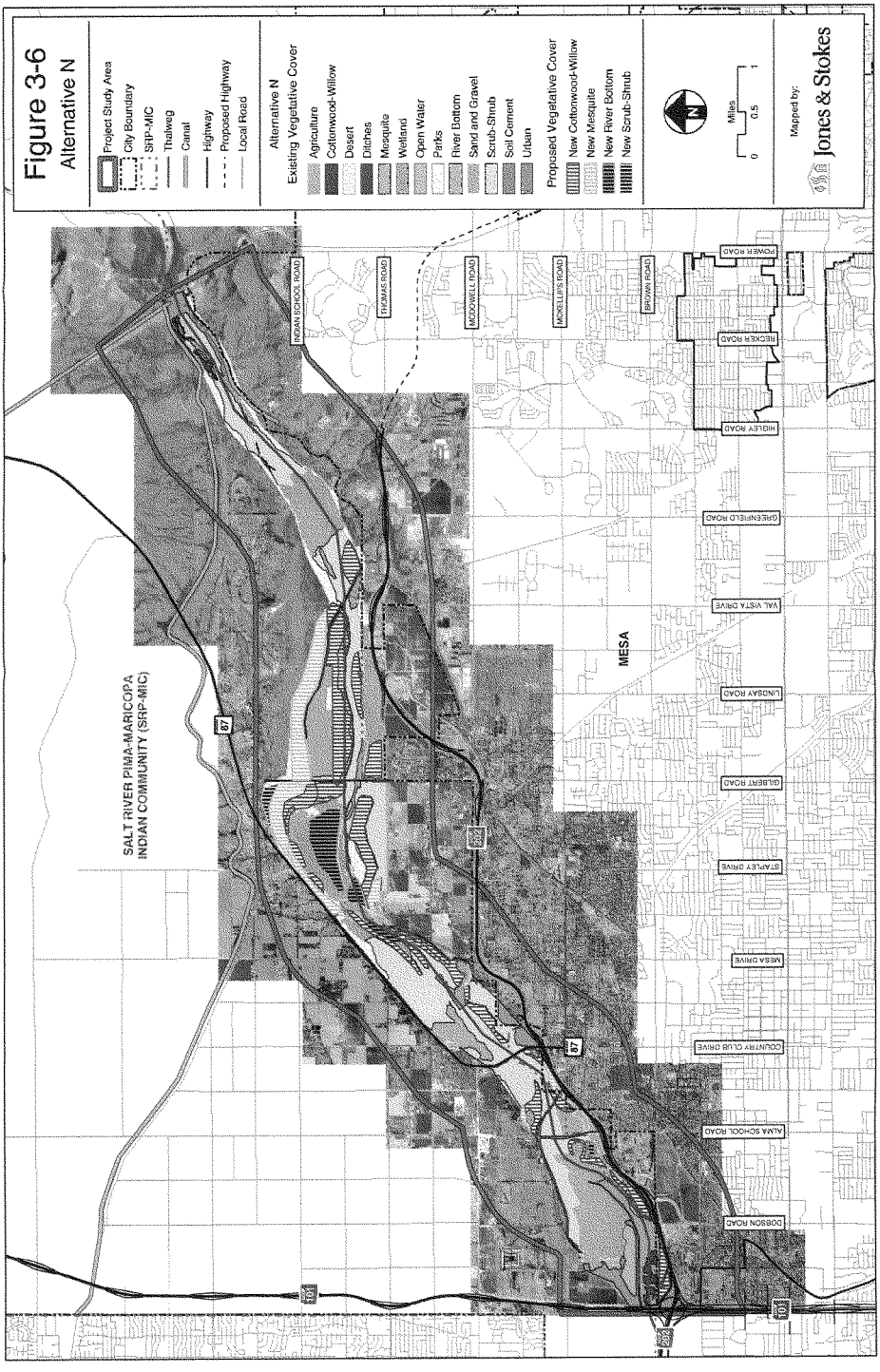


Figure 3-6
Alternative N
Project Study Area
City Boundary
SRP-MIC
Thalweg
Canal
Highway
Proposed Highway
Local Road
Alternative N
Existing Vegetative Cover
Agriculture
Cottonwood-Willow
Desert
Ditches
Mesquite
Wetland
Open Water
Parks
River Bottom
Sand and Gravel
Scrub-Shrub
Soil Cement
Urban
Proposed Vegetative Cover
New Cottonwood-Willow
New Mesquite
New River Bottom
New Scrub-Shrub
Miles
0
0.5
1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY (SRP-MIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
202
60

A WT would be constructed in the riverbed near the existing Hennessey Drain outlet, near the east end of Reach 6. A berm of coarse rock would be constructed on the upstream side of the WT to provide some protection from scour during flow events and help force flows away from the south bank. The WT would be lined with a low-permeability liner system to help maintain surface water levels and the saturated soil conditions necessary for vegetation growth. The WT would be adjacent to a new CW stand at its upper (east) end, taking advantage of the saturated soil conditions, and would be irrigated using surface water from the Hennessy Drain and either SBIN or flood irrigation.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to river bottom. CW, MS, and SD would be planted on the overbank area. The MS and SD will be irrigated using groundwater from a new well. The CW will be irrigated using surface water diverted from an irrigation canal. The water will be distributed using SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to river bottom. WT and CW would be established at Evergreen Drain. The CW would be irrigated using groundwater from the new well, and the WT would be supported by runoff from Evergreen Drain.

The south bank will be vegetated with CW and a small stand of MS. Surface water and stormwater will be used to irrigate these areas, with the water distributed by a SBIN.

A grade control structure would be placed in the main channel of the river at the center point of the former Gilbert Quarry. As noted in the description of this structure under Alternative F, this structure would help protect the channel and the newly-restored riparian area from head cutting associated with extensive mining that has occurred downstream. The structure would span the entire width of the riverbed, approximately 1,500 feet, and be designed to the estimated scour depth. Figure 3-5 shows the longitudinal profile of the Salt River with the structure.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. The majority of this area will be left unvegetated due to the presence of the landfill. However, a narrow strip of CW would be established along the north bank of the river, at the edge of the main channel. The area will be irrigated using surface and stormwater distributed by a SBIN.

The area along the south bank would support CW, MS, and a relatively large WT. Two surface water outlets on the south bank would supply water to the SBIN to irrigate the vegetation. The western outlet would support the WT as well as surrounding CW and MS. Since this southern area is relatively protected from the main channel, damage to the channel and the irrigation system would occur less frequently.

Reach 3: A drainage channel would be constructed to drain the southern portion of Reach 4 to supply water to a new CW stand along the south bank that would be a continuation of the CW stand at the western end of Reach 4. Water would be conveyed to the CW using the SBIN.

Reach 2: The northern portion would support a WT surrounded by CW to the west, south, and east and MS to the north. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River, if the water is of sufficient quality.

The south bank would include a small WT and small areas of CW and MS. One stand of CW would surround the wetland; the second stand would be downstream of the first, with the stand of MS located between the two CW areas. The WT would be constructed near the Country Club Storm Drain on the existing river bottom and will need to withstand stormwater runoff.

MWWTP effluent would support two WT areas created at Alma School Road downstream of the old quarry. The western WT will be flanked by CW to the west that will continue into Reach 1. The CW will be irrigated using SBIN. A small area south of the wetlands will be reshaped and converted to new river bottom.

Reach 1: The CW stand adjacent to the western WT of Reach 2 will continue westward into the main channel of the river.

An old recharge area on the south side of the river would be converted from ruderal vegetation to a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area is MWWTP effluent.

No activity is planned for the north side of the river. The SRPMIC has expressed an interest in developing this area for commercial purposes.

3.2.4.1 Water Sources - Related Structures

Nine new irrigation diversion structures, no new WWTP diversion structures, and one new well are proposed for Alternative N.

3.2.4.2 Water Demand

The total annual evapotranspiration demand for Alternative N is 7,736 acre-feet (Table 3-5).

Table 3-5. Vegetated Area and Evapotranspiration Rate for Alternative N

Reach	Area (acres)	Evapotranspiration (acre-feet)
1	51	320
2	141	905
3	29	181

Reach	Area (acres)	Evapotranspiration (acre-feet)
4	152	1,057
5	434	2,224
6	580	3,048
Total	1,387	7,736

3.2.5 ALTERNATIVE O (PREFERRED ALTERNATIVE)

Under the Preferred Alternative, the Corps would vegetate large portions of the project area and provide minimal support or flood control structures. A layout of the proposed restoration for Alternative O is provided in Figure 3-7. Activities proposed within specific reaches are described below.

Reach 9 and 8: Invasive plant species, primarily salt cedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No planting was proposed in Reach 7 because of the Higley Quarry Plant. It is assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the affect of the Higley mining operations the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

A grade control structure would be placed in the main channel at the center point of the former Gilbert Quarry. The infrastructure is needed to guarantee the river cross-section to maintain the project features. Therefore, the grade control structure is necessary to stabilize the river. However, it also provides incidental protection of Gilbert Road Bridge. The structure would span the entire width of the riverbed, approximately 1,000 feet, and be designed to the estimated scour depth.

Reach 6: Relatively large areas of CW and MS would be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and would be irrigated using groundwater from a new well. In both areas the water will be distributed by flood irrigation or by a SBIN.

Because the vegetation surrounds the GRUSP site, it may affect or be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction.

On the south bank of the river, two areas of CW would be planted. One CW would be located in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain. The second CW would be a relatively narrow strip along the southern edge of the main channel. Both areas would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to new river bottom. CW and MS, and a small pocket of SD would be planted on the overbank area. The MS and SD would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from the irrigation canal via the SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to new river bottom. WT and CW would be established at Evergreen Drain, on the north side of the channel. The CW would be irrigated using ground water from the new well, and the WT would be supported by run off from Evergreen Drain.

The south bank would be vegetated with CW and a small stand of MS. Surface water and stormwater would be used to irrigate these areas. Irrigation of the CW and MS would be done by SBIN.

A grade control structure would be placed in the main channel at the center point of the former Gilbert Quarry. This structure would help protect the newly-restored channel and upstream riparian areas, as well as protect the Gilbert Road Bridge from head cutting associated with downstream mining activities. The structure would span the entire width of the riverbed, approximately 1,000 feet, and be designed to the estimated scour depth.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. This area would be left unvegetated due to the presence of the landfill. The area along the south bank would support CW, MS and WT. Two surface water outlets on the south bank would supply water to the SBIN to irrigate the vegetation. The western outlet would support the WT as well as surrounding CW and MS. Since the southern area is relatively protected from the main channel, damage to the channel and the irrigation system has the potential to occur less frequently.

Reach 3: CW and MS stands would be established on the north and south banks. The SBIN network installed to irrigate vegetation installed along the south bank in Reach 4 would be extended to supply water to the CW vegetation in Reach 3. Water would be conveyed using the SBIN.

Reach 2: The northern portion would support a WT feature surrounded by CW to the west, south, and east. These features would be supported by surface water outlets, and maintained

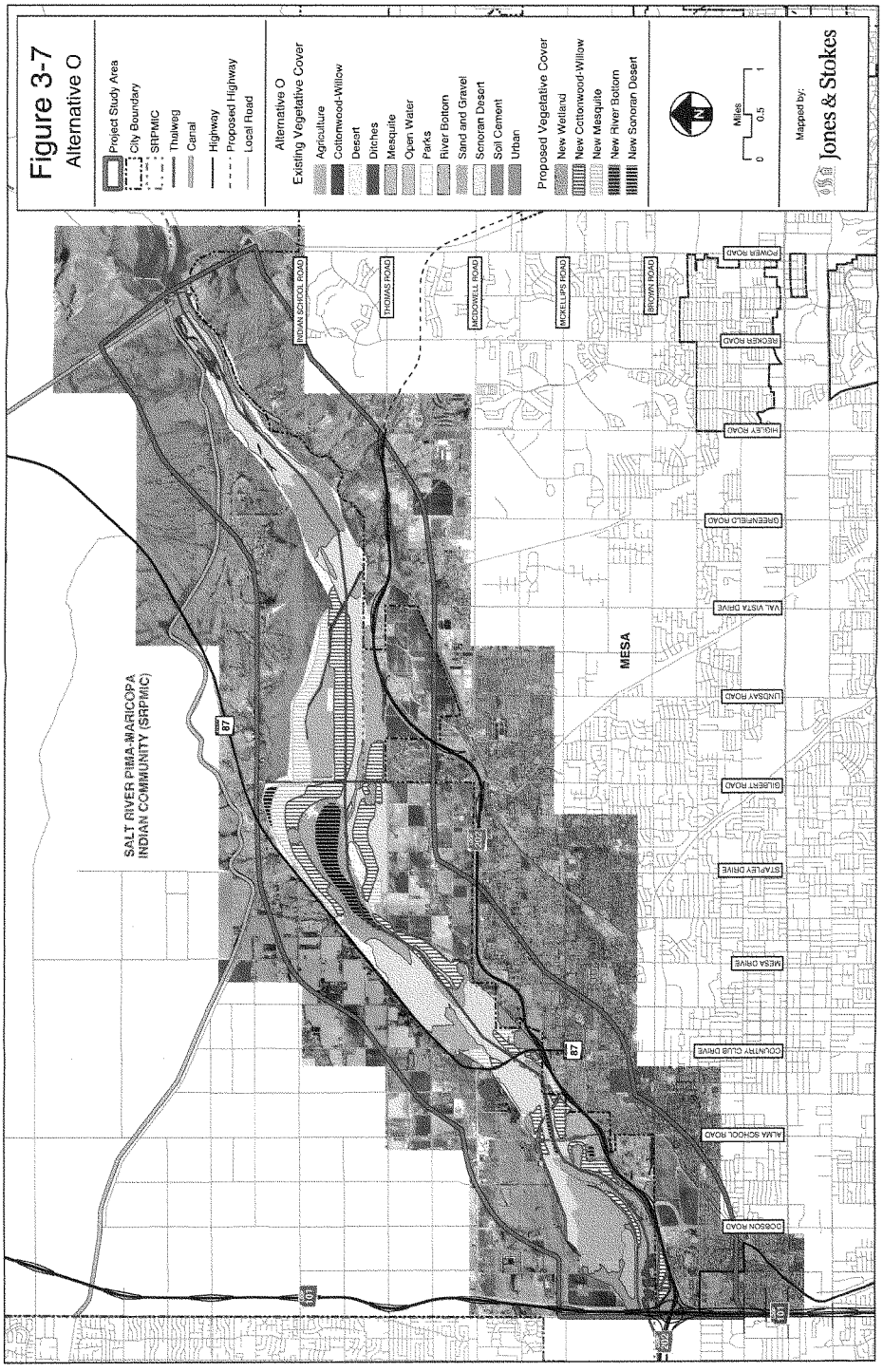


Figure 3-7
Alternative O
Project Study Area
City Boundary
SRPMIC
Thalweg
Canal
Highway
Proposed Highway
Local Road
Alternative O
Existing Vegetative Cover
Agriculture
Cottonwood-Willow
Desert
Ditches
Mesquite
Open Water
Parks
River Bottom
Sand and Gravel
Sonoran Desert
Soil Cement
Urban
Proposed Vegetative Cover
New Wetland
New Cottonwood-Willow
New Mesquite
New River Bottom
New Sonoran Desert
N
Miles
0
0.5
1
Mapped by:
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SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY (SRPMIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
60
202

using a SBIN. Additional water may be supplied by a golf course located north of the Salt River, if it is of sufficient quality.

The south bank would support two wetland features and small areas of CW and MS. One small stand of CW would surround the wetland; the second stand would be downstream of the first. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand storm water runoff.

Two wetland feature would be created in the old quarry downstream of Alma School Road . The larger WT to the east and a second smaller WT located just south would both be surrounded by CW stands. The CW would be irrigated using SBIN. A small area, south of the wetlands, would be reshaped and converted to new river bottom.

Reach 1: This Reach would support one wetland feature and two CW stands. The WT would be located to the north, within the main channel and would connect with a CW stand along the north bank. The percolation ponds found immediately outside of the southern bank would be planted with CW. This area would be supported using the existing irrigation infrastructure.

3.2.5.1 Water Sources - Related Structures

Eight new irrigation diversion structures, no new WTTP diversion structures, and one new well are proposed for Alternative O.

3.2.5.2 Water Demand

The total annual evapotranspiration demand for Alternative O is 8,550 acre-feet (Table 3-6).

Table 3-6. Vegetated Area and Evapotranspiration Rate for Alternative O

Reach	Area (acres)	Evapotranspiration. (acre-ft)
1	66	475
2	226	1,565
3	29	181
4	152	1,057
5	434	2,224
6	580	3,048
Total	1,486	8,550

3.2.6 ALTERNATIVE E

A layout of the proposed restoration for Alternative E is provided in Figure 3-8. Activities proposed within specific reaches are described below.

Reaches 9 and 8: Invasive plant species, primarily saltcedar, would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes were proposed in Reach 7 due to the presence of the active Higley Quarry. It was assumed that any vegetation planted would be damaged due to in-channel mining operations.

Reach 6: The existing drainage channel along the north side of the GRUSP site would be extended past Gilbert Road to supply water to northern portion of Reach 5. This channel presently carries Salt River Project water from the Hennessey Drain to the GRUSP.

CW would be planted south of the GRUSP site and MS and SD would be planted north of the GRUSP site. The CW would be irrigated using a SBIN. Water from the drainage channel would be diverted to the SBIN for CW use. MS and SD would be planted north of the drainage channel and irrigated using SBIN and/or a drip/bubbler system. Groundwater from a new well would be the source of water. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction.

On the south bank, the former quarry would be reshaped and seeded to establish SD. MS would be planted upstream of the quarry outside of the 20-year floodplain, with the area irrigated using SBIN with water diverted from the Hennessey Drain. The south bank would be stabilized with

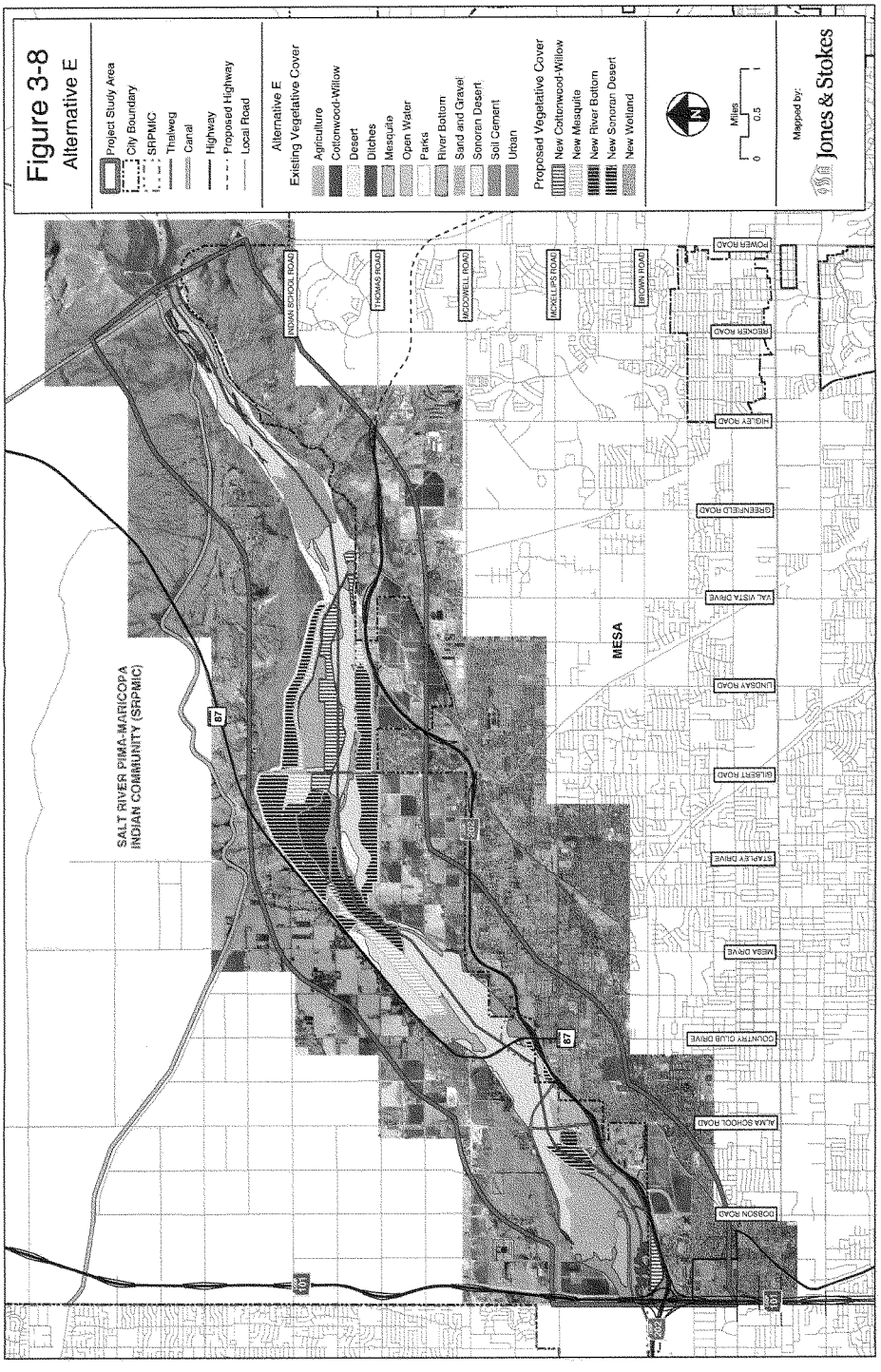


Figure 3-8
Alternative E
Project Study Area
City Boundary
SRPMIC
Thalweg
Canal
Highway
Proposed Highway
Local Road
Alternative E
Existing Vegetative Cover
Agriculture
Cottonwood-Willow
Desert
Ditches
Mesquite
Open Water
Parks
River Bottom
Sand and Gravel
Sonoran Desert
Soil Cement
Urban
Proposed Vegetative Cover
New Cottonwood-Willow
New Mesquite
New River Bottom
New Sonoran Desert
New Wetland
N
Miles
0
0.5
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY (SRPMIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
202
60

soil cement or coarse rock to prevent headcutting that could compromise the establishment of vegetation.

A WT and CW area would be established at the Hennessey Drain and GRUSP diversion. A berm of coarse rock would be constructed on the upstream side of the WT to provide some protection during flow events and contribute to forcing flow away from the south bank. The WT would be lined with a low-permeability liner system to help maintain surface water level and the saturated soil conditions necessary for vegetation growth. The WT would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using SBIN and or flood irrigation. Surface water from the Hennessey Drain would be used to irrigate this area.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to river bottom. The north drain from Reach 6 would continue downstream to Reach 5 to provide water to CW, MS, and SD in and around the new river bottom. The MS and SD would be irrigated using SBIN with groundwater from a new well.

A WT would be created on a terrace at the Evergreen Drain outlet. Groundwater from a new well can be used for additional water, if necessary. The WT would be designed to handle stormflows and disperse stormwater laterally. Side drains would be constructed to disperse the stormwater. The CW and MS surrounding the WT will be irrigated using SBIN.

On the south bank, from Gilbert Road to Lehi Cemetery, SD would be established in the upland area and irrigated with a SBIN, using diverted surface water. The south riverbank in this area would be stabilized (Figure 3-4), preferably using soil cement, to prevent erosion and the loss of newly established vegetation. If implemented, the structure would be 5,000 feet long, 30 feet tall, and 6 feet deep.

The main channel of the river would be reshaped to allow the establishment of river bottom and to increase channel conveyance capacity. Although naturally occurring flow events could also be used to reshape the river bottom, mechanical reshaping would provide material to use for the construction of proposed features.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. MS could be established in this area if there are no water quality issues and the soil layer over the landfill cap is sufficiently deep to allow trees to establish an adequate root system. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace via SBIN.

Reach 3: No activity is planned in this area.

Reach 2: Along the north bank and within the channel between Alma School Road and Longmore Road, SD would be established and irrigated using SBIN and surface water. A WT and small CW stand would also be established and irrigated using runoff from a golf course.

Along the south bank, a WT would be constructed near the Country Club Storm Drain on the existing river bottom. It appears that the wetland area is protected from main channel flow, but

the WT will need to be able to withstand stormwater runoff. CW would be planted immediately adjacent to the WT. This area would be located in a high-velocity area and would suffer damage during flow events, on average once every 3 years. However, these flow events would also allow the transport of seeds and vegetative propagules further downstream, aiding establishment of vegetation in new areas.

The old quarry at Alma School Road would be converted to new river bottom.

Bank stabilization with soil cement is recommended for the south bank between Country Club Road and Alma School Road (Figure 3-4) to prevent a southerly migration of the river resulting in damage to project features and Highway 202. Soil cement bank protection in this area would be 3,000 feet long, 40 feet tall and 6 feet deep.

Reach 1: An abandoned water recharge area on the south side of the river would be converted from ruderal vegetation to a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area is MMWTP effluent.

The only measure that would be applied to the main channel of the river is the eradication of invasive vegetation species, provided that no threatened or endangered species are associated with them, followed by possible enhancement plantings to avoid reoccurrence of invasive plants.

3.2.6.1 Water Sources - Related Structures

Four new irrigation diversion structures, no new WWTP diversion structures, and one new well are proposed for Alternative E.

3.2.6.2 Water Demand

The total annual evapotranspiration demand for this alternative is 4,568 acre-feet (Table 3-7).

Table 3-7. Vegetated Area and Evapotranspiration Rate for Alternative E

Reach	Area (acres)	Evapotranspiration (acre-feet)
1	38	242
2	98	261
3	0	0
4	128	384
5	577	1,461
6	575	2,191
Total	1,416	4,540

3.2.7 ALTERNATIVE A

A layout of the proposed restoration for Alternative A is shown in Figure 3-9. Activities proposed within specific reaches are described below.

Reach 9 and 8: Invasive plant species, primarily saltcedar, would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of invasive species, native vegetation would be planted in its place. Because of the relatively good habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes are proposed in Reach 7 due to the presence of the active Higley Quarry. It is assumed that any vegetation planted would be damaged due to in-channel mining operations.

Reach 6: In the northern part of the reach, SD would be planted on both the north and south sides of the GRUSP site. The SD would be irrigated using a SBIN and water diverted from the drainage channel. Because the vegetation surrounds the GRUSP site, it may affect and be affected by, the groundwater mound created by the GRUSP. The issues involved in planting around the GRUSP site will be further addressed prior to construction.In the southern part of the reach, SD would be established at the Hennessy Drain, where the north and south GRUSP channels diverge. This area would be irrigated using SBIN and/or flood irrigation. Surface water from the Hennessey Drain would be used as a water source.

Reach 5: The old Gilbert Quarry would be reshaped to create new river bottom. A new groundwater well would be drilled to provide water to SD planted in and around the new river bottom. The SD would be irrigated by SBIN. This water source can also be supplemented by overland flow from water diverted from the Evergreen Drain during storm events.

On the western end of the south bank, a small area of SD would be established along the upland area. The SD would be irrigated with SBIN using diverted surface water.

Reach 4: No activity is planned for this reach.

Reach 3: No activity is planned for this reach.

Reach 2: No activity is planned for this reach.

Reach 1: No activity is planned for this reach.

3.2.7.1 Water Sources - Related Structures

Three new irrigation diversion structures are proposed for this alternative.

3.2.7.2 Water Demand

The total annual evapotranspiration demand for this alternative is 1,001 acre-feet (Table 3-8).

Table 3-8. Vegetated Area and Evapotranspiration Rate for Alternative A

Reach	Area (acres)	Evapotranspiration (acre-feet)
1	0	0
2	0	0
3	0	0
4	0	0
5	198	396
6	298	595
Total	496	992

3.3 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER EVALUATION

Ten additional alternatives were developed and evaluated during the alternatives formulation and screening process but were eliminated from further consideration. A brief description of each of these alternatives is provided below, including the rationale for elimination from further analysis.

Figure 3-9
Alternative A
Project Study Area
City Boundary
SRPMIC
Thalweg
Canal
Highway
Proposed Highway
Local Road
Alternative A
Existing Vegetative Cover
Agriculture
Cottonwood-Willow
Desert
Ditches
Mesquite
Open Water
Parks
River Bottom
Sand and Gravel
Sonoran Desert
Soil Cement
Urban
Proposed Vegetative Cover
New Cottonwood-Willow
New Mesquite
New River Bottom
New Sonoran Desert
New Wetland
N
Miles
0 0.5 1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY (SRPMIC)
MESA
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
ROCKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STAPLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
60
101

3.3.1 ALTERNATIVE B

Vegetation Community Restoration

Under Alternative B, invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW planted to discourage reestablishment of invasive species.

Native MS and SD vegetation would also be planted north and south of the GRUSP site and at the Hennessey Drain outlet.

In the middle reaches, a MS bosque would be created on a floodplain terrace at the outlet of the Evergreen Ditch, and SD vegetation would be planted along the south bank of the channel. Depending on water quality issues, SD vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a small MS bosque and SD planting area would be constructed along the south bank of the channel near the Country Club Storm Drain.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, a low-flow channel and a spillway would be constructed to convey flow within the Gilbert Quarry. Riprap or soil cement would be placed on both sides of the spillway to prevent scouring and along the north bank of the channel to increase flow conveyance.

new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- five structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either SBIN (composed of a network of shallow ditches), flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.2 ALTERNATIVE C

Vegetation Community Restoration

Under Alternative C invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation planted to discourage reestablishment of invasive species. Native CW, MS, and SD would also be planted along two water distribution channels downstream of the Hennessey Drain near the GRUSP site. A WT feature with CW vegetation would be created on the riverbed near the outlet of the Hennessey Drain.

In the middle reaches, SD, CW, and MS vegetation would be planted on the overbank area near the Gilbert Quarry, and a WT feature would be created at the Evergreen Ditch outlet. SD, CW, and MS vegetation would be planted around the WT feature to create a buffer from stormflows. Depending on water quality issues, SD vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a small WT feature with SD, CW, and MS vegetation would be created near the Country Club Storm Drain.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, two water distribution channels would be created to convey irrigation and stormwater from the Hennessey Drain to downstream planting areas. A coarse rock berm would also be constructed near the Hennessey Drain outlet to protect the south bank from erosion during high flow events. Additionally, the Gilbert Quarry pit would be reshaped and a new river bottom created to convey flow. In the lower reaches, soil cement would be placed on the south bank between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion.

Seven new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- six structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.3 ALTERNATIVE D

Vegetation Community Restoration

Under Alternative D invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation planted to discourage reestablishment of invasive species.

In the middle reaches, SD, CW, and MS vegetation would be planted on the overbank area near the Gilbert Quarry, and a WT feature would be created immediately west of Gilbert Road. CW and MS vegetation would be planted around the WT feature to create a buffer from stormflows. Depending on water quality issues, SD vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a WT feature would be created within the main channel and a small strip of CW vegetation would be planted along the northern channel edge. An elongated WT feature with CW and MS vegetation would also be created along the south bank.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, the Gilbert Quarry pit and the river bottom would be reshaped to convey flow, and a grade control structure would be installed to control bed degradation and protect newly planted vegetation. Immediately downstream of the grade control structure, soil cement would be placed on the north bank (approximately 5,500 linear feet) to stabilize the bank and prevent future erosion.

Under this alternative, seven new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- six structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.4 ALTERNATIVE G

Vegetation Community Restoration

Under Alternative G invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation would be planted to discourage reestablishment of invasive species.

Native CW and MS vegetation would also be planted along two newly created water distribution channels located downstream of the Hennessey Drain. Additionally, a WT feature with CW vegetation would be created on the riverbed near the outlet of the Hennessey Drain.

In the middle reaches, CW and MS vegetation would be planted in and around the dry lakebed that would be created from the Gilbert Quarry pit, and a WT feature would be created at the Evergreen Ditch outlet. CW and MS vegetation would be planted around the WT feature to create a buffer from stormflows. CW and MS vegetation would also be planted along the banks of the newly created diversion channels as they extend downstream. Depending on water quality issues, SD vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. CW and MS vegetation would be planted around the WT feature to create a buffer from stormflows. A second WT feature would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, two water distribution channels would be created to convey irrigation water and stormwater from the Hennessey Drain. A coarse rock berm would also be constructed near the Hennessey Drain outlet to protect the south bank from erosion during high flow events. Additionally, the Gilbert Quarry pit would be filled and reshaped, and four spillways would be constructed to convey flow. Riprap or soil cement would be placed on both sides of the spillways to prevent scouring and along the north bank of the channel to increase flow conveyance.

Downstream of the quarry the main channel would be reshaped to create river bottom and increase channel conveyance capacity. Soil cement would be placed along the south bank to protect Lehi Cemetery. In the lower reaches, soil cement would be placed on the south bank

between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion.

Ten new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- nine structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.5 ALTERNATIVE H

Vegetation Community Restoration

Under Alternative H invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation would be planted to discourage reestablishment of invasive species. Native MS and SD vegetation would be planted along two newly created water distribution channels downstream of the Hennessey Drain. Additionally, a WT feature with MS vegetation would be created on the riverbed near the outlet of the Hennessey Drain.

In the middle reaches, CW and MS vegetation would be planted in and around the dry lakebed that would be created from the Gilbert Quarry pit, and a WT feature would be created at the Evergreen Ditch outlet. MS and a small amount of CW vegetation would be planted around the WT feature to create a buffer from stormflows. MS vegetation would also be planted along the banks of the newly created diversion channels as they extend downstream. Depending on water quality issues, SD and MS vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. MS and SD vegetation would be planted around the WT feature to create a buffer from stormflows. A second WT feature would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, two water distribution channels would be created to convey irrigation and stormwater from the Hennessey Drain. A coarse rock berm would also be constructed near the Hennessey Drain outlet to protect the south bank from erosion during high flow events. Additionally, the Gilbert Quarry pit would be filled and reshaped, and a spillway would be constructed to convey flow. Riprap or soil cement would be placed on both sides of the structure to prevent scouring and along the north bank of the channel to increase flow conveyance.

Downstream of the quarry the main channel would be reshaped to create river bottom and increase channel conveyance capacity. Soil cement would be placed along the south bank to protect Lehi Cemetery. In the lower reaches, soil cement would be placed on the south bank between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

Ten new diversion and/or supply structures would be constructed to provide irrigation for the planting areas:

- nine structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.6 ALTERNATIVE I

Vegetation Community Restoration

Under Alternative I invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation would be planted to discourage reestablishment of invasive species.

In the middle reaches, SD vegetation would be planted on benches along the newly created low-flow channel extending downstream from the Hennessey Drain to Gilbert Road, and two pockets of CW vegetation would be planted on terraces immediately above the 5-year floodplain. Additionally, a WT feature bordered by CW vegetation would be created on the riverbed near the outlet of the Hennessey Drain.

In the middle reaches, CW vegetation would be planted in the reshaped Gilbert Quarry pit, and WT features would be created within the channel. CW and MS vegetation would be planted around the WT features to create a buffer from stormflows.

In the lower reaches of the project area, WT features would be created at the upstream and downstream (Alma School Road) ends of the low-flow channel. Strips of CW vegetation would be planted along the channel to create a buffer from stormflows.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, a low-flow channel would be constructed from the downstream end of the Hennessey Drain to Gilbert Road to increase flow conveyance capacity. Buried dikes would be constructed in the overbank area to control lateral movement of the low-flow channel. A coarse rock berm would also be constructed near the Hennessey Drain outlet to protect the newly created wetland and the south bank from erosion during high flow events.

Farther downstream, the Gilbert Quarry pit would be reshaped to create river bottom, and the north bank would be set back and armored with riprap or soil cement to prevent scouring and increase flow conveyance. Downstream of the quarry the main channel would be reshaped to create river bottom and increase channel conveyance capacity, and grade control structures would be installed to control bed degradation and protect newly planted vegetation. Soil cement would also be placed along the south bank (approximately 5,500 linear feet) to protect the island immediately south of the Gilbert Quarry.

In the lower reaches, soil cement would be placed on the south bank between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion, and buried dikes would be constructed in the overbank area to control lateral movement of the low-flow channel.

Nine new diversion and/or supply structures would be constructed to provide agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain to the planting areas.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.7 ALTERNATIVE J

Vegetation Community Restoration

Under Alternative J invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation planted to discourage reestablishment of invasive species.

In the middle reaches, CW and MS vegetation would be planted along the main channel near the GRUSP site, and CW vegetation would be planted in the abandoned quarry depression directly east of Gilbert Road. A WT feature bordered by CW vegetation would also be created on the riverbed near the outlet of the Hennessey Drain. SD, MS, and CW vegetation would be planted in the reshaped Gilbert Quarry pit. Near Gilbert Road a WT feature would be created and the south bank would be planted with MS and CW vegetation. Depending on water quality issues, SD and MS vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill).

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. Two small pockets of CW vegetation would be planted near the WT feature to create a buffer from stormflows. A second WT feature surrounded by CW vegetation would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, the abandoned quarry east of Gilbert Road would be reshaped to create river bottom, and the south bank would be armored with soil cement to prevent erosion. A coarse rock berm would be constructed near the Hennessey Drain outlet to protect the newly created wetland and the south bank from erosion during high flow events.

Farther downstream, the Gilbert Quarry pit would be reshaped to create river bottom, and the south bank (approximately 5,500 linear feet) would be armored with soil cement to prevent erosion. The main channel, downstream of the Evergreen Drain outlet, would be reshaped to create river bottom and increase channel conveyance capacity.

In the lower reaches, a drainage channel would be constructed to supply irrigation water to planting areas, and the abandoned quarry would be reshaped to create river bottom. Soil cement

would also be placed on the south bank between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion.

Twelve new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- Eleven structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.8 ALTERNATIVE K

Vegetation Community Restoration

Under Alternative K invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation planted to discourage reestablishment of invasive species.

In the middle reaches, CW and MS vegetation would be planted along the North channel bank near the GRUSP site, and a WT feature would be created on the riverbed near the outlet of the Hennessey Drain. CW vegetation would be planted around the WT feature to provide a buffer against stormflows. SD, MS, and CW vegetation would be planted in the overbank areas, and a WT feature would be created at the Evergreen Drain outlet. WT features would also be created near Gilbert Road and planted with MS and CW vegetation to create buffers from stormflows. Depending on water quality issues, SD and MS vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill). Additionally, a WT feature with CW and MS vegetation would be created along the south bank.

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. Two small pockets of CW vegetation would be planted near the WT feature to create a buffer from stormflows. A second WT feature surrounded by CW vegetation would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, a coarse rock berm would be constructed near the Hennessey Drain outlet to protect the newly created wetland and the south bank from erosion during high flow events. In the lower reaches, a drainage channel would be constructed to supply irrigation water to downstream planting areas.

Twelve new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- eleven structures to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.9 ALTERNATIVE L

Vegetation Community Restoration

Under Alternative L invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation would be planted to discourage reestablishment of invasive species.

In the middle reaches, CW and MS vegetation would be planted along the main channel near the GRUSP site, and two WT features would be created on the riverbed near the Hennessey Drain outlet. WT features would be created near Gilbert Road and upstream of the Evergreen Drain outlet. CW vegetation would be planted around the WT features to provide a buffer against stormflows and in designated areas along the channel banks.

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. Two small pockets of CW vegetation would be planted near the WT feature to create a buffer from stormflows. A second WT feature surrounded by CW vegetation would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, the abandoned quarry east of Gilbert Road would be reshaped to create river bottom, and the south bank would be armored with soil cement or riprap to prevent erosion and increase flow conveyance capacity. A grade control structure would be constructed in center of the abandoned quarry to prevent bed degradation, and to protect the Gilbert Road Bridge and newly planted vegetation. Soil cement would also be placed on the south bank between Country Club Road and Alma School Road to stabilize the bank and prevent future erosion.

Eight new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- seven structure to divert agricultural tailwater and stormwater from the North Canal;
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.10 ALTERNATIVE M

Vegetation Community Restoration

Under Alternative M invasive plant species, primarily saltcedar, would be removed in the upper reaches of the project area and CW vegetation would be planted to discourage reestablishment of invasive species.

In the middle reaches, WT features would be created on the upper channel banks and on the riverbed near the Hennessey Drain outlet. CW vegetation would be planted around the WT features to provide a buffer against stormflows. The abandoned quarry depression directly east of Gilbert Road would also be planted with CW vegetation. WT features would be located on the upper channel bank near Gilbert Road, at the Evergreen Drain outlet, and along the south bank. WT features would be planted with MS and CW vegetation to create buffers from stormflows. Depending on water quality issues, SD and MS vegetation may also be planted on a floodplain terrace north of the channel (Tri-City Landfill). Additionally, a series of WT features would be created along the south bank and planted with CW and MS vegetation.

In the lower reaches of the project area, a WT feature would be created on the existing river bottom near the Country Club Storm Drain. Two small pockets of CW vegetation would be planted near the WT feature to create a buffer from stormflows. A second WT feature surrounded by CW vegetation would be created near Alma School Road, downstream of the old quarry.

Flow Conveyance Improvements, Diversion/Supply Structures and Irrigation

In the middle reaches of the project area, the abandoned quarry on the south bank upstream of Gilbert Road would be reshaped to create river bottom, and the south bank would be armored with soil cement to prevent erosion. A coarse rock berm would be constructed near the Hennessey Drain outlet to protect the newly created wetland and the south bank from erosion during high flow events.

Farther downstream, the Gilbert Quarry pit would be reshaped to create river bottom, and a grade control structure would be constructed in the center of the quarry pit to prevent bed degradation, and to protect the Gilbert Road Bridge and newly planted vegetation. Additionally, the south bank (approximately 5,500 linear feet) would be armored with soil cement to prevent erosion. In the lower reaches, a drainage channel would be constructed to supply irrigation to planting areas.

Twelve new diversion and/or supply structures would be constructed to provide irrigation water for the planting areas:

- eleven structure to divert agricultural tailwater and stormwater from the Evergreen Ditch and Hennessey Drain; and
- one new well located near the GRUSP site.

Irrigation water from new and existing sources would be distributed to the planting areas by a network of lined irrigation channels and underground pipes. The planting areas would be irrigated using either an SBIN composed of a network of shallow ditches, flood irrigation, or a drip irrigation system.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.3.11 ALTERNATIVE N

Non-Structural Measures

Under Alternative N the following non-structural measures would be implemented individually or in combination.

- allocation of water for restoration;
- zoning controls;
- elimination of gravel mining;
- best management practices (BMPs);
- land set-asides; and
- re-operation of upstream dams.

Rationale for Rejecting Alternative from Further Consideration

This alternative was rejected from further consideration because initial screening based on HGM modeling concluded it would not achieve the restoration objectives set forth in the purpose and need statement.

3.4 RECREATION OPTIONS

3.4.1 INTRODUCTION

The goal of the recreation component is to provide opportunities for visitors of all ages, abilities, and backgrounds to enjoy this unique resource while developing an awareness, knowledge, and understanding of desert riparian habitat and its relationship to the surrounding environment. Additionally, it presents an opportunity to acknowledge and understand the influence of the Salt River on the environment and cultures throughout the Valley's history. Visitors to potential recreation facilities along the study area reach could participate in a variety of pursuits from enjoying scenic views, picnicking with the family, learning about the habitat, or exploring the resource on foot, by bicycle, or on horseback.

Recreational components that were considered for this project have been limited to trails and a Cultural Center. More aggressive recreational components, such as recreational lakes, sporting centers, sports fields, etc., were rejected as out of harmony with the character of this project. The following section discusses the general nature of the planned trails. Section 3.4.3 discusses the Cultural Center. Later sections discuss how various trail alignments were combined with the Cultural Center to create recreation plan alternatives, referred to herein as "Recreation Options." Three options are then presented for consideration.

3.4.2 TRAILS

3.4.2.1 Description of Trail Amenities

The trails are proposed as multi-use trails, available for access by pedestrians, bicyclists, wheelchairs, and equestrians. Motorized vehicles would be prohibited, with the exception of project maintenance vehicles and motorized wheelchairs.

Access to the trails would be available to both SRPMIC Community members and also to non-Community members. Use of the trails would be limited to daylight hours and after dark lighting will not be available along the trails or at the rest stops.

The following design elements are currently anticipated for the trails:

- 12-foot wide dirt trail/path surfaced with decomposed granite, crushed aggregate or similar
- Trail lined with boulders or curbing to define the trail location. (Curbing along both sides of the trail assumed for costing purposes)
- Parking lot and trailhead with appropriate signage at major access points. For costing purposes, one such parking lot is assumed for every four trail miles.
- Mileage markers every 1/4 mile
- Plaques or similar markers or signs at significant project feature locations to educate the public relative to cultural, biological or environmental aspects of the project.
- Concrete benches approximately every quarter mile
- Rest stops spaced at approximately one per mile, each perhaps overlooking a significant project feature. Each rest stop is currently envisioned as including a 12'x12' shade structure constructed on a concrete pad, one metal picnic table, two trash receptacles, a bike stand, low height masonry wall, and a stand alone plaque or other signage to discuss a nearby project feature or to present other historical, cultural or educational material.
- As appropriate, incorporate art that highlights the cultural, historical or environmental aspects of the project into the design of such things as bike racks, rest stations, shade structures, signage, etc.
- Gates at the major access points, so that the trails can be closed at night and/or during maintenance activities.
- Guard posts or other barriers at access points to prevent unauthorized vehicular access.
- No fencing is currently contemplated.
- Signage at major street crossings, both to identify the street and to identify the trail.
- At bridged crossings, the trail will cross under the bridge to avoid conflict with vehicular traffic on the roadways. At unbridged crossings (e.g., McKellips Road), the project will include construction of a refuge island in the middle of the roadway as a zone of

protection for pedestrians. The project will not include pedestrian overpass bridges or traffic signals for pedestrian access.

Potable water is not available within the project boundaries. Therefore, drinking fountains and restrooms are not included.

Where possible, the trails have been designed to connect with the City of Mesa's existing trail system along the canals within the City of Mesa. Refer to Figure 3-10 for the City of Mesa's existing trail system.

3.4.2.2 Construction Costs for the Trails

The estimated construction cost of the trails, including the amenities described in the foregoing section and including design and construction contingencies, is approximately $270,000 per trail mile. More detailed information on trail construction costs is provided in the Appendix E of the final feasibility study report.

3.4.2.3 Operation and Maintenance Costs for the Trails

Based on City of Mesa experience with their trails, the operation and maintenance costs for the trails are anticipated to be approximately $50,000 per year per trail mile.

3.4.2.4 Trail Visitation Rates

The City of Mesa has several trails that are similar in design and use to the trails proposed for the project. There currently are no recorded data available for usage rates on the existing City of Mesa trails. Visitation estimates provided herein are based on City of Mesa Parks and Recreation staffers personal observations and estimates of trail use.

The City of Mesa Parks and Recreation staffers estimate that approximately 30 people per day will use each project trail mile in the summer (for the purposes of this section, "summer" is defined as June through September) and 45 people per day per trail mile in the winter (i.e., the rest of the year). This equates to an average usage rate for the entire year of approximately 40 people per day per trail mile.

The City of Mesa Parks and Recreation staffers also provided the following additional information about anticipated, estimated peak usage rates on the trail system. Peak days for trail usage are Saturday and Sunday. Peak hours for trail usage are estimated to be between 6 a.m. and 9 a.m. and again between 3 p.m. and 6 p.m. The table below summarizes estimated usage during different peak and non-peak periods.

Table 3-9. Estimated Trail Usage

Trail Usage Period	Visitors
Average Winter Month Usage	45 users per day
Average Summer Month Usage	30 users per day
Usage Averaged Year-Round	40 users per day
Winter Peak Days (Sat & Sun)	70 users per day
Winter Non-Peak Days (weekdays)	35 users per day
Peak Hour on Peak Day in Winter	7.8 users per hour
Non-Peak Hour on Peak Day in Winter	3.9 users per hour
Peak Hour on Non-Peak Day in Winter	3.9 users per hour
Non-Peak Hour on Non-Peak Day in Winter	1.9 users per hour
Summer Peak Days (Sat & Sun)	46.7 users per day
Summer Non-Peak Days (weekdays)	23.4 users per day
Peak Hour on Peak Day in Summer	5.2 users per hour
Non-Peak Hour on Peak Day in Summer	2.6 users per hour
Peak Hour on Non-Peak Day in Summer	2.6 users per hour
Non-Peak Hour on Non-Peak Day in Summer	1.3 users per hour

3.4.3 CULTURAL CENTER

3.4.3.1 Description of Cultural Center

The concept for the Cultural Center comes from a programming document for a "Museum and Cultural Center," as provided to the project team by SRPMIC staff ("Museum and Cultural Center Conceptual Design 20% Submittal" by David N. Sloan and Associates, StastnyBrun Architects, Inc., and Native American Design Collaborative). The programming document discusses a complex of several buildings that, taken together, comprise the Museum and Cultural Center (hereafter referred to only as the "Cultural Center"). Figure 3-11 shows the proposed layout of the Cultural Center. The individual buildings listed in the programming document are shown below with their estimated square footages.

City of Mesa Parks and Recreation Multiuse Path Master Plan

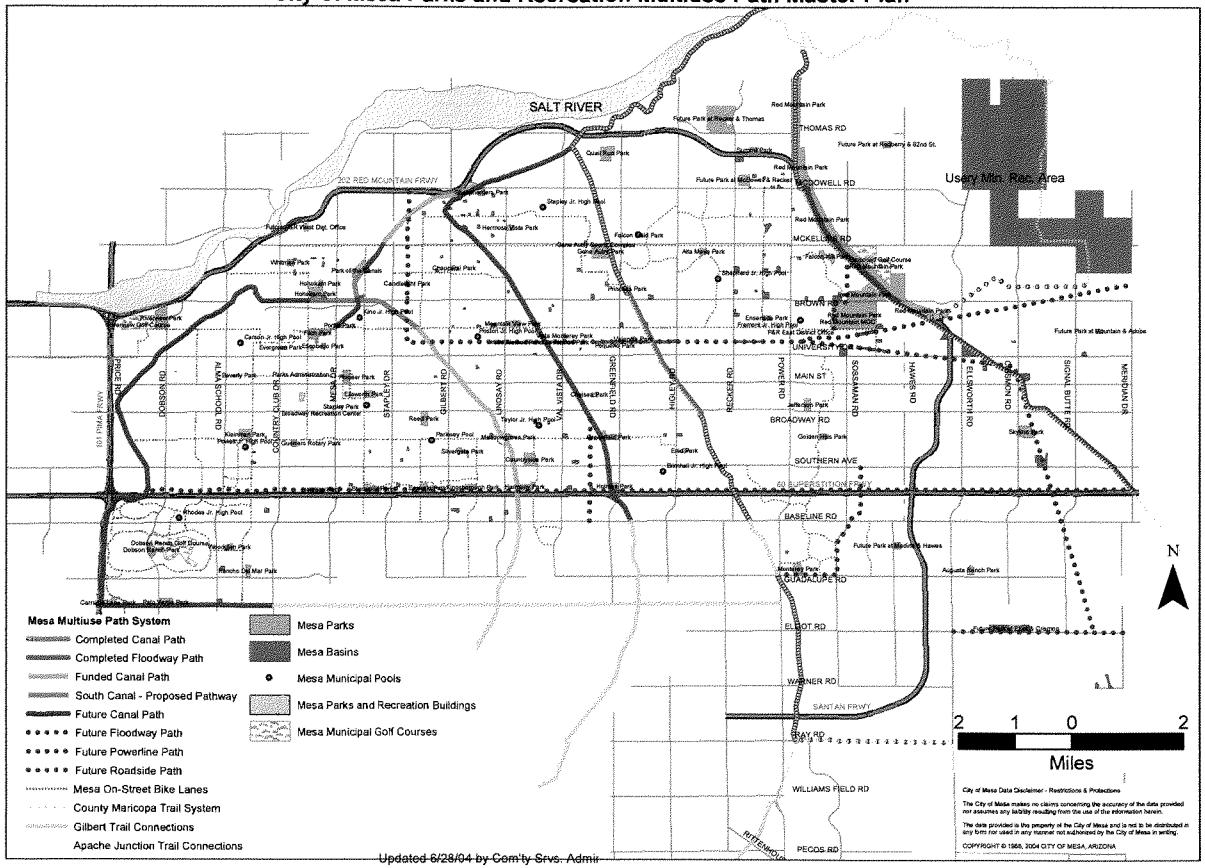


Figure 3-10

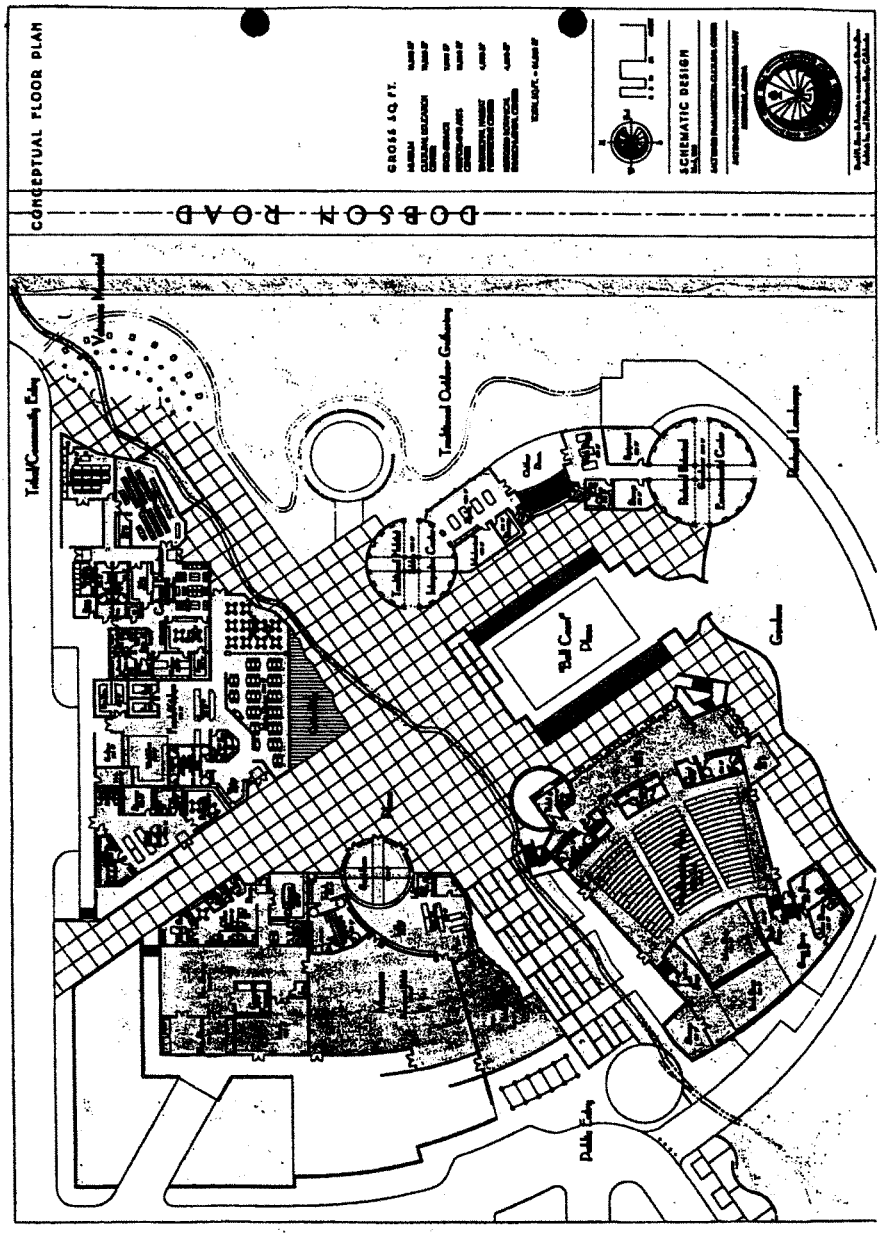

CONCEPTUAL FLOOR PLAN
DOBSON ROAD
GROSS SQ. FT.
SCHEMATIC DESIGN

Figure 3-11

Table 3-10. Square Footage of Cultural Center Buildings

Buildings Included in the Programming Document	Estimated Square Footage
Museum	19,200
Cultural Education Center	10,200
Performing Arts Center	18,200
Food Services	7,900
Traditional Habitat Interpretive Center	4,000
Restored Environmental/Botanical Center	4,800
Total Square Footage	64,300

The project trail system will have ties and connections to the Cultural Center. Refer to the attached recreation option plans.

3.4.3.2 Costs and Eligibility for Cost-Sharing

Not all elements within the Museum and Cultural Center complex are eligible for cost sharing by the Corps. A list of cost-sharable items is given below with the estimated costs of each element.

Table 3-11. Cultural Center: Preliminary Estimate of Cost-Sharable Elements

Design Element	Additional Comments	Estimated Costs
Museum: Restrooms (only) in the Museum or as a stand-alone building	Restrooms are a support feature for the trail system	615SF x $100/SF = $61,500
Habitat Interpretive Center: Outdoor demonstration area only	Exact character of the outdoor demonstration area not yet determined	1050 SF x $15/SF for hardscape = $15,750
Ramadas and Outdoor Shelters	None	1 each x $15,000/ea = $15,000 (other ramadas are already built into the cost of the project trails)
Access Road and Parking	Limit cost to a small parking lot to support the trailhead, not the full cost of the parking lot for the Cultural Center	Estimated $10,000 for a small (12 cars) asphalt paved parking lot
Utilities	Portion of the overall utility installation costs for the Cultural Center to support the restrooms	Estimated $20,000 for restroom utilities
Electrical lighting	For the parking lot, restrooms and ramadas	$15,000
Miscellaneous:	None	4 each x $2,000/ea = $8,000
Picnic Tables		8 each at $160/ea = $1,280
Trash Receptacles		5 each at $600/ea = $3,000
Benches		10 each at $120/ea = $1,200
Signs		
Total Estimated Construction Cost of Cost-Sharable Improvements		$150,730

As shown in Table 3-11, the construction cost for cost-sharable items at the Cultural Center are anticipated to be in the range of $100,000 - $200,000. For reference only, according to the programming document, the total construction cost of the entire Cultural Center complex is estimated to be $10,978,600.

For the purposes of this report, it is assumed that Corps participation in the Cultural Center will be limited to the elements listed in the table above and that the non-federal sponsor will provide other funding to allow the remainder of the Cultural Center to be added to the project during the Preliminary Engineering Design (PED) phase as a "betterment." The "betterment" will be entirely locally funded. The portion of the Cultural Center included in the project during the feasibility phase is limited to the cost-sharable items. The cost-sharable items (taken alone) are

referred to hereafter as the "restroom/ramada facility," but it shall be understood that such term includes the parking lot and other associated improvements listed in the table above. Furthermore, where the recreation plans show a "Cultural Center," it shall be understood to mean a cost-sharable "restroom/ramada" facility that will be upgraded during PED to a Cultural Center (via a locally funded "betterment").

3.4.3.3 Operation and Maintenance Costs for the Cultural Center

The operation and maintenance costs discussed previously for the trail system ($50,000 per trail mile per year) are adequate to cover the minimal O&M costs for the restroom/ramada facility. The O&M costs for the upgraded Cultural Center are immaterial, since the upgrade to a full Cultural Center will be a "betterment" fully funded by the local sponsor. Economic justification for said "betterment" is not required in the feasibility study.

3.4.3.4 Visitation Rates for the Cultural Center

For the purposes of the feasibility study, visitation numbers will not be credited to the restroom/ramada facility as a stand-alone feature. (By itself, the restroom/ramada facility has little very "draw.") For the purposes of the feasibility study, the restroom/ramada facility is viewed as being part of the trail system, and will be justified based on the visitation numbers for the trail system.

Visitations for the upgraded Cultural Center are immaterial since economic justification of said "betterment" is not required in the feasibility study.

3.4.3.5 Location for the Cultural Center

In past iterations of this report, the Cultural Center has been shown at the southeast corner of the intersection of Dobson Road and McKellips Road, with an alternative location at the southwest corner of Gilbert Road and the Beeline Highway. The Corps has since ruled that the Cultural Center must be within the limits of the river restoration project to be eligible for cost sharing by the Corps. Therefore, the location at Dobson Road and McKellips Road has been discarded in favor of the location at the intersection of Gilbert Road and the Beeline Highway.

3.4.4 RECREATIONAL OPTIONS

Three recreation options are presented herein for consideration. Each option includes the Cultural Center location at the southwest corner of Gilbert Road and Beeline Highway and varies the trail alignments.

3.4.4.1 Option A

In Option A (Figure 3-12) , a trail on the west end of the project would connect to the City of Mesa's Riverview Park where an existing underpass under the freeway is located. It would also connect to Dobson Road at the existing Dobson Road freeway underpass. From these connection points, trail users could proceed south on Dobson Road (using existing bike paths and sidewalks within the Dobson Road right-of-way) to connect to the City of Mesa's existing trail system along the Tempe Canal. The City of Mesa's existing trail system is shown in Figure 3-10 for reference.

In Option A, a trail on the south side of the river between Gilbert Road and Val Vista Drive would serve to connect residents living north of the Red Mountain Freeway (the 202 Freeway) to the City of Mesa's existing trail system along the South Canal. At Gilbert Road, trail users could use sidewalks and bike paths within the Gilbert Road right-of-way to access South Canal to the south. At Val Vista Drive, the trail would tie in to the South Canal at the existing underpass for the canal under the freeway. Thus, connection to the South Canal trail would be complete. Option A also includes placement of a Cultural Center at the southwest corner of the intersection of Beeline Highway and Gilbert Road. A trail is included along Gilbert Road from the Cultural Center to Thomas Road. This connector trail would allow residents living south of the river to more easily access the Cultural Center and would also provide a tie between the Cultural Center and the trail along the south side of the river discussed above.

Option A would include the development of approximately 7.8 miles of trails.

3.4.4.2 Option B

Option B is the same as Option A, with the exception that it deletes the trail on the south side of the river between Gilbert Road and Val Vista Drive (Figure 3-13). This option offers the fewest recreational opportunities of the three options that are presented, but is also the least costly.

Option B would include the development of approximately 5.1 miles of trails.

3.4.4.3 Option C

Option C includes all of the features of Option A, plus a continuous trail on the south side of the river between the Pima/Price Freeway (SR 101) and Val Vista Drive (Figure 3-14). Of the three options, this option provides the most recreational opportunities. It provides for connectivity to the City of Mesa's existing trail systems on the east and west ends of the project and for connection to the arterial street grid.

Option C would include the development of approximately 13.6 miles of trails.

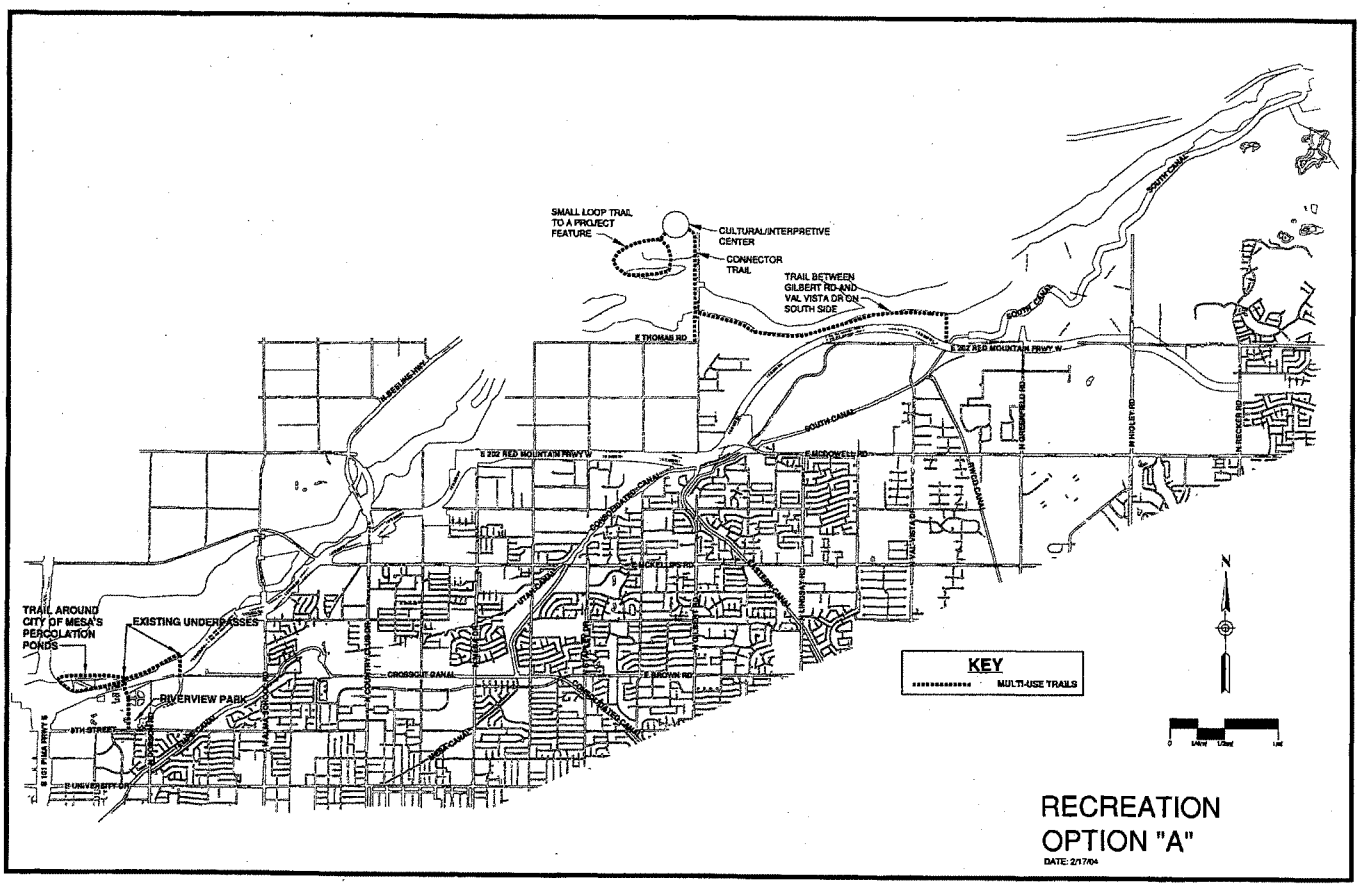

SMALL LOOP TRAIL TO A PROJECT FEATURE
CULTURAL/INTERPRETIVE CENTER
CONNECTOR TRAIL
TRAIL BETWEEN GILBERT RD AND VAL VISTA DR ON SOUTH SIDE
E THOMAS RD
E 202 RED MOUNTAIN FRWY W
SOUTH CANAL
E MCDOWELL RD
E MCKELLIPS RD
E BROWN RD
CROSSCUT CANAL
TRAIL AROUND CITY OF MESA'S PERCOLATION PONDS
EXISTING UNDERPASSES
RIVERVIEW PARK
9TH STREET
E UNIVERSITY DR
KEY
MULTI-USE TRAILS
N
RECREATION OPTION "A"
DATE: 2/17/04

Figure 3-12

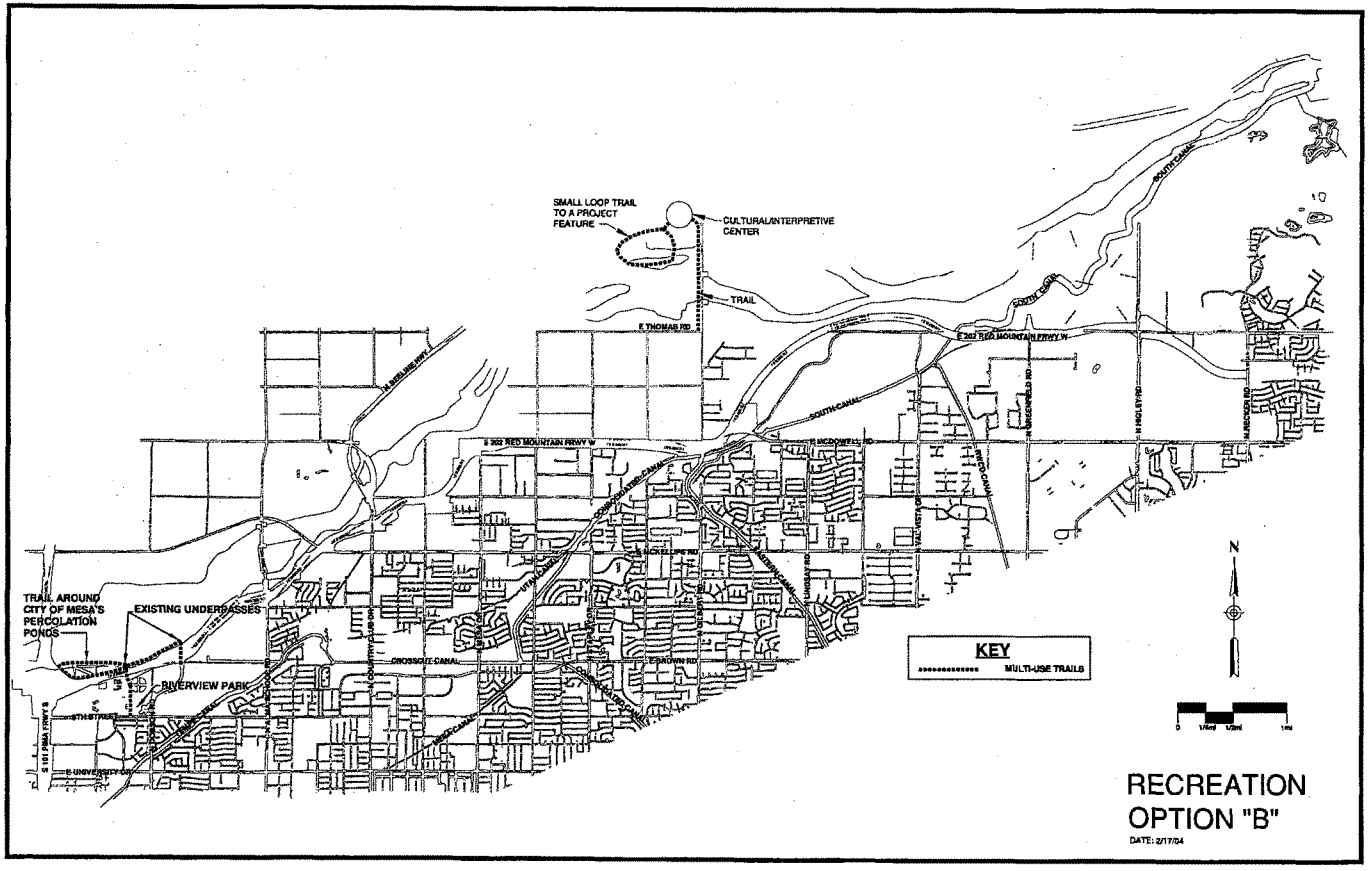

SMALL LOOP TRAIL TO A PROJECT FEATURE
CULTURAL/INTERPRETIVE CENTER
TRAIL
E THOMAS RD
E 202 RED MOUNTAIN FRWY W
SOUTH CANAL
N MERLINE HWY
E MCDOWELL RD
N GREENFIELD RD
N HIGLEY RD
N RECKER RD
RWCD CANAL
VAL VISTA DR
N LINDSAY RD
E MCKELLIPS RD
E BROWN RD
CROSSCUT CANAL
UTAH CANAL
N COUNTRY CLUB DR
TRAIL AROUND CITY OF MESA'S PERCOLATION PONDS
EXISTING UNDERPASSES
RIVERVIEW PARK
5TH STREET
E UNIVERSITY DR
S 101 PIMA FRWY S
KEY
MULTI-USE TRAILS
N
0
1/4mi
1/2mi
1mi
RECREATION OPTION "B"
DATE: 2/17/04

Figure 3-13

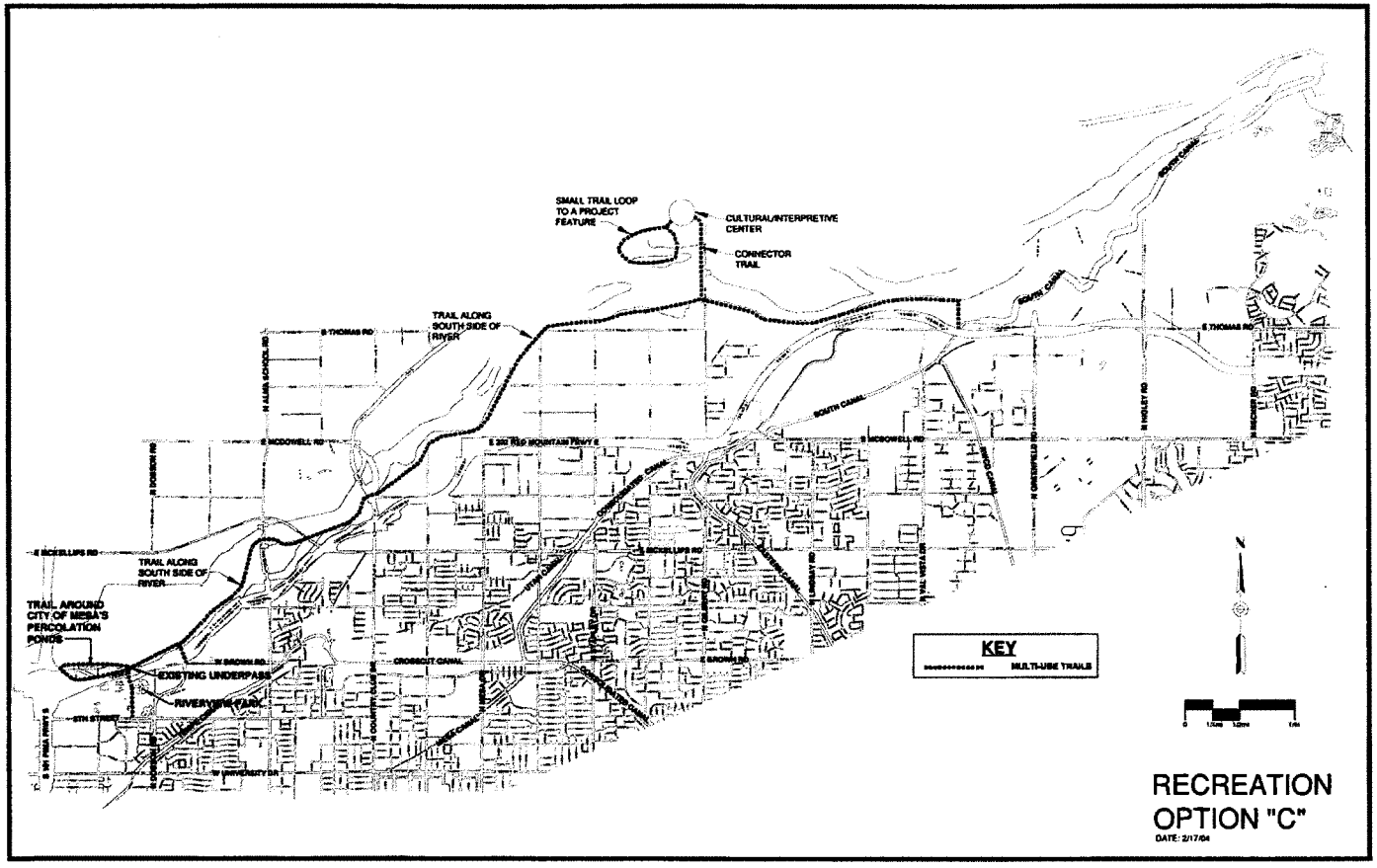

SMALL TRAIL LOOP TO A PROJECT FEATURE
CULTURAL/INTERPRETIVE CENTER
CONNECTOR TRAIL
TRAIL ALONG SOUTH SIDE OF RIVER
TRAIL ALONG SOUTH SIDE OF RIVER
TRAIL AROUND CITY OF MESA'S PERCOLATION PONDS
EXISTING UNDERPASS
RIVERVIEW PARK
CROSSCUT CANAL
SOUTH CANAL
KEY
MULTI-USE TRAILS
RECREATION OPTION "C"
DATE: 2/17/04

Figure 3-14

3.4.5 COST/BENEFIT ANALYSIS

The Corps has performed a cost/benefit analysis that is presented in Appendix E of the final feasibility study report. Based on this analysis Option B was selected as the preferred recreation option.

3.5.6 CONCLUSION

Option B was selected by the SRPMIC Tribal Council as the preferred recreation option to be incorporated into the restoration project.

CHAPTER 4. AFFECTED ENVIRONMENT

This chapter provides a description of the existing conditions within the Va Shly'ay Akimel project study area. The information presented comprises the environmental baseline for determining the nature and magnitude of environmental impacts of the proposed action and alternatives. For this project, the study area is defined as an area extending between the Pima Freeway and Granite Reef Dam along the Salt River. The width of the project study area is 1 mile to either side of the river's thalweg, or the centerline of the drainage flow within the river channel, for a total width of 2 miles.

4.1 GEOLOGY AND TOPOGRAPHY

4.1.1 INTRODUCTION

This section describes the topography and geologic conditions of the Va Shly'ay Akimel study area. This section is based on the analysis contained in the geotechnical appendix to the *Va Shly'ay Akimel Environmental Restoration Study, Salt River Pima-Maricopa Indian Community and City of Mesa, Maricopa County, Arizona* (U.S. Army Corps of Engineers 2003).

4.1.2 REGIONAL GEOLOGY AND TOPOGRAPHY

The study area is located in the eastern portion of Maricopa County, north of the City of Mesa boundaries. The study area is characterized by relatively flat terrain. Slopes in the study area range from 0–2 %, and alluvial soils occur within the river floodplains.

The project area is in the Phoenix basin of the Salt River Valley. The area is geomorphically located within the Gila Lowland Section of the Sonoran Desert Subprovince, a part of the Southern Basin and Range Physiographic Province. This province is characterized by broad, gently sloping, connected alluvial valleys (basins) bounded by moderately high, rugged, northwest- to southeast-trending mountains (ranges). During the late Miocene epoch (Tertiary period), the mountain ranges were extensively dissected, uplifted, and downdropped by northwest- to southwest- and east- to west-trending sub-parallel normal faults.

Extensive volcanic activity accompanied the faulting. From the late Miocene until the late Pliocene, the ranges deeply eroded and filled their downdropped areas (basins) with sediments, which were later consolidated into sedimentary rocks. From the end of the Pliocene until recent (Holocene) time, the basins, including the Salt River Valley, filled with unconsolidated and occasional semi-consolidated sediment eroded from the ranges. The thickest accumulations of Valley alluvium formed during the early to middle Quaternary period.

The alluvium of the Salt River Valley is in the final stages of development, as evidenced by the numerous low-lying isolated hills (inselbergs) that project above the valley surfaces. These hills represent peaks of former mountain ranges that are now almost completely buried by alluvial

material. The mountain ranges that border the project area consist mostly of Tertiary-age sedimentary and volcanic rocks that lie unconformably upon an ancient Precambrian igneous and metamorphic basement complex. The complex is composed predominantly of igneous granite and diorite, metamorphosed schist, gneiss, and volcanic rock. The Tertiary rocks are made up of volcanic basalt, andesite, rhyolite, sedimentary sandstone, siltstone, and conglomerate.

The Phoenix basin consists of Quaternary sediments that constitute the valley fill. These consist mostly of poorly to well-consolidated (cemented) and unconsolidated gravel, sand, silt, and clay, representing several environments and ages of deposition. The total thickness of the alluvial material ranges from near 0 feet along the mountain fronts to nearly 10,000 feet under the valley interior. The valley fill materials tend to be of a coarser consistency near the mountain fronts and finer in the interior of the valley. Near the Salt River, the valley fills have been eroded as the river formed terraces during its evolution.

4.1.2.2 Local Geology and Topography

The Va Shly'ay Akimel project area extends east and west along the Salt River, which flows west into the Phoenix basin from the Superstition and Goldfield mountain ranges. The Salt River floodplain is located within the gentle, flat slopes of the basin. The study area extends west from Granite Reef Dam to the Pima Freeway (SR 101).

The predominant surface materials within the Va Shly'ay Akimel project area consist of Quaternary-age river sediment deposited as alluvium and terraces and, to a lesser extent, sheetwash-deposited alluvium and slope-deposited colluvium. Thick layers of alluvium and terrace have accumulated within the major streams, tributaries, and floodplains of the Salt River. Streambed alluvium and terraces are flanked, covered, and underlain by thinner layers of wind- and sheetwash-deposited alluvium and bedrock colluvium.

Quaternary sediments consist of:

1) Salt River Valley alluvium and terraces — unconsolidated to well-cemented gravel and boulders interbedded with irregular silt, sand, and gravel lenses; and

2) Colluvium — loose- to well-cemented silt, sand, clay, and gravel.

Salt River Valley terrace deposits lie exposed above the Salt River channel in locations throughout the project area. The terraces consist of thick, well-cemented to non-cemented sand and gravel and are considered older than the alluvium within the confines of the Salt River. However, contacts between the two types of deposits are gradational at depth, which means they are undifferentiated and both remain of Quaternary age. The terrace and alluvial deposits in turn overlie thick Tertiary sedimentary and volcanic rocks beneath the basin and interface with Tertiary rocks along mountain ranges and inselbergs. The very thick Precambrian basement complex underlies basin terrace and alluvium at maximum depths of greater than 3,300 feet.

4.1.2.3 Soils

The interior floor of the Salt River Valley is comprised of thick layers of alluvium. The U.S. Department of Agriculture categorizes the soils in the vicinity of the river channel in a group known as the hyperthermic torrifluvents association, which are well-drained to excessively well-drained soils which exist on nearly level or gently sloping surfaces. These soils are often sandy to gravelly, but may include lenses of finer particles. They are often redistributed by water flows in active channels.

As defined by the Farmland Protection Act, approximately 3,262 acres of prime farmland exist within the project boundaries. Effects to the prime and unique farmland are discussed in the "Geology and Topography" section in Chapter 5.

4.1.2.4 River Topography

The Salt River is characterized by scour-and-fill events, floods, and channel shifts. The Salt River once was characterized by meandering flows throughout the river system. More recently, however, urban development in the region has changed the Salt River from a meandering channel to a straight channel with high banks in several reaches. A large groundwater retention/recharge basin is located within the Salt River in the central portion of the study area.

The Salt River channel has shifted within the floodplain several times from the 1880s to the present — meandering on the north side of the floodplain during some periods and on the south side during others. Channel shifts have distributed alluvial material across the entire width of the floodplain. The alluvium deposited by the river consists of cobbles, sands, silts, and clays from numerous tributary streams within the watershed.

Scour-and-fill events over time have degraded the river in some areas and improved it in others. The scour-and-fill transportation of sediment has produced numerous thick deposits within the fluvial system: cobble lag surfaces, sand sheets (macro-forms), channel sidebars, mid-channel bars, point bars, and overbank deposits. Many of these deposits have been disturbed in recent years by intensive mining for sand and gravel. Mining activity alters later transportation events by removing and compacting material, thereby reducing the amount of sediment transported and loosening other sediments. In addition, sand pits serve as depositional traps for fine sediments.

Sediment transported in a scour-and-fill setting tends to move in waves or pulses, rather than at a constant rate over time. In essence, slugs of sediment are periodically moving downstream during flow events. Floodflows are probably the most important events in the transportation of sediment, and have the highest potential to move material. During a flood, the bulk of the sediment is moved as bedload; but there is also movement of sediment as wash load, in solution and suspension. Prior to the damming of the Salt River, smaller flow events moved sediment (fine sands, silts, and clays) by incising downward into the larger slugs of sediment found in the channel. However, the amount of sediment moved in these smaller events is small in comparison with the amount of material moved during a flood.

Within the study area, the geomorphic characteristics of the river channel have been significantly affected by human encroachment. Historically, the river channel actively migrated, changing channel configuration in response to river flow events (i.e., peak discharge and duration). However, the construction of levees and road crossings have restricted the potential channel width and confined the lateral migration of the river channel. Currently, approximately 12 miles of the river have been altered by the construction of levees along the left and right channel banks (approximately 45% of the total bank length) (West 2002). Additionally, other factors such as gravel mining operations have substantially changed channel planform and geometry. Mining and associated upstream and downstream bed degradation have resulted in the creation of steeper, less stable, channel banks with a higher erosion potential, leading to the gradual widening of the stream channel.

4.1.2.5 Gradient

The longitudinal profile or gradient of the stream channel shows a change in elevation of approximately 140 feet between Granite Reef Dam and the Pima Freeway. This constitutes a vertical drop of approximately 2 feet per 1,000 feet of channel length. However, there are number of local variations in channel profile and planform associated with human encroachment. In particular, historic and current gravel mining activities within the project area have lowered the channel invert elevation in areas subject to mining, and increased the upstream channel gradient. These changes in the longitudinal channel profile have resulted in up steam headcutting as the channel tries to re-establish a more stable profile. If left unchecked, erosion and headcutting associated with mining activities may result in the undermining of existing infrastructure such as the Gilbert Road Bridge. Additionally, because sediments are trapped by the gravel mining pits, downstream sediment supplies are reduced resulting in downstream channel bed and bank erosion (West 2002).

4.1.2.6 Faulting and Seismicity

Faults in central Arizona are generally short, discontinuous, normal faults, some of which have been interpreted to displace Quaternary formations. Most fall within the Jerome-Wasatch Structural Zone, an approximately 47-mile-wide band that extends from Utah into Mexico. In Utah, the zone is associated with current earthquake activity and displays evidence of abundant Quaternary faulting. In Arizona, the zone includes the Main Street Fault in the northwest corner of the state and the Verde Fault, located approximately 56 miles north of the Va Shly'ay Akimel study area. Both faults are considered to be potentially active.

The proposed project is located in Zone 1 of the Seismic Zone Map of the Contiguous States, an area of low seismicity. Approximately 30 earthquakes with maximum epicentral intensities between II and VI on the Modified Mercalli Intensity Scale (MM) have occurred within this seismic zone from 1870 through 1980. The seismic historical record for the last 124 years indicates that only one major damaging earthquake in the region has occurred. This 1887 earthquake was centered in Sonora, Mexico, which is outside Seismic Zone 1.

The 7.2-MM Sonora earthquake was located more than 255 miles from Tempe, Arizona, and expressed 31 miles of surface rupture with approximately 10 feet of normal displacement, causing rockfalls in the project study area. The most recent (1974) events, located northeast of the study area, recorded Richter magnitudes of only 2.5 and 3.0.

4.1.2.7 Subsidence

Available information suggests that subsidence in the project area has not occurred. Ground failure in the form of (pumping) subsidence and earth-fissures has occurred in other areas of the Phoenix Basin. The closest ground failure occurrences to the project study area are near Luke Air Force Base, west of the study area, where 1–3 feet of subsidence has been measured and exhibits the shape of a 2-mile-diameter "bowl" depression.

Earth fissures and subsidence are both produced by groundwater (pumping) withdrawal, whereby ground (soil) compresses (subsides) because it has lost the support of water within its pores. Earth fissures develop when the soil subsides differentially and pulls apart.

The Phoenix area will continue to be affected by subsidence because of groundwater overdraft, principally where groundwater withdrawal is most severe.

4.1.3 REGULATORY SETTING

Topography and geomorphologic resources and issues related to geotechnical hazards are primarily under local jurisdiction. The local grading plans and ordinances contain policies for the protection of geologic features and avoidance of geologic hazards. Many local jurisdictions adopt the Uniform Building Code or adopt local building codes to ensure that structures meet minimum safety standards. Building codes in each jurisdiction establish standards for construction depending on soil conditions, slopes, and the potential for ground movement and faulting.

4.2 HYDROLOGY AND WATER RESOURCES

4.2.1 INTRODUCTION

The following discussion characterizes the hydrology and water quality conditions of the Va Shly'ay Akimel study area. The information presented below is based largely on the following reports:

- Va Shly'ay Akimel, Salt River, Arizona—Draft Feasibility Report and Draft Environmental Impact Statement (U.S. Army Corps of Engineers 2003)
- Tres Rios Feasibility Study, Salt River, Arizona (U.S. Army Corps of Engineers 2000)

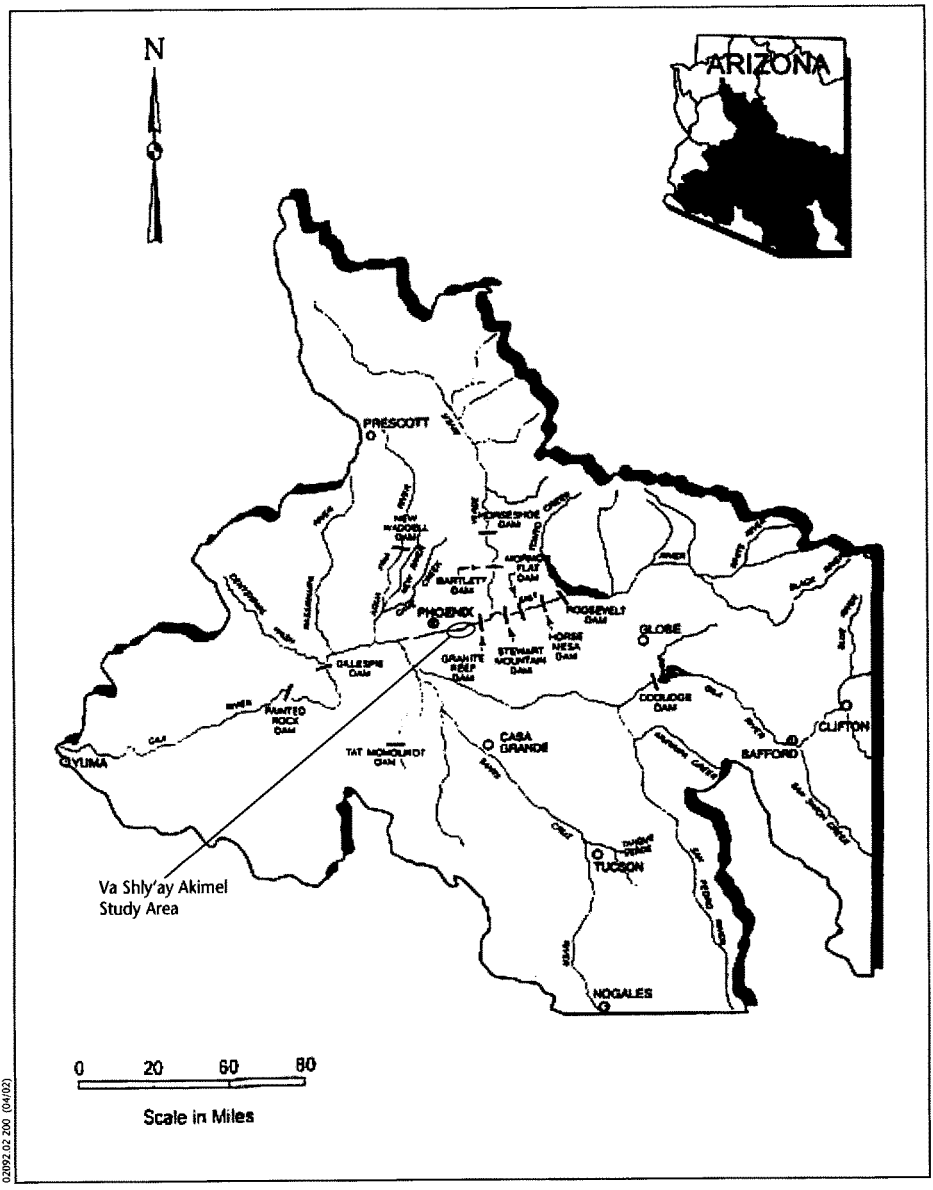
In addition, a number of reference materials, cited in the text below, were used to characterize the relevant hydrologic and water quality conditions in the study area.

4.2.2 REGIONAL HYDROLOGY AND SURFACE WATER RESOURCES

4.2.2.1 Background

The Salt River drains 14,500 square miles of mountainous desert terrain in central and eastern Arizona (Figure 4.2-1) and is the largest tributary to the Gila River. The river rises in the White Mountains of eastern Arizona and flows generally westward to its junction with the Verde River, a northern tributary that drains the edge of the Colorado Plateau near Flagstaff, Arizona. From this junction near the City of Mesa, the Salt River flows westward across the broad Salt River Valley to its confluence with the Gila River, about 14 miles west of the Phoenix Sky Harbor airport. The Phoenix metropolitan area is near the center of the Gila River basin and lies within the lower Salt River Valley. After the junction with the Salt River, the Gila River continues westward and joins the Colorado River near Yuma, Arizona.

Annual average rainfall in the lower Salt River Valley is approximately 8 inches; rainfall at the highest elevations of the watershed ranges up to 14 inches annually (U.S. Geological Survey 1991). Rainfall is less than the evapotranspiration rate in all months of the year. Precipitation is derived primarily from two types of weather systems: summer thunderstorms and regional storms. Summer thunderstorms in July and August develop from the flow of subtropical air masses from the Gulf of Mexico. These two months are responsible for the majority of the total annual rainfall. Regional storms from the Pacific Ocean generate gentle, widespread showers during the fall and winter months. Summers are hot, with daily temperatures exceeding 100° F from mid-June through August. Mean daily temperatures in the summer range from 65° F to 104° F. The relative humidity is low, ranging from approximately 20% to 50%. Winters are mild, with mean daily temperatures ranging from 35° F to 70° F.



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Jones & Stokes

Figure 4.2-1
Gila River Basin

4.2.2.2 Dam System

During the 20th century, the Phoenix area has changed from an agricultural region to an urban region, resulting in significant changes in the physical characteristics of the rivers in the area. Agricultural and urban activities have given rise to an intricate network of structures associated with the river used for irrigation, drainage, erosion protection, and flood control. Numerous upstream dams on the Salt and Gila Rivers have radically altered the natural hydrologic regime of the rivers (Table 4.2-1). The Salt River Project (SRP) operates seven dams within the Salt River watershed. Six of these dams are operated as storage reservoirs; the Granite Reef dam is a diversion dam and does not have storage capacity. Stored water is allocated for hydropower, municipal and industrial supply, and agriculture. Modifications to the Theodore Roosevelt Dam also include an allocation for flood control. The total space for water-supply storage behind these dams is approximately 1.9 million acre-feet (ac-ft), with an additional 560,000 ac-ft for flood control. Modified Theodore Roosevelt Dam is the largest facility and receives drainage from approximately 5,800 square miles. The Verde River is the principal tributary and watershed of the Salt River (6,700 square miles). Its flows are partially controlled by Horseshoe Dam (located furthest upstream) and Bartlett Dam (approximately 25 miles upstream of the confluence with the Salt River), which provide an additional 310,000 ac-ft of storage. New Waddell Dam is located on the Agua Fria River northwest of Phoenix and downstream of the project study area.

Table 4.2-1. Major Dams and Reservoirs in the Gila River Basin

Dam	River	Reservoir	Date of Origin	Storage (acre-feet)
Waddell	Agua Fria	Lake Pleasant	1927	165,000[a]
Bartlett	Verde	Bartlett Lake	1939	178,000
Horseshoe	Verde	Horseshoe Lake	1949	109,000
Stewart Mountain	Salt	Saguaro Lake	1930	70,000
Mormon Flat	Salt	Canyon Lake	1925	58,000
Horse Mesa	Salt	Apache Lake	1927	245,000
Granite Reef	Salt	None	1908	0
Roosevelt	Salt	Roosevelt Lake	1911	1,600,000[b]
Coolidge	Gila	San Carlos Lake	1928	1,222,000
Painted Rock	Gila	Painted Rock Lake	1959	2,500,000

[a] Indicates original storage capacity before modifications that are presently underway to expand capacity.

[b] Black pers. comm.

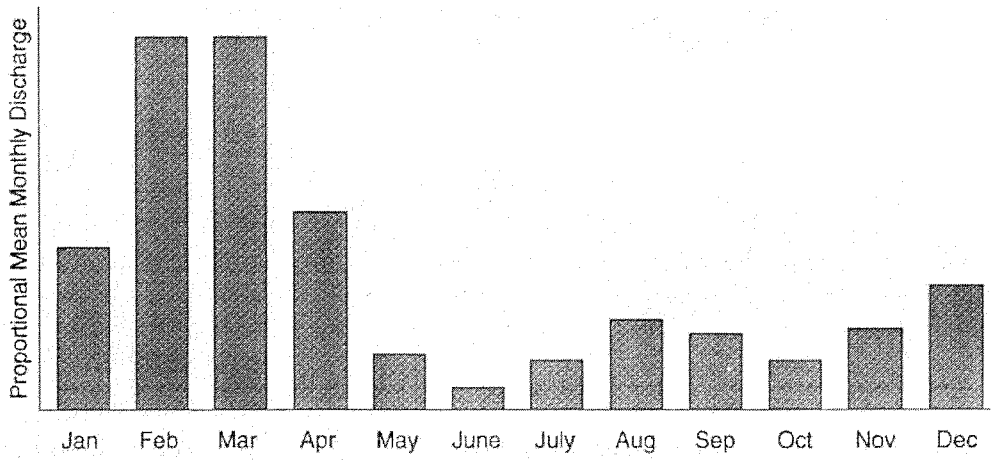
Source: Graf et al. 1994

The dams have significantly altered the natural hydrologic regime of the lower Salt River and have changed both the magnitude and timing of flows. The SRP primarily releases water from, reservoirs to meet shareholder water demands, but also releases water for other purposes including minimum flow requirements, power generation, and flood-control. The system of dams has eliminated perennial flow and steady, high winter flows. Since Bartlett Dam began operating on the Verde River in 1938, the lower Salt River has contained water only as a result of controlled or uncontrolled releases from Granite Reef Diversion Dam. Granite Reef Diversion Dam is located about 3 miles downstream of the Salt-Verde confluence, and is the most downstream SRP dam. The purpose of this facility is to divert upstream reservoir releases into the Arizona Canal (for the area north of the Salt River), and the South Canal (for the area south of the Salt River). The canals crisscross the Phoenix metropolitan area for water delivery to agricultural, municipal, and industrial uses. There are no releases during climatically drier years, such as the period between 1942 and 1964, and the Salt River is dry during those times except for stormwater runoff, groundwater emergence, and effluent.

Before 1938, an average of 413,000 ac-ft of water flowed through the channel annually (U.S. Army Corps of Engineers 1997). The estimated pre-development, average annual watershed yield was about 1,250,000 ac-ft (U.S. Geological Survey 1991). Since 1965, the channel has carried an average of only 293,000 ac-ft of water per year, with less than 10,000 ac-ft in almost three-fifths of the years (U.S. Army Corps of Engineers 1997). Hydrologic modeling used to develop a water-control plan for Modified Theodore Roosevelt Dam indicates that water would have spilled over Granite Reef Diversion Dam in only 34 of 105 years under the current configuration of dam operations (U.S. Army Corps of Engineers 2000). The resulting frequency of spills is approximately once every 3 years.

When water is spilled over Granite Reef Diversion Dam, the flow is typically sustained for several days or more, and of significant magnitude. Since 1965, there have been about two releases per year, and they have lasted an average of 22.5 days, with a peak mean daily flow of 13,960 cubic feet per second (cfs). The median predicted spill pattern at Granite Reef Diversion Dam has a peak discharge of 28,000 cfs, a 5-day average flow rate of 15,000 cfs, and a 10-day average flow rate of 10,000 cfs (U.S. Army Corps of Engineers 2000).

Little data exist to document the pre-development, seasonal flow fluctuations in the Salt River. In the pre-settlement era prior to 1900, the river was one of the few perennially watered riparian areas of the Sonoran desert, with highly productive cottonwood, willow, and mesquite habitats. Analyses of pre-development conditions indicate that Salt River streamflow infiltrated and recharged groundwater upstream of Indian Bend Wash near Scottsdale. Groundwater discharged to the channel to provide perennial baseflow in downstream sections of the channel (U.S. Geological Survey 1991). Under natural conditions, flows peaked in late winter (February and March), supplied by storms and snowmelt (Figure 4.2-2). Flows were lowest in June, averaging only 6% of the mean high flows in February. Data for 1965 through 1993 show flows occurring most frequently during March and April and least frequently during July and August, much like the natural flow pattern. In normal years, or years with minimal downstream releases, the system of dams upstream of the study area effectively delays the flows by 1 month. However, this is not the case in years with large flow events (1993) or wet years (1983). This delay becomes



SOURCE:
Graf et al. 1994

Jones & Stokes

Figure 4.2-2
Proportional Natural Mean Monthly Discharge of the Salt River

insignificant, however, in light of the length of periods without flow in a river that is perennial under natural conditions.

4.2.2.3 Flood Hazards

During periods of serious flood potential, large volumes of water are released from upstream dams and may cause flood damage in the Phoenix metropolitan area. Damaging floods with flows exceeding 100,000 cfs occurred in the lower Salt River in 1978, 1980, 1983, and 1993. These floods resulted in damages to residences and agricultural areas in and around the study area. Environmental managers have sought a clearer understanding of river forms and processes that are now partly natural but significantly modified. Figure 4.2-3 shows the limits of the 100-year floodplain within the study area. In general, the designated 100-year floodplain is narrowly confined within the limits of the channel banks and ranges in width from several hundred feet to over 1 mile, depending on the location. Significant problems related to flooding within the study area include large floodflows that can:

- cause damage to agricultural and residential areas in and around the study area;
- destroy habitat through inundation and scouring effects; and
- erode landfills, adding sediment, pollutants, and debris to the study area.

The magnitudes of peak annual discharges on the Salt River are comparable to those of peak flows before Bartlett Dam began operating, but high flows have occurred less frequently since 1938 (Figure 4.2-4). The mean peak annual discharge was 32,000 cfs before 1938, and has been 16,500 cfs from 1938 to the present (Jones & Stokes 2000). This apparent reduction in flood magnitude results from the frequency of low-flow years. Since 1938, the peak discharge has been greater than 10,000 cfs in only 1/4 of the years, whereas before 1938, flows exceeded 10,000 cfs in 2/3 of the years. Upstream dams have exacerbated the high-flow conditions that have occurred by delaying the release of runoff into the river. Prior to damming, a peak annual discharge greater than 100,000 cfs occurred in only 1 year on record, while three such flows have occurred in the past 16 years. Table 4.2-2, presented on the next page, shows estimated flow values for variable frequency and duration flows within the Salt River at Granite Reef Dam and downstream in the Phoenix metropolitan area at Central Avenue (U.S. Army Corps of Engineers 1997).

Table 4.2-2. Inundation-Duration Frequency Values for the Salt River

	Frequency (Years)						
Duration	500	200	100	50	20	10	5
Discharge (cfs) Exceeded for Specified Duration, Salt River at Central Avenue[1]							
Peak	240,000	202,000	166,000	135,000	87,000	53,000	20,200
1 Day	190,000	145,000	100,000	70,000	40,000	21,000	8000
3 Day	100,000	75,000	60,000	40,000	22,000	11,000	3500
5 Day	70,000	55,000	40,000	29,000	15,000	7000	2100
10 Day	46,000	33,000	25,000	18,000	10,000	5200	1500
30 Day	25,000	19,000	15,000	10,000	5300	2700	800
60 Day	14,000	9000	7000	5000	2800	1400	(0)[2]
Discharge Exceeded for Specified Duration, Salt River at Granite Reef Dam							
Peak	250,000	210,000	175,000	150,000	100,000	60,000	22,000

[1] Discharges exceeded for specified frequencies, with durations greater than or equal to 1 day, are approximately equal throughout the Rio Salado Project reach. Central Avenue is used as a reference location.

[2] During the 5-year event, the upstream release from the Salt River Project reservoirs does not last for 60 days. A flow rate of approximately 200 ft^3/s is exceeded for 53 days during this event. Results are based upon simulation of Balanced Hydrographs.

Source: U.S. Army Corps of Engineers 1997

The peak 100-year flood flow at Granite Reef Dam is 175,000 cfs, slightly larger than what would occur in downstream reaches due to channel infiltration. The data also indicates that the 5-year frequency flow produces measurable flow in the channel downstream of Granite Reef Dam, but the channel would remain dry in the Phoenix area due to upstream storage in the watershed and channel infiltration.

Although flooding is a natural and even vital process in natural riparian systems, it is of particular concern in downstream reaches of the Salt River because of the prevalence of saltcedar, an exotic nuisance species. Saltcedar is very effective at spreading into disturbed areas and can generally establish itself more rapidly than native riparian species with one exception. If flooding occurs during spring when cottonwood and willow are dispersing seeds, native vegetation can outcompete saltcedar. As an example of this process, after the 1993 flood, additional vegetation established itself in the river downstream of Phoenix. The Flood Control District of Maricopa County (FCDMC) applied for a Section 404 permit to resume channel clearing. The permit was denied because of habitat removal concerns expressed by the Arizona Game & Fish Department (AGFD).

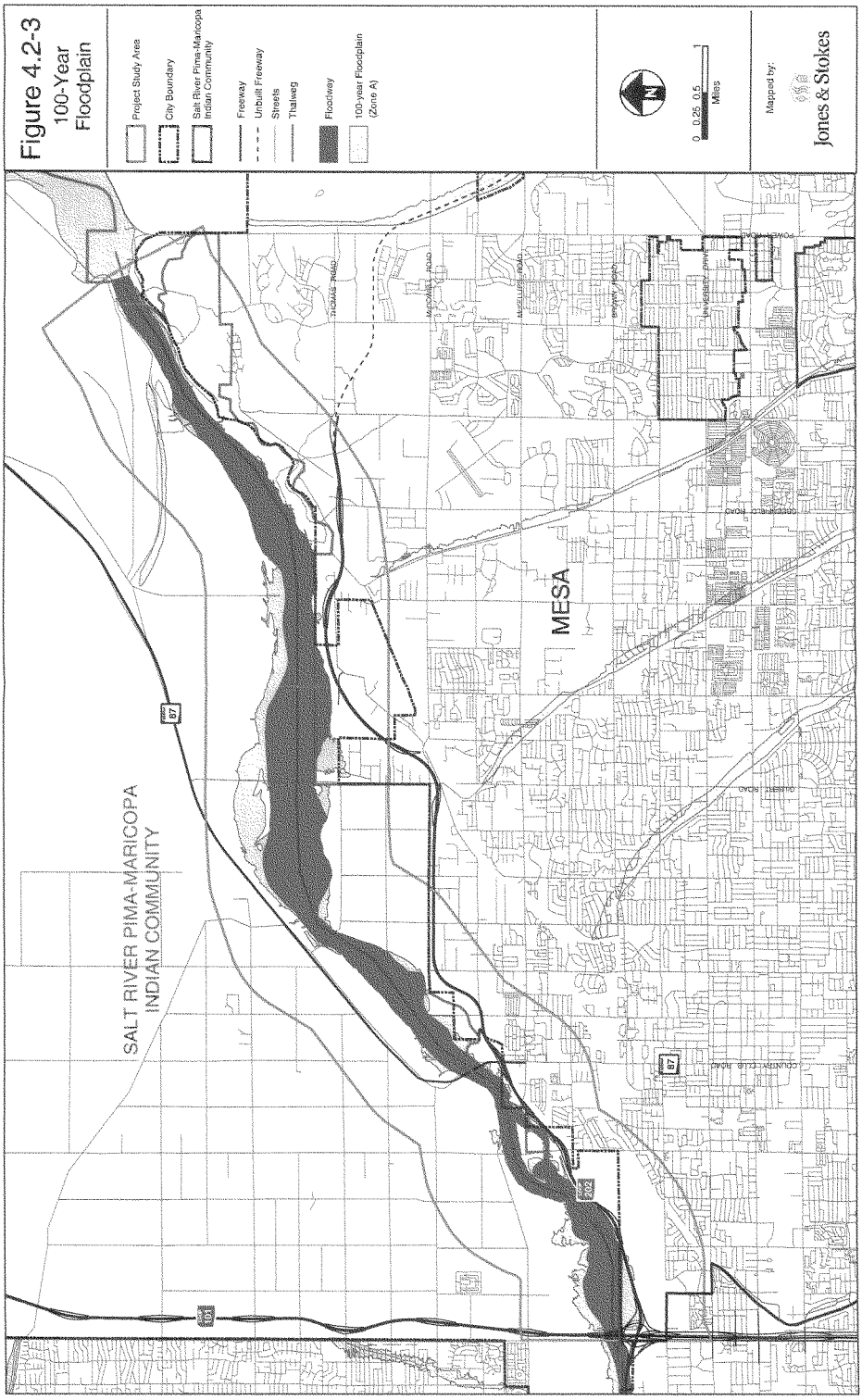
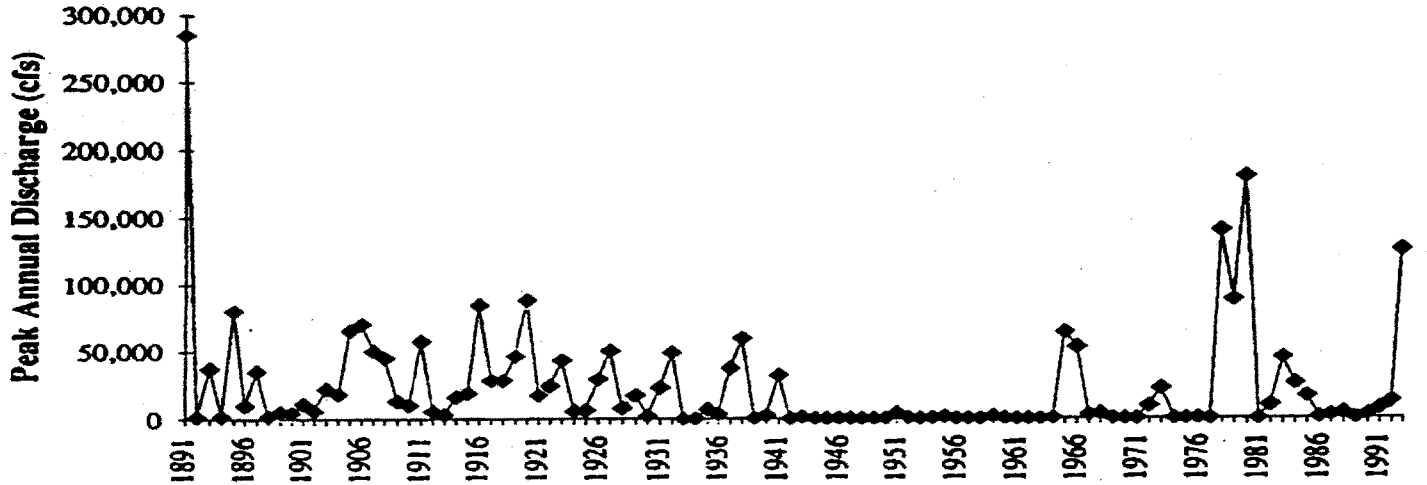


Figure 4.2-3
100-Year
Floodplain
Project Study Area
City Boundary
Salt River Pima-Maricopa
Indian Community
Freeway
Unbuilt Freeway
Streets
Thalweg
Floodway
100-year Floodplain
(Zone A)
0 0.25 0.5
Miles
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA
INDIAN COMMUNITY
MESA
87
60
THOMAS ROAD
McDOWELL ROAD
McKELLIPS ROAD
BASELINE ROAD
UNIVERSITY DRIVE
COUNTRY CLUB ROAD



Source: Graf, et al 1994

Jones & Stokes

Figure 4.2-4
Annual Peak Flow of the Salt River for Major Releases from Granite Reef Dam, 1891-1993 (data from the Salt River Project)

4.2.2.4 Local Hydrologic Characteristics

The study area is located upstream of several other planned restoration projects, including the first phases of the Rio Salado Project and the Tres Rios Project. The City of Mesa, which has experienced rapid growth and residential development in recent years and has highly urbanized land-use areas, borders the south channel. The area to the north of the channel consists largely of undeveloped land owned by the Salt River Pima-Maricopa Indian Community. Numerous small, ephemeral drainage channels located along the north side of the channel discharge localized stormwater runoff to the Salt River from the nearby hills. The Buckhorn Mesa Project in the City of Mesa serves to consolidate and direct stormwater drainage to the Salt River through a single discharge channel immediately upstream of Granite Reef Dam (Flood Control District of Maricopa County 2002). The Buckhorn Mesa Project consists of four earthen dams with interconnecting floodways. Anecdotal information and hydrologic studies conducted for the initial phases of the Rio Salado Project (U.S. Army Corps of Engineers 1997) indicate that local stormwater drainage is rarely sufficient to generate continuous flow within the Salt River channel. For example, modeling results for predicted 10-year frequency flood events in the much larger Indian Bend Wash basin (peak discharge of 9,000 cfs) indicate that flows would be reduced to 1,500 cfs at Mill Avenue and 140 cfs at Central Avenue, and flows would completely infiltrate into the channel substratum shortly downstream (U.S. Army Corps of Engineers 1997).

4.2.3 GROUNDWATER

This section provides a brief overview of the hydrogeology, depth to groundwater, and direction of groundwater flow in the Salt River Valley. The Salt River Valley lies within the basin and range physiographic province and is characterized by broad alluvial valleys separated by rugged mountains. The valley is underlain by a wide variety of unconsolidated to variably consolidated sedimentary deposits that are several thousand feet thick in places. The sediments include unconsolidated clay, silt, sand and gravel, caliche, gypsum, mudstone, siltstone, sandstone, conglomerate, and anhydrite. Discontinuities in lateral lenses and interbedded deposits may exist in older units where high-angle faults exist. Groundwater recharge of aquifer units within the lower Salt River Valley occurs primarily as rainfall-induced subsurface influx from the mountain–valley fringe; rainfall on the valley floor is generally insufficient to contribute to groundwater recharge (U.S. Geological Survey 1991).

The Arizona Department of Water Resources (ADWR) regulates groundwater in Arizona and has identified the groundwater basin underlying lower Salt River Valley as the Phoenix Active Management Area (AMA). The Phoenix AMA comprises two distinct but interconnected alluvial groundwater basins: West Salt River Valley (WSRV) and East Salt River Valley (ESRV). These two units are divided by subsurface geologic outcroppings located near Priest Road in Tempe. Both basins generally comprise three separate hydrogeologic aquifer-layer units. The U.S. Bureau of Reclamation (USBR), the U.S. Geological Survey (USGS), and ADWR have independently identified these units, although the descriptions and nomenclature used by these agencies differ slightly. The three hydrogeologic units are: (1) the Lower Alluvial Unit (LAU), (2) the Middle Alluvial Unit (MAU), and (3) the Upper Alluvial Unit (UAU). Groundwater within the aquifer units is generally unconfined. The Salt River flows over the

UAU and was once the most important source of groundwater recharge for this unit. Composed predominantly of gravel and sand, the UAU ranges from 100 to 400 feet thick under the Salt River. The unit is thinnest near mountain fronts and bedrock outcrops, such as Tempe Butte and lower Papago Park. Water within the UAU is legally referred to as sub-flow to differentiate it from groundwater in the MAU and LAU. Historically, surface flows from streams and washes provided most of the water that recharges the UAU. Presently, the minor recharge sources, such as seepage from canals and irrigated land, underflow along major streams, and rainfall, have become more important.

Depth to groundwater has fluctuated greatly since development of the Salt River Valley began in the late 1890s (Table 4.2-3). Initially, diversion of water from the river for irrigation led to a rise in the water table. Canal seepage locally raised the water table as much as 20 feet above the natural water table. As development proceeded, groundwater became an important water source for agriculture. More than 75% of the pumped groundwater in the Salt River Valley is now used for agriculture. Drought conditions and pumping between 1895 and 1905 caused a decline in the well levels of 8–20 feet in the Mesa-Tempe area. The water table declined steadily from the 1930s into the 1960s as a result of increased pumping. The magnitude of declines varied spatially, from a few feet in some places to a few hundred feet in others. Where shallow bedrock forces water to the surface, depth to groundwater is only 10–30 feet greater than in the early 1900s.

Table 4.2-3. General Depths (Feet) to Groundwater near the Lower Salt River

Year	Granite Reef Dam to McKellips Road	McKellips Road to Mill Avenue	Mill Avenue to I-10	I-10 to 23rd Avenue	23rd Avenue to 91st Avenue	91st Avenue to Agua Fria River
1900	0–40	0–10	0–40	ND	ND	ND
1913	10–50	0–10	0–10	0–10	0–10	0–10
1945	50–150	0–50	0–10	10–50	10–50	0–10
1952	100–140+	20–80	40–60	40–60	20–40	<20–40
1964	ND	ND	ND	80–100	60–80	40–60
1972	ND	ND	ND	60–80	40–60	<20–40
1986	190–250	90–140	10–60	ND	ND	ND

ND = no data.

Sources:
1900 and 1986: Thomsen and Miller 1991
1913 and 1945: McDonald et al. 1947
1952: Wolcott 1952
1964 and 1972: U.S. Bureau of Reclamation 1976

During the 1980s, pumping of groundwater declined in the Salt River Valley. Data for seven wells along the Salt River for 1987 through 1992 indicate that while recent groundwater levels have not exhibited a distinct upward or downward trend, they have fluctuated considerably. Depth to groundwater decreases downstream, from an average of approximately 260 feet near Granite Reef Dam to less than 10 feet near Buckeye. For the period from 1987 to 1992, upstream water levels fluctuate the most from year to year, on average 7–19 feet, and exhibit the greatest range in levels.

The groundwater flow direction is predominantly east to west in both the ESRV and WSRV, although withdrawals have affected the flow of groundwater and even reversed its direction from historical patterns in some cases. In the ESRV, groundwater flows from the Salt River towards cones of depression located north of the Santan Mountains, east of Mesa, and in the Scottsdale–Paradise Valley area. In the WSRV, groundwater flows from the Salt River toward a major cone of depression near Luke Air Force Base, approximately 15 miles west of Phoenix (Figure 4.2-5). To a lesser extent, groundwater also flows in a northwestward direction toward a second cone of depression in the Deer Valley area. Drawdown in the Deer Valley and Queen Creek areas in the 1940s and 1950s caused groundwater to flow away from the Salt River rather than toward it. The Deer Valley low persisted into the 1980s, at which time the extensive low near Luke Air Force Base in the WSRV became more prominent. Before these pumping effects began, the movement of water toward the river channel and flow within the channel created a mound of groundwater under the channel, which was accessed by a variety of riparian plants. Deflecting flow away from the river contributes to the water-table decline near the river and reduces the groundwater mound.

4.2.4 WATER QUALITY

4.2.4.1 Contaminants

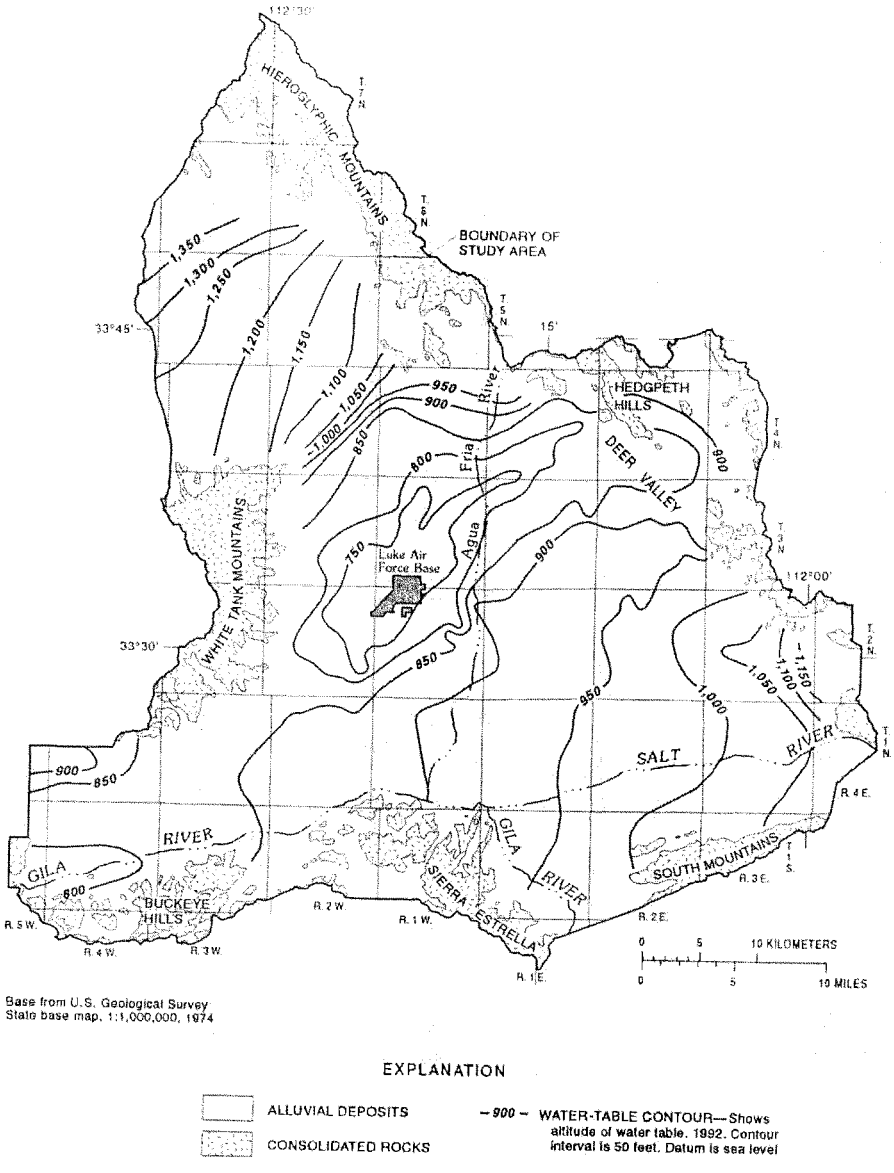
Surface-water and groundwater contaminants include naturally occurring and artificial (human-made) substances that can be introduced into a system from a variety of sources. Federal agencies (primarily the U.S. Environmental Protection Agency [EPA]) and state agencies establish water quality standards, which vary by water use (e.g., drinking water, irrigation, recreation). Contaminants in the surface waters and groundwater of Arizona fall into seven categories: volatile organic compounds (VOCs), pesticides, metals, nutrients, ions, microorganisms, and radiological substances (Table 4.2-4).

Table 4.2-4. Types of Water Contaminants in the Lower Salt River

Contaminant Category	Principal Contaminants	Typical Sources	Potential Health Impacts
Volatile organic compounds (VOCs)	Organic solvents Trichloroethene (TCE) Tetrachloroethylene (PCE) 1,1,1 Trichloroethane (TCA) Chloroform 1,1 Dichloroethane (DCE) 1,1 Dichloroethane (DCA) Benzene	Landfills Underground storage tanks Airports High technology industry	Carcinogen
Pesticides	Dibromochloropropane (DBCP) Ethylene dibromide (EDB)	Agriculture (soil fumigants) Urban runoff	Toxics Carcinogen
Metals	Arsenic Barium Boron Chromium Copper Iron Lead Manganese Selenium Zinc	Landfills Mines Metal finishing Natural origin	Toxics Carcinogen
Nutrients	Nitrate	Agriculture (fertilizers) Wastewater treatment Septic tanks Industrial manufacturing	Methemoglobinemia (blue-baby disease)
Ions	Total dissolved solids (TDS) Sulfate Chloride Fluoride	Mines Agriculture Natural origin	Taste, hardness Laxative effect Toxics
Micro-Organisms	Fecal coliform	Septic tanks Wastewater treatment	Infectious disease
Radiological		Mines Natural origin	Carcinogen

Source: Graf et al. 1994

Similar quality issues exist for all water sources in the lower Salt River, namely contamination by VOCs and various metals, ions, nutrients, and herbicides. As previously discussed, surface water naturally provides the main source of recharge for groundwater. Shallow groundwater in other reaches of the river often emerges in the channel, creating surface flows. Effluent from



Jones & Stokes

Figure 4.2-5
Groundwater Elevations in the Salt River Valley

wastewater treatment plants (WWTPs) and other industries contributes to both surface and subsurface flows. Thus, contaminants do not remain in one part of the system and may affect all water sources.

The most prevalent water contaminants in the lower Salt River area are VOCs, organic solvents widely used by both small and large industries and airports and often found in landfills. VOCs are the primary contaminants associated with federal Superfund sites and State of Arizona Water Quality Revolving Assurance Fund (WQARF) sites, and are most frequently present in water as a result of improper disposal of industrial solvents, degreasers, and other compounds. Major disposal practices that have led to groundwater contamination include injection of waste into dry wells, disposal in surface impoundments that leak dumping into dry washes, unregulated landfilling, and leaking of underground storage tanks. Water quality violations cited by the Arizona Department of Environmental Quality (ADEQ) show the presence of VOCs in groundwater in areas near every reach of the lower Salt River, especially in the central Phoenix area (Jones and Stokes Associates 2000).

Metals as contaminants are not as extensively distributed as VOCs. Possible sources of metal contamination include landfills, mines, metal finishing, and natural origins. When water quality exceeds water quality standards, it frequently appears to be linked to the remobilization of contaminated sediments during higher-than-normal flows. Although metals appeared in some of the Salt River Project groundwater wells, their concentrations did not exceed the maximum allowable limits. The exact sources and extent of contamination of surface waters by mercury and other metals remains unclear, but it can be assumed that sediments play an important role in their distribution.

Several ions and nutrients also exceed maximum allowable levels in groundwater, surface water, and effluent in the study reach. Nitrates are added to the hydrologic system from a variety of sources, including runoff from agricultural fertilizer, animal feed-lot wastes, and subsurface domestic septic leachate, and ranged from 2 to 172 milligrams per liter (mg/l) in SRP-operated wells throughout the valley in 1989 (Jones and Stokes Associates 2000). Near the Salt River, wells in five out of six reaches exceeded the EPA standard. Historically, nitrate levels have increased as a result of leaching of irrigated soils and sewage seepage. Wells in all reaches of the river exceeded recommended concentrations of bicarbonate and chloride, 90 mg/l and 250 mg/l, respectively. Groundwater from an extensive 103 square-mile area of the basin located generally north of the Salt River and between Phoenix and Glendale exceeds EPA's Maximum Contaminant Level water-quality standard of 45 mg/l (U.S. Geological Survey 1997). Boron presents another potential danger to plants and is present at problematic levels in wells in the lower four reaches of the river. Boron is found naturally in the Salt River waters, but various sources contribute to elevating levels in groundwater: WWTPs; municipal sewer systems, which in some areas employ heavy use of boric acid to control cockroaches; and leaching from irrigated fields that receive wastewater or sludge.

Total dissolved solids (TDS) probably warrant the least concern among all contaminants. Historically, TDS concentrations in surface waters and groundwater exceed the recommended standards for irrigation waters (500 mg/l), ranging between 500 and 5,000 mg/l. The irrigation that has been conducted over a long period in the valley has produced little long-term change in

the chemical quality of the groundwater since 1900. TDS concentrations in both the groundwater and surface water of the Salt River increased during the first half of this century, peaking around 1950 at 3,500-4,000 mg/l. More recent data show that TDS concentrations have declined since then, probably as a result of groundwater recharge. Data from the SRP wells suggest that TDS poses the greatest danger to plants in the lower reaches of the river. In 1989, TDS concentrations in SRP wells ranged from 230 to 3,670 mg/l, with a median of 910 mg/1. TDS concentrations are generally lower in the surface waters of the Salt and Verde Rivers and averaged 552 mg/1 and 282 mg/1, respectively, in 1989 above Granite Reef Dam. These concentrations are significantly lower than historical measurements. TDS levels in the Salt River at low flow were 1,850 mg/1 in 1900, 2,490 mg/l in 1912, 2,900 mg/1 in 1930, and 3,500 mg/l in 1943. TDS concentrations on average vary with the amount of flow. For example, during the 1978–80 floods, TDS concentrations in the Salt and Verde Rivers ranged between 100 and 900 mg/1 at lower flows and between 200 and 500 mg/1 at higher flows. Although TDS in surface waters and groundwater may cause problems for salt-sensitive crops and other plants, the present concentrations do not significantly differ from more natural conditions along the Salt River.

Urban stormwater runoff also has the potential to generate discharges of contaminants of concern. The USGS in cooperation with FCDMC have conducted specialized studies of contaminants in urban stormwater runoff in Maricopa County (U.S. Geological Survey 1995a, U.S. Geological Survey 1995b). Based on data collected in 1993 through 1994, stormwater could degrade water quality with oil and grease, pesticides, dissolved trace metals, and ammonia (U.S. Geological Survey 1995a). The highest levels of aquatic toxicity were detected in watersheds that receive drainage from residential and commercial land uses. Streamflow samples from the Salt River were not toxic. Ammonia, lead, and zinc loads that were discharged in stormwater were also found to accumulate in channel-bed sediments. Toxicity of bed materials was detected in undeveloped drainage basins and developed basins. Naturally occurring levels of zinc, and copper to a lesser extent, may be responsible for sediment toxicity in undeveloped areas. Recoverable concentrations of zinc and cadmium were most correlated with sediment toxicity from bed material in developed drainage basins. Previous sampling conducted in 1991 and 1992 was evaluated to identify differences in contaminant loading patterns (U.S. Geological Survey 1995b). The data indicated that loading was most directly correlated with the percentage of impervious land area and commercial or industrial land uses. Localized areas in the Cities of Chandler, Mesa, Paradise Valley, and Peoria appeared to contribute a large proportion of the total loads evaluated. These areas were typically impervious in excess of 40% of the total area and contained high-density commercial, industrial, or residential development. A national assessment of stormwater quality from 11 major municipal areas indicated that contaminant-loading stormwater runoff per unit land area was generally better than other areas (U.S. Geological Survey 1994). Compared to other municipalities, contaminant loading in Phoenix from residential, commercial, and industrial drainage basins ranked fourth, second, and third lowest, respectively.

4.2.4.2 Potential Water Quality Stressors

The Water Quality Technical Committee (WQTC) for the first phases of the Tres Rios Project identified 10 categories of stressors that could affect the quality of the surface waters and

groundwater in the Salt River Valley (Tres Rios River Management Committee–Water Quality Technical Committee 1998). These stressors are described below, and Table 4.2-5, which follows, shows the relationship between these stressors and pollutants of concern.

Table 4.2-5. Relationships between Pollutants of Concern and Stressors

Pollutants of Concern	Stressors									
	Floodflows	Stormwater Regulated by NPDES	Unregulated Stormwater	Agricultural Stormwater Runoff	Agricultural Drainage	CAFO Runoff	WWTP Discharges	Landfill Leachate	Groundwater Inflow	Sand and Gravel Releases
Sediments/Solids	M	M	M	M	M	M	NA	NA	NA	M
Inorganic Contaminants										
Beryllium	DG	EE	EE	DG	DG	DG	NE	DG	DG	DG
Boron	DG	M/P	M/P	DG	DG	DG	NE	DG	EE	DG
Copper	DG	M	M	P	P	NA	P	P	EE	DG
Cyanide	DG	M	M	DG	DG	DG	NE	DG	DG	DG
Mercury	DG	EE	EE	P	P	DG	EE	P	DG	DG
Nitrate	DG	M/P	M/P	P	M	M	P *	DG	M/P	DG
Selenium	DG	M/P	M/P	DG	DG	DG	EE	DG	EE	DG
Thallium	DG	M	M	DG	DG	DG	NE	DG	DG	DG
Organic Contaminants										
Bromodichloromethane	NA	NA	NA	NA	NA	NA	P	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA	P	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	P	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA	P	NA	NA	NA
Pesticides										
Chlordane	DG	EE	DG	DG	DG	DG	NE	DG	DG	NA
DDD	DG	EE	DG	P	P	DG	NE	DG	DG	NA

Pollutants of Concern	Stressors									
	Floodflows	Stormwater Regulated by NPDES	Unregulated Stormwater	Agricultural Stormwater Runoff	Agricultural Drainage	CAFO Runoff	WWTP Discharges	Landfill Leachate	Groundwater Inflow	Sand and Gravel Releases
DDE	DG	EE	EE	P	P	DG	EE	DG	DG	NA
DDT	DG	EE	DG	DG	DG	DG	EE	DG	DG	NA
Diazinon	DG	DG	DG	DG	DG	DG	M	DG	DG	NA
Dieldrin	DG	EE	DG	DG	DG	DG	EE	DG	DG	NA
Lindane	DG	EE	DG	DG	DG	DG	M	DG	DG	NA
Toxaphene	DG	EE	DG	DG	DG	DG	EE	DG	DG	NA
Other parameters										
Dissolved Oxygen	NA	DG	DG	P	P	M	P	NA	NA	NA
Total Dissolved Solids	NA	DG	DG	P	M	M	P	M	M	NA

* Less for WWTPs with NdeN.

M = major source of given pollutant of concern

P = probable source of given pollutant of concern

M/P = potential to be a major to probable source of a given pollutant of concern

EE = exceedance extrapolated for given pollutant of concern using Middle Gila Watershed study data

NE = no exceedance for given pollutant of concern using Middle Gila Watershed study data

DG = data gap

NA = not applicable

Source: Tres Rios River Management Committee—Water Quality Technical Committee 1998

1401

Floodflows

Floodflows are the releases from upstream dams. The flows vary in quantity from minor flows in the channel to the projected 100-year floodflows. Both minor and flood flows associated with dam releases are controlled by the dam spillgates. Floodflows transport substantial amounts of sediment that originates from tributary flows entering the Salt and Gila Rivers from upstream portions of the river channels and from erosion in the study area. Substantial scouring of the Salt River channel occurs during floodflows and is partially related to levee maintenance activities, channelization projects, and removal of material for gravel mining operations (U.S. Geological Survey 1995c). Floodflows erode landfills in and adjacent to the river, adding trash and debris to the materials transported by the flow. Much deposition of sediment and landfill materials occurs in the riparian areas in the Tres Rios study area (Jones and Stokes Associates 2000).

The floodflows can contain pollutants of concern derived from tributary stream inflow, erosion of sediments, and landfills. Large quantities of water in floodflows can dilute the concentration and transport the contaminants through the study area to downstream areas. There is very little information, however, on the chemical constituents in floodflows.

Stormwater Runoff

Stormwater flows enter the Salt River through storm drains, and many sources of urban- and industrial-site runoff in the Phoenix metropolitan area are regulated as part of the National Pollutant Discharge Elimination System (NPDES) stormwater permit program (described below under "National Pollutant Discharge Elimination System Stormwater Discharge Permits" in Section 4.2.3). In Maricopa County, the Cities of Mesa, Scottsdale, Phoenix, Tempe, and Glendale have interconnected and shared drainage systems and cooperate with the FCDMC to implement provisions of a municipal NPDES stormwater permit. The FCDMC conducts stormwater monitoring at 16 locations throughout Maricopa County. However, urban areas with populations of less than 100,000 (e.g., Cashion, Tolleson, Avondale, Laveen) are not required by current regulations to obtain stormwater permits or perform stormwater quality monitoring. These communities will be required to obtain permits and conduct stormwater monitoring by 2003, and the FCDMC will also be responsible for these activities. The quality of water from storm drains varies depending on the length of time between storm events, the amount of flow, and the source of stormwater runoff. If long periods pass between storm events, pollutants accumulate in greater amounts before they are washed away by runoff. In this case, concentrations of pollutants are greater than when runoff events are more frequent. The amount of flow also affects concentrations. During high stormwater-runoff periods, the concentrations of pollutants are diluted by the quantity of flow. The concentration of pollutants also changes during a flow event. *First flush* is a term used to describe the initial flow in a runoff event, when the concentrations are generally the greatest.

Stormwater runoff often contains a significant amount of sediment that is washed from undeveloped land and other sources, as well as chemical contaminants or pollutants. The types of chemical pollutants will vary depending on the land uses within the particular drainage area.

Potential water quality impacts associated with runoff from industrial sites are projected to be minimal because the compliance requirements of stormwater NPDES permits require each industrial site to have a stormwater pollution prevention plan (SWPPP). Runoff from turf areas has the potential to contain pesticide and fertilizer residuals. Runoff from paved areas can contain hydrocarbon products, metals, and anything spilled on the pavement.

Unregulated Stormwater Runoff

There are many areas where stormwater is not collected in a drainage system and the runoff flows overland or in streets until it flows into the river channels. This type of stormwater runoff is referred to as unregulated because the quality of runoff is not subject to NPDES stormwater permit program requirements. The pollutants of concern in unregulated stormwater runoff could include sediment and a variety of chemical components, depending on the land use of the area generating the runoff.

Agricultural Stormwater Runoff and Irrigation Tailwater

Agricultural land uses can be the source of agricultural stormwater runoff. Most of the agricultural stormwater runoff is from fields, but it can also originate from equipment yards. In most cases, the agricultural runoff from fields and equipment yards is collected in the irrigation drainage canals adjacent to fields and equipment yards and then discharged to the river channels. In some locations where the farm fields are near river channels, the stormwater runoff can flow directly into the river channels. The agricultural stormwater runoff from fields can contain large amounts of sediment because plowing and cultivation break up the soil surface and make the soil susceptible to erosion. The field stormwater runoff can contain pollutants of concern associated with agriculture, such as nitrates (from fertilizers), pesticides, and herbicides.

Past irrigation practices often resulted in the application of excess irrigation water, which was drained from fields into drainage canals and released into the rivers. Discharges of excess irrigation water, or tailwater, are not regulated and their quality is not monitored. Water conservation rules restricting irrigation water use have resulted in a substantial reduction in farm-field drainage but have not eliminated it.

Concentrated Animal-Feeding Operations

Concentrated animal-feeding operations (CAFOs) can produce very poor quality discharges if the site drainage is not controlled. Animal wastes can drain from the site into storm drains or irrigation systems, including both water supply laterals and drainage canals. The principal pollutant of concern from such operations is nitrate. Bacterial pathogens and other microbiological pollutants, biochemical oxygen demand (BOD), total suspended solids, and nutrient loads can also be generated at a CAFO site. CAFO sites are not located within the Salt River channel, however, uncontrolled runoff from CAFO operations can enter the Salt River through canals and storm drainage systems.

Regulations are in place to require control of CAFO discharges by means of an agricultural general permit of the Arizona Aquifer Protection Permit program (Arizona Administrative Code, Title 18, Chapter 9, Article Z [R18-9-201 to 203]). CAFO discharges are also regulated through NPDES permits under the Clean Water Act. The Natural Resources Conservation Service (NRCS) has a pilot program to provide funding to control CAFO discharges at selected sites.

Wastewater Treatment Plant Discharges

All WWTPs that discharge to surface waters are required to have NPDES permits that include requirements to monitor the quality of the effluent prior to discharge. There are several WWTPs with discharge permits for the Salt River. Discharges from the City of Mesa Northwest Water Reclamation Plant near SR 101 infiltrate into the Salt River bed. During winter, reclaimed water from the WWTP is discharged to the Salt River. When hydrologic conditions permit, the flow from the plant can continue downstream beyond the study area. Groundwater monitoring data collected near the plant indicate that contaminant concentrations are relatively low and that the soil is effective at degrading potential contaminants of concern (Fox et al. 2001). Dissolved organic carbon (DOC) concentrations were reduced from 5–7 mg/l to less than 1 mg/l within 12 to 24 months of travel time in the groundwater plume emitted from the discharge. The majority of trace organic compounds were reduced in concert with DOC, and nitrate and DOC levels were lower than ambient background groundwater conditions.

Sand and Gravel Mining

Sand and gravel mining operations use pumped groundwater to sort and wash the aggregate materials. These mining operations are usually in the river channels or adjacent to the channels on the riverbanks. Before being pumped for use in these operations, the groundwater flows through materials similar to the mining aggregate. It is therefore expected that the mining will not result in any significant change in the chemical constituent concentrations in the water. Mining can greatly increase the sediment load in the water, however, and mining operations located within waters of the United States are required to have Section 404 permits and Section 401 water quality certification to minimize impacts on water quality. The major water quality impact results when there is an accident that releases water from a mining site or when the site is inundated during flood events in the river and stockpile material is transported downstream. During a flood, any sediment generated by sand and gravel mines is overwhelmed by the sediment transported by the floodflow. Currently, there are active sand and gravel mining operations in the Salt River.

4.2.5 REGULATORY SETTING

This section describes the federal and local agencies that have jurisdiction over water projects on rivers in the study area and that provide for flood protection in the study area. This section also presents information on the federal flood insurance program and pertinent water quality regulations.

4.2.5.1 Agency Jurisdiction

Several governmental agencies have administrative interests in the lower Salt and lower Gila Rivers. Upstream dams were built by or are operated by USBR, the U.S. Bureau of Indian Affairs, and the Salt River Project. The U.S. Army Corps of Engineers (Corps) built and operates a major flood control structure downstream of the study area. In Maricopa County, where the entire study area is located, municipalities have direct interests in management of the rivers, and the FCDMC is the primary entity providing for flood protection.

U.S. Army Corps of Engineers

Since its original legislative mandate in 1927 for flood-related work in the United States, the Corps has acquired significant responsibility for flood control and related efforts on the lower Salt River. Although the Corps has not built local channel facilities along the lower Salt River, the agency has constructed Painted Rock Dam to protect irrigation works on the lower Gila River from inundation and channel erosion. The dam, begun in 1957 and completed in 1960, can store 2.5 million ac-ft of water, with controlled releases of up to 22,000 cfs. The Corps has several proposed projects related to the lower Salt River. Although it is not known which, if any, of the projects may eventually be completed, they represent an indication of the Corps' interest in the study area.

U.S. Bureau of Reclamation

USBR has primary responsibility for the development and delivery of water resources. The 1902 Reclamation Act was intended to provide federal investment (with subsequent repayment by users) and expertise in the development of water resources, primarily in the western states. The Reclamation Reform Act of 1982 brought about significant adjustments in USBR's operating methods, recognized leasing, and changed payment procedures.

Salt River Project

Until the mid-20th century, the SRP was primarily a water storage and delivery agency for agricultural users. After World War II, however, the Phoenix urban area grew rapidly, and the mission of the SRP changed focus. In 1903, the local community included fewer than 20,000 people; by 1967, the population had grown to 800,000; and in 1994, the population approached 2 million. To accommodate the shift from an agricultural to an urban emphasis, the SRP adjusted to address urban water delivery issues, and it became a major component of the regional electrical power grid. The SRP operates the seven major dams upstream of the metropolitan area on the Salt River, and therefore must be taken into account in any plans for managing river flows and floods through the urban area. The SRP also owns land parcels in and near the river channel.

Flood Control District of Maricopa County

The FCDMC is also a primary agency involved with the management of the lower Salt River and the portion of the Gila River included in the present study. Although Maricopa County had undertaken some flood control efforts on a relatively small scale before the early 1980s, widespread, coordinated projects became much more common after the Arizona State Legislature mandated the formation of county flood control districts. The FCDMC builds various flood control structures, often in cooperation with other agencies, such as the Arizona Department of Transportation (ADOT) and the NRCS. In addition, the FCDMC manages floodplain development by delineating floodplains and administering regulations for floodplain users. The FCDMC coordinates the participation of the county in the National Flood Insurance Program, administered by the U.S. Department of Housing and Urban Development, as established by congressional action in 1968 and revised in 1973. The availability of federally insured loans and other federal assistance related to floodplains depends on adherence to federal and state rules and regulations as administered by the FCDMC. In exercising its responsibilities, the FCDMC has completed 32 projects and structures within Maricopa County, including vegetation clearing projects, levee construction, bank stabilization, and channel improvements.

Municipalities and Indian Communities

The municipalities of Mesa, Tempe, and Phoenix and the Salt River Pima-Maricopa and Gila River Indian Communities have direct interests in the lower Salt River because the stream flows directly through their jurisdictions. Tempe has committed itself to an ambitious effort to convert 5 miles of the Salt River channel and adjoining areas into a variety of land uses ranging from habitat reconstruction to intensive commercial and residential activities. In 1989, the City of Tempe adopted the Tempe Rio Salado Master Plan to guide the development under the general direction of the City of Tempe Community Development Department. ADOT, in work associated with the Red Mountain Freeway on the north bank of the river, channelized the stream from the Hohokam Expressway (roughly the alignment of 48th Street) and Mill Avenue, and the FCDMC extended the project upstream to McClintock Drive, a short distance upstream from Indian Bend Wash (a Corps project). The channel design includes grade control structures to limit scour, channel migration, and degradation, and the general capacity of the channel is 250,000 cfs. The expected 100-year flood for the reach after the completion of improvements to Roosevelt Dam is 160,000 cfs.

Federal Emergency Management Agency

Congress, alarmed by increasing costs of disaster relief, passed the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. The intent of these acts is to reduce the need for large public-funded flood control structures and disaster relief by restricting development on the floodplain.

The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program to provide subsidized flood insurance to communities that comply with FEMA

regulations that limit development in floodplains. FEMA issues flood insurance rate maps for communities participating in the program. These maps delineate flood hazard zones in the community and are updated as flood control improvements are implemented.

4.2.5.2 Water Quality Regulations

Clean Water Act

Placement of dredged or fill materials into waters of the United States is regulated under Section 404 of the Clean Water Act, which is administered by the Corps. Under the act, the state must issue or waive Section 401 water quality certification for the project to be permitted under Section 404. Water quality certification requires the evaluation of water quality considerations associated with dredging or placement of fill materials into waters of the United States.

The EPA requires states to identify and establish beneficial uses and water quality objectives for surface and groundwater resources. The Arizona Department of Environmental Quality (ADEQ) is the responsible agency and the water quality standards are established in the Arizona Administrative Code, Title 18, Chapter 11. Numerical and narrative water quality objectives are established to protect designated uses. The Salt River from the location of the Phoenix 24th Street WWTP extending downstream to the confluence with the Gila River is classified as an effluent dependent water body under Title 18 and ADEQ regulates effluent discharges within this reach on a site-specific basis.

Section 303(d) requires states to identify water resources that are impaired by contaminants and failing to meet ambient surface water quality objectives. The applicable regulations require development of a Total Maximum Daily Load (TMDL) program for 303(d) listed water bodies. TMDL programs identify sources of the contaminants, available assimilative capacity of the water body that would result in water quality objectives being met, and allocates the allowable daily load to dischargers within the watershed. The TMDL implementation plan is then developed to regulate and control the loading of contaminants in the watershed. The Salt River is listed as being impaired by chlordane, DDT metabolites, pH, and toxaphene in the lower reach of the channel extending from near the Phoenix Sky Harbor Airport to the confluence with the Gila River (Arizona Department of Environmental Quality 1998). The TMDLs for these constituents are proposed to be developed before 2007.

National Pollutant Discharge Elimination System Discharge Permits

Established by Section 402 of the Clean Water Act, NPDES is the primary federal program that regulates point-source discharges to waters of the United States. The EPA granted the State of Arizona primacy on December 5, 2002. The state program is called the Arizona Pollutant Discharge Elimination System (AZPDES) program and is administered by the Arizona Department of Environmental Quality, Water Quality Department in Phoenix, Arizona.

In 1992, the EPA promulgated rules for a General Industrial Storm Water Permit under the NPDES, which requires property owners to file a notice of intent to discharge stormwater runoff to waters of the United States from specified industrial activities, including mining. The permit requires dischargers to eliminate non-stormwater discharges to stormwater systems, develop and implement a SWPPP, perform inspections of stormwater pollution prevention measures, and monitor water quality. In 1998, EPA transferred permittees previously covered by the 1992 permit to EPA's multi-sector general permit, which was issued in 1995. Multi-sector permits are currently required for municipalities with populations greater than 100,000. Phase II of the NPDES rules, which were adopted in 2003, requires municipalities with populations greater than 10,000 to develop and implement multi-sector permits.

In 1992, the EPA promulgated rules for a General Construction Storm Water Permit under the NPDES, which will require landowners to file a notice of intent to discharge stormwater runoff to waters of the United States from land disturbances of more than 5 acres. The permit generally requires dischargers to eliminate non-stormwater discharges to stormwater systems, develop and implement a SWPPP, and perform inspections of stormwater pollution prevention measures. The grading that would occur as part of this project would be more than 5 acres, and therefore a SWPPP will be required. These requirements have been incorporated into the AZPDES permit program.

Safe Drinking Water Act

Water quality standards for drinking water are established and regulated by the federal Safe Drinking Water Act of 1986. The maximum contaminant levels, which apply to metals and other toxic compounds in drinking water, are subject to revision, and additional compounds may be added. The Arizona Safe Drinking Water Program is administered by the ADEQ, except for Underground Injection Control permits, which are still issued by the EPA Region 9 office in San Francisco, California.

4.3 BIOLOGICAL RESOURCES

This section contains a summary of biological resources located or potentially occurring in the Va Shly'ay Akimel project study area. Information was derived from published and unpublished reports, Jones & Stokes' file information, and field surveys.

For the purpose of this report, the project study area includes a 14-mile-long section of the Salt River within the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa, Arizona, located between the Pima Freeway (SR 101), and Granite Reef Dam (Figure 1-2). The study area extends 1 mile to either side of the thalweg, or center of the river channel, for a total width of 2 miles.

Field surveys were conducted in March 2002 and March 2003 by Jones & Stokes biologists. The objectives of the surveys were to map cover types, to identify biological resources, and to describe existing conditions in the project study area. Cover types were mapped on black and white aerial photographs (scale 1"=500') taken in January 2001 and were then digitized using ArcInfo version 8.1. The minimum mapping unit for most cover types was 10 acres, with a 1-acre minimum mapping unit observed for sensitive cover types (e.g., riparian and wetland habitats).

Ten special-status wildlife species are considered to have the potential to occur in the project study area and are evaluated in this study. No special-status plants (other than protected native plants) or fish have been recorded in or are expected to occur in the project study area. The area could potentially support the desert tortoise and Mexican garter snake. The scientific and common names of plants and wildlife discussed in this section are listed in Appendix D.

4.3.1 ENVIRONMENTAL SETTING

Historically, the project study area supported significant biological resources including extensive riparian and marsh habitats. Urban development, diversion of water to support agriculture, and domestic livestock grazing have eliminated or altered most of the natural vegetation communities that occupied the project study area leaving only scattered remnants of the original vegetation communities. Modifications of the river system, such as damming and flow diversion, currently allow no natural flow through the project study area except during flood events. Vegetation communities in the project study area have been highly modified from their original state and currently contain a mosaic of degraded natural communities and manmade artificial communities.

A classification system was developed for this study based on several sources, including a list of cover types supplied to Jones & Stokes by the U.S. Army Corps of Engineers, Jones & Stokes file information, and recent publications (Brown 1982, Szaro 1989). The classification system categorized habitat types in the project study area by the type of vegetation cover. Table 4.3-1, which follows, summarizes the mapped cover types and subtypes in the project study area and characteristics of each. This section describes the important biological communities that occur in

the project study area and their characteristic vegetation and wildlife. The general locations of these cover types are shown in Figure 4.3-1.

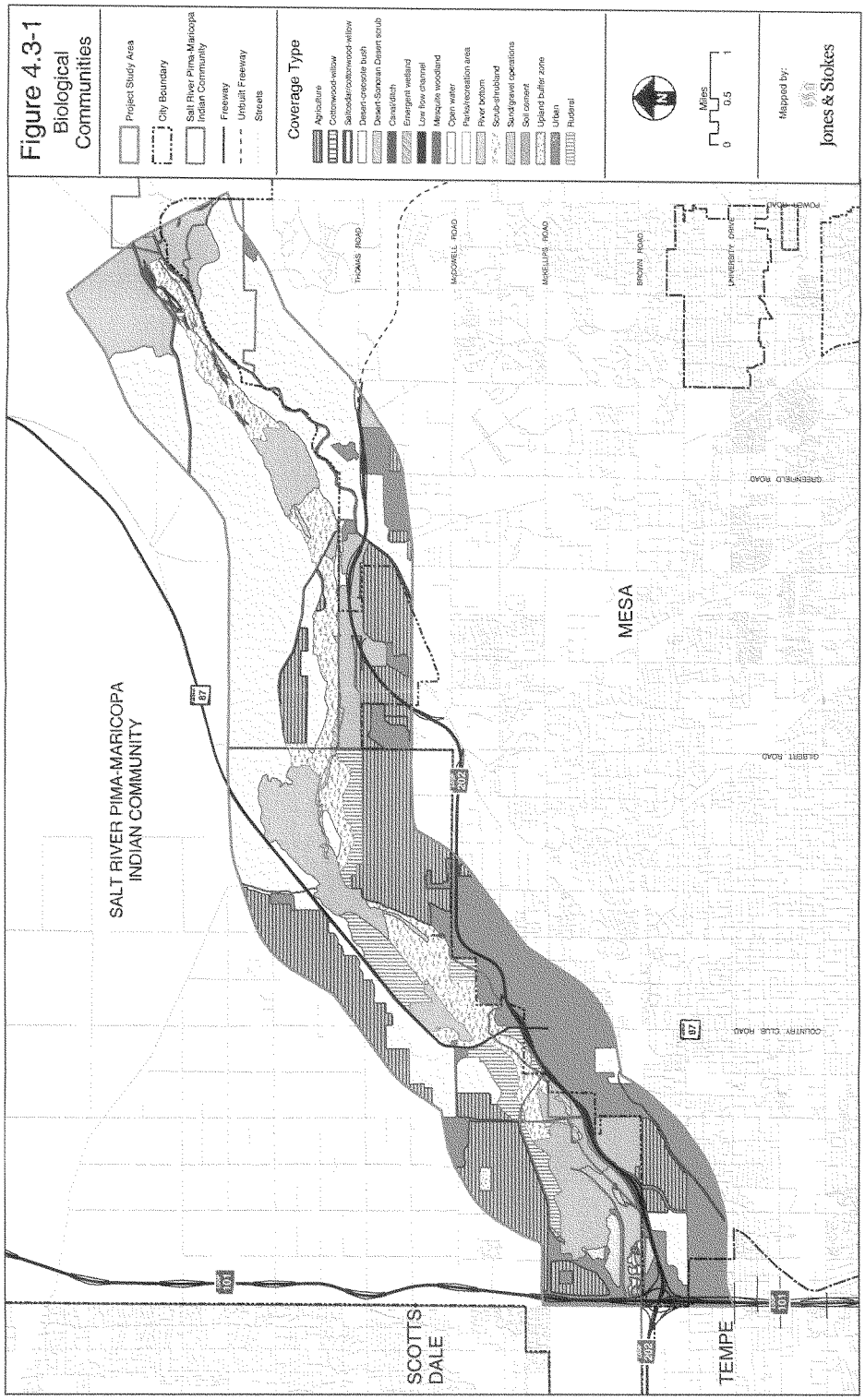


Figure 4.3-1
Biological Communities
Project Study Area
City Boundary
Salt River Pima-Maricopa Indian Community
Freeway
Unbuilt Freeway
Streets
Coverage Type
Agriculture
Cottonwood-willow
Saltcedar/cottonwood-willow
Desert creosote bush
Desert-Sonoran Desert scrub
Canal/ditch
Emergent wetland
Low flow channel
Mesquite woodland
Open water
Parks/recreation area
River bottom
Scrub-shrubland
Sand/gravel operations
Soil cement
Upland buffer zone
Urban
Rudural
Miles
0 0.5 1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
SCOTTS DALE
TEMPE
MESA
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
GILBERT ROAD
COUNTRY CLUB ROAD
UNIVERSITY DRIVE
GREENFIELD ROAD
87
202
101

Table 4.3-1. Cover Types Present within the Va Shly'ay Akimel Project Study Area

Major Cover Type	Subtype	Description	Extent in Acres	Percentage of Project Study Area
Agricultural Lands	Irrigated Pasture	Used for cattle grazing	187.3	1%
	Citrus	Orange groves	554.7	3%
	Fallow/Ruderal Field	Plowed fields not used for at least a year.	618.6	4%
	Unclassified Agriculture	Plowed and unplanted at the time of the survey.	1901.7	11%
Cottonwood-willow Forest	Young cottonwood-willow forest	Dominated by native trees, generally with saltcedar in the understory.	40.2	<1%
	Saltcedar/ cottonwood-willow forest	Dominated by saltcedar with scattered native species.	31.2	<1%
Desert Areas	Creosote bush/white bursage	Dominated by Creosote bush and white bursage	5,226.4	30%
	Sonoran desert scrub	Dominated by Creosote bush, saguaro, cholla, and paloverde	782.1	4%
Ditch/Canal	None	Aqueducts and major ditches	167.4	1%
Emergent Wetlands	None	Dominated by Cattails, with scattered tules	73.0	<1%
Low Flow Channel	None	Low flow channels in the active channel	16.9	<1%
Open Water	Groundwater recharge basin	City of Mesa recharge basins near SR 101.	91.7	<1%
	Sand/gravel operation ponds	Permanent ponds associated with active sand/gravel operations	11.8	<1%
Parks and Recreation Areas	None	Golf courses and parks	279.6	2%
River Bottom	None	Unvegetated river bottom covered mostly with cobbles.	251.8	1%
Scrub-Shrublands	None	Dominated by ironwood, triangle leaf bursage and creosote.	1,419.0	8%

Major Cover Type	Subtype	Description	Extent in Acres	Percentage of Project Study Area
Sand-Gravel Operations	None	Operations within the active channel	1,961.6	11%
Soil Cement	None	Soil cement on the active slopes of the channel	34.0	<1%
Upland Buffer Zone	None	Newly established shrubs and scrub dominated by a mixture of native and non-native shrubs	86.5	<1%
Urban	None	Residential, industrial, or transportation	2,999.7	17%
Ruderal	None	Disturbed areas not associated with agricultural clearing, mostly weedy herbaceous species.	699.5	4%

4.3.2 COVER TYPE DESCRIPTIONS

4.3.2.1 Agricultural Lands

Vegetation

Agricultural lands are common in the project study area occupying 19% of the total area. Generally, agricultural uses include irrigation for cattle grazing, orchards (citrus), and crops such as cotton, small grains, and assorted vegetables.

Wildlife

Agricultural lands in general have low to moderate wildlife value. The composition and structure of commercially produced agricultural croplands lack the diversity of more productive wildlife habitats.

Plants important for wildlife food and shelter are often absent or reduced to rows at the edges of the fields. While these fencerows provide corridors for animals to move from place to place, many are isolated and fragmented, greatly reducing the wildlife value. Small mammals such as mice, voles and rats frequent such fencerows and may forage on crops such as alfalfa and small grains. The abundance of small mammals using these edge habitats serves to attract larger predators, including medium-sized mammals such as coyote, gray fox, and bobcat, as well as avian predators (e.g., red-tailed hawk, northern harrier, American kestrel, barn owl, and great horned owl). Bird species favoring open habitats such as killdeer, mountain plover, greater roadrunner, mourning dove, white-winged dove, horned lark, and various ground-feeding granivorous sparrows and finches will forage in agricultural fields.

4.3.2.2 Cottonwood-Willow Forest

Vegetation

Cottonwood/willow forest is uncommon in the project study area occupying less than 1% of the total project study area. This cover type is representative of high-quality riparian habitat in Arizona. Riparian habitats are defined as habitats or ecosystems that are associated with adjacent bodies of water (rivers, lakes, or streams) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. They are further characterized by having diverse assemblages of plant and animal species in comparison with adjacent upland areas.

Recruitment of most woody riparian vegetation in the southwest has been shown to correlate with high flows followed by a year or more without high flows. Water availability in the project study area is regulated largely by upstream irrigation diversion dams. Because of the modification of the Salt River system, groundwater elevations have been lowered and this has contributed to the decline in riparian extent and cover. These same conditions have also favored

the establishment and dominance of non-native saltcedar. The vegetation structure of most stands of cottonwood/willow within the project study area show evidence of disturbed and early successional conditions consistent with past histories of water diversion, infrequent severe floods, and land clearing. These plant species are also found in narrow, linear strands of vegetation oriented in the main direction of water flow that may occur in riverine flood channels and along the banks of streams. An example of cottonwood/willow habitat can be found near the City of Mesa Wastewater Treatment Plant (Mesa WWTP), where return flows permit re-establishment of riparian vegetation.

Of the total project study area acreage, 1% consists of cottonwood/willow habitat (Figure 4.3-1). In terms of height, basal area, and density, Fremont cottonwood and Goodding's willow are the dominant canopy species in the cottonwood/willow associations in the project study area, along with saltcedar. The cottonwood/willow riparian habitat is patchy in the project study area and much of the original stands of this habitat have been replaced by the invasive and non-native saltcedar.

For the purpose of this report, riparian habitat was separated into two subtypes; young cottonwood/willow forest, and saltcedar/cottonwood/willow forest based on differences in species dominance within each subtype. Both subtypes support varying combinations of cottonwoods, willows and saltcedar in the canopy.

The saltcedar/cottonwood/willow subtype in the project study area is dominated by dense stands of saltcedar with scattered cottonwoods or willows in the canopy. Saltcedar has been labeled an "extreme" phreatophyte because of its ability to tap and exploit deep water tables (Duncan et al. 1993). Saltcedar is also highly salt tolerant and has been shown to thrive on groundwater with a high concentration of salt (Duncan et al. 1993). This ability to disperse highly concentrated salt excretions provides saltcedar with a competitive advantage over native plants, such as willows and cottonwoods (Duncan et al. 1993). In contrast, the cottonwood/willow forest subtype is characterized by small, generally young, native trees with a canopy dominated by cottonwoods and willows. This type also commonly has saltcedar, desert broom, marsh fleabane, and desert willow as associates in the canopy or understory.

Wildlife

Cottonwood/willow forest, although uncommon in the project study area, stands out as the most important remnant wildlife habitat in the area. Cottonwood/willow supports the densest and most diverse wildlife communities in valleys and deserts. The diversity of plant species and growth forms provide a variety of foods and microclimate conditions for wildlife. Cottonwoods and willows provide substantial nesting support for large birds, such as great blue heron, red-tailed hawk, American kestrel, western screech owl, great horned owl, and northern flicker.

Although saltcedar has displaced large amounts of riparian and other vegetation along the Salt River, the remaining riparian habitat still provides high wildlife value, especially for resident and migratory birds. Great blue heron, great egret, western yellow-billed cuckoo, and black-crowned

night-herons are also known to roost in the cottonwood/willow vegetation and would then forage in nearby habitats.

The remaining cottonwood/willow habitats are especially important for resident and migratory neotropical songbirds because these and other native riparian habitats have high wildlife value and have substantially declined throughout the western United States. Many bird species use cottonwood/willow habitats in the project study area, including Anna's hummingbird, ash-throated flycatcher, black phoebe, dusky flycatcher, western wood pewee, western kingbird, tree swallow, house wren, Bewick's wren, verdin, Lucy's warbler, yellow warbler, yellow-rumped warbler, and red-winged blackbird.

The most common mammals in cottonwood/willow habitats in the Salt River Valley area are the cactus mouse, deer mouse, and western harvest mouse. White-throated woodrat, hispid cotton rat, coyote, and bobcat are also common in these cottonwood/willow habitats (CH2M HILL et al. 1997).

Some of the common reptiles occurring in this same area include the tree lizard, earless lizard, side-blotched lizard, desert spiny lizard, western whiptail, banded gecko, desert blackheaded snake, common kingsnake, banded sand snake, and western diamondback rattlesnake. The tree lizard, which has been characterized as a terrestrial riparian lizard (Omart et al. 1988), is among the most common species observed in the cottonwood/willow and saltcedar trees in the vicinity (CH2M HILL et al. 1997).

Many native wildlife species, especially riparian-dependent or riparian/marsh-dependent birds (e.g., southwestern willow flycatchers [discussed in more detail below under "Special-Status Species"], summer tanager, and western yellow-billed cuckoo) require large tracts of native riparian trees and shrubs for cover, nesting, and foraging.

4.3.2.3 Desert Areas

Vegetation

Desert areas are the most common cover type in the project study area occupying 34% of the total area. They are characterized by relatively undisturbed arid lands in the project study area. For the purpose of this study, desert areas were separated into two subtypes: creosote bush/white bursage, and Sonoran desert scrub. The creosote bush/white bursage subtype is characterized by mostly creosote bush with scattered white bursage and other small shrubs in the canopy. This community type is variable from monotypic stands of creosote bush to a more diverse canopy in the transition zone between it and Sonoran desert scrub. Sonoran desert scrub is uncommon in the project study area, and is only present in the uplands near Granite Reef Dam. Characteristic species are typically more diverse and include creosote bush, saguaro, yellow paloverde, cholla, and barrel cactus.

Wildlife

Desert areas in the project study area are likely to support some bird species that will not occur in other habitat types in the region. This wildlife habitat type is used by many bird species, including mourning dove, white-winged dove, Lucy's warbler, Bell's vireo, Abert's towhee, elf owl, Gila woodpecker, verdin, and house finch. Other avian desert specialists including curve-billed thrasher, phainopepla, canyon towhee, and black-throated sparrow, which favor the Sonoran desert scrub and cholla cactus habitats (Phillips et al. 1964, Witzeman et al. 1997). Mammals that use this habitat include coyote, gray fox, bobcat, pocket gopher, black-tailed jackrabbit, desert cottontail, and cactus mouse. Reptiles often found in desert habitat include earless lizard, side-blotched lizard, desert spiny lizard, western whiptail, gopher snake, common kingsnake, banded sand snake, and western diamondback rattlesnake.

4.3.2.4 Ditch/Canal

Vegetation

Ditches and Canals in the project study area occupy 1% of the total area. These features include large aqueducts such as the Arizona Canal and the Southern Canal, and several smaller ditches used for the transportation of irrigation water.

Wildlife

Ditches and canals, as they occur in the project study area, offer moderate to low wildlife value. These features are only rarely lined with any vegetation that could serve as corridors or cover for wildlife. The larger concrete-lined aqueducts serve as marginal foraging and loafing areas for several species of waterfowl including mallard, common merganser, and American coot. During field surveys, belted kingfisher, osprey, and black phoebe were observed foraging in the vicinity of the larger aqueducts.

4.3.2.5 Emergent Wetlands

Vegetation

Emergent wetlands are uncommon in the project study area, occupying less than 1% of the project study area on lands in the floodplain of the Salt River near the Mesa WWTP, near the Granite Reef Dam, and in scattered areas around gravel mining operation ponds that have been abandoned or are not routinely cleared of vegetation. Emergent wetlands in the project study area are dominated by obligate wetland species including cattails, tule, dock, and knotweeds.

Wildlife

Emergent wetlands support high-quality wildlife habitat, and support a large diversity of wildlife species. In addition, the federal- and state-listed Yuma clapper rail has historically been recorded in small numbers in the emergent wetlands found along the Salt River above and below Phoenix (Monson and Phillips 1981). Other species known to occur in emergent wetland habitat in the project study area include great blue heron, black-crowned night-heron, cinnamon teal, black-bellied whistling duck, mallard, northern pintail, western sandpiper, spotted sandpiper, and marsh wren (Jones & Stokes 2000).

Many other migratory waterfowl, shorebirds, and wading birds are expected to use emergent wetlands in the project study area. Terrestrial wildlife species expected to use the emergent wetlands include bobcats, raccoons, coyotes, muskrats, and ground squirrels.

4.3.2.6 Low-Flow Channels

Vegetation

Low-flow channels in the Salt River have been almost entirely eliminated, occurring in less than 1% of the project study area near the Granite Reef Dam. Vegetation, when present, consists of Bermuda grass, salt heliotrope, and sedges.

Wildlife

Although, low-flow channels within the project study area can attract waterfowl and migatory birds, because of their small size and poor quality these channels do not represent a significant value to wildlife. .

4.3.2.7 Open Water

Vegetation

Open water habitat is uncommon in the project study area, occupying less than 1% of the total area. For the purpose of this report, the open water cover type was separated into two subtypes: sand/gravel operation ponds and groundwater recharge basins. Vegetation is lacking within the sand/gravel operation ponds. The groundwater recharge basins, located north of the Mesa WWTP adjacent to the SR 101/202 interchange, contain a variety of submerged aquatic plant species. The basins are shallow but remain flooded most of the year through a constant input from the Mesa WWTP.

Wildlife

Open water habitat along the Salt River has high wildlife value. The open water habitat supports large numbers of water birds that feed or breed in the area. For example, during the 4-5 March 2002 and 2003 field reconnaissance, large numbers of water birds were observed feeding and roosting in several large open water features adjacent to the Pima Freeway (SR 101), including 12 species of ducks. Mallard and cinnamon teal are known to nest near open water habitats of Maricopa County (Witzeman et al. 1997), and may nest within the project study area. Aquatic snakes, amphibians, and turtles are likely to occur in some of the open water habitats.

Fish

Few quantitative and comprehensive inventories of fish species have been undertaken on the Salt River system (CH2M HILL et al. 1997). Fifteen native fish species and 29 introduced fish species have been recorded in the Salt River and Phoenix Canal systems (Marsh and Minckly 1982). Fish habitat in the region has been altered because of elevated nutrient levels in the WWTP effluent discharge. This has resulted in abundant growths of algae and emergent aquatic and submergent vegetation. Dissolved oxygen levels in the water column vary widely. If native fish species are still present in the Salt River system, their occurrence would likely be limited by low dissolved oxygen levels (CH2M HILL et al. 1997).

4.3.2.8 Parks and Recreation Areas

Vegetation

Parks and recreation areas occupy 2% of the project study area and include turf-covered lands used for activities such as golf and other recreation activities. These areas generally contain non-native ornamental trees and shrubs.

Wildlife

Parks and recreation areas, as they occur in the project study area, offer moderate wildlife value. Parks and golf courses planted with non-native ornamental trees and shrubs provide some foraging and roosting habitat for resident and migrating birds, and smaller manmade ponds may support waterfowl and fish. Wildlife species occurring in parks and recreation areas are expected to be similar to those found in urban areas and in close association with human activity. The rock dove, European starling, house finch, and house sparrows are among those species known to be common in parks and recreational areas.

4.3.2.9 River Bottom

Vegetation

The river bottom cover type was located in 1% of the total project study area. This cover type is largely unvegetated and is characterized by cobble in the active channel of the Salt River.

Wildlife

River bottom habitat provides low wildlife value because the vegetation is sparse or grows in clumps, but the habitat is used by many wildlife species for foraging or sunning. Many species of snakes and lizards use cobble habitats for sunning during the morning and evening. Cobble habitats often trap small fish and amphibian tadpoles as the river water recedes during spring or summer. These small fish and tadpoles then become prey for water birds (e.g., herons, egrets, and gulls), raccoons, skunks, and aquatic snakes.

Quailbush, found in the river bottom habitat, is used by many birds, mammals, and reptiles for feeding and cover. Many of the wildlife species that use river bottom habitat are also found in habitats associated with of sand/gravel operations.

4.3.2.10 Scrub-Shrublands

Vegetation

Scrub-shrublands are present within the active channel of the river and occupy 8% of the project study area. They are dominated by combinations of burro brush, rabbit brush, quailbush, saltbush, and occasionally by creosote bush. Many of these areas have been highly disturbed from Off-Highway Vehicle (OHV) traffic and mining activities and contain little or no vegetation cover. If the total vegetation cover was less than 10%, the area was mapped as unvegetated river bottom; if water was present, it was mapped as low flow channel.

Wildlife

Scrub-shrublands as they occur in the project study area, offer moderate wildlife value. The shrub and scrubland vegetation provides foraging and resting cover for small and medium-sized mammals, snakes and lizards, and various terrestrial birds including Gambel's quail, greater roadrunner, loggerhead shrike, curve-billed thrasher, and verdin.

4.3.2.11 Sand/Gravel Operations

Vegetation

Sand/gravel operations are common in the project study area, occupying 11% of the total area. Next to water diversion, these operations appear to be a large factor contributing to habitat alteration within the historic river channel. Because these operations are characterized by a large amount of disturbance in the active channel, vegetation is mostly lacking, but includes mostly weedy non-native species that tend to colonize quickly after disturbance.

Wildlife

Sand/gravel operations provide low wildlife value because the areas tend to be characterized by high human activity and disturbance from the operation of heavy equipment. Because the vegetation is sparse, there is little foraging or resting cover for wildlife species. Many of the wildlife species that use sand/gravel operations are also found in river bottom habitat.

4.3.2.12 Upland Buffer Zone

Vegetation

The upland buffer zone is uncommon in the project study area, occupying less than 1% of the project study area. A mixture of non-native and native species on the upper terrace and floodplain of the river characterize the upland buffer zone. Within the project study area, the presence of upland buffer zone is highly variable depending on the level of disturbance from urban, agricultural, and industrial uses. Typical species associated with this zone include mesquite, rabbit brush, acacia, blue paloverde, creosote, saltcedar, and tree tobacco.

Wildlife

The upland buffer zone supports many of the wildlife resources of the desert habitats, and provides low to moderate wildlife value because of its lack of abundance and its proximity to disturbed habitats. Although the upland buffer zone area supports good plant diversity and structure, it is not an abundant habitat type within the project study area.

4.3.2.13 Urban Areas

Vegetation

Urban areas are common in the project study area occupying 17% of the total area. Major land uses include residential, commercial and industrial uses. Generally, non-native ornamental plants and small patches of turf dominate urban areas.

Wildlife

Urban areas have low wildlife value because they provide minimal cover and food sources. Wildlife species often using urban areas include northern mockingbird and mourning dove, in addition to those species known to be common in parks and recreational areas. Urban areas tend to support wildlife species with high tolerances to human activity and disturbance. Medium-sized mammals adapted to take advantage of urban areas include opossum, raccoon, striped skunk, and coyote.

4.3.2.14 Ruderal

Vegetation

Ruderal areas are common in the project study area occupying 4% of the total area. These areas are characterized by a highly disturbed surface with little or no vegetation cover. Characteristic species found in this habitat include introduced annual plant species, including London rocket and filaree, and scattered native shrubs (saltbush, creosote, and burro brush) and non-native shrubs, including Russian thistle.

Wildlife

Ruderal areas have low wildlife value because they provide minimal cover for foraging and resting. Because of the open nature of ruderal areas, raptors such as white-tailed kite, red-tailed hawk, and American kestrel are commonly found hunting in these habitats.

One raptor species able to utilize the flatter ruderal habitats is the western burrowing owl. Until the early eighties, western burrowing owl was common along the north bank of the Salt River, however housing and industrial development, and high OHV use in former western burrowing habitat have made it increasingly uncommon in Maricopa County. (Witzeman et al. 1997.) Three western burrowing owls were observed in ruderal habitat in the project study area during the March 2002 field reconnaissance. None were seen during the March 2003 field reconnaissance.

4.3.3 HGM MODELING RESULTS

As part of the plan formulation process, the Corps selected the Hydrogeomorphic (HGM) assessment modeling method to quantify the anticipated habitat benefits that would be gained or lost by implementing each of the proposed ecosystem restoration alternatives for the Va Shly'ay Akimel project area. Although HGM was originally developed as a tool for classifying and evaluating wetlands, it has been recognized that the functional approach of this method is also applicable to areas associated with aquatic habitats that may not be wetlands, such as many riparian systems. HGM consists of a classification phase and an assessment phase. It groups wetland or riparian systems on the basis of three criteria: 1) geomorphic setting, 2) water source, and 3) hydrodynamics, chosen because these criteria are assumed to fundamentally influence how the systems function. "Geomorphic setting" refers to the landform and position of the wetland system in the landscape (e.g., a depression in the middle of a watershed). "Water source" refers to the primary water source that supports the system (e.g., precipitation, overbank flooding, or groundwater). "Hydrodynamics" refers to the level of energy and the direction that water moves in the system (e.g. the level of energy in a riverine floodplain is generally higher than in an isolated wetland and its movement is generally downstream). The resulting riverine wetland subclasses used for this project are all associated with low gradient perennial and ephemeral river systems in Arizona.

HGM assessment areas are called Partial Wetland Assessment Areas, or PWAAs. The basic difference between a PWAA and a vegetation cover type is that a PWAA has a functioning hydraulic connection to the ecosystem. For example, a mesquite bosque that is now separated from the river by a levee and therefore is no longer inundated by large flood events, is still a mesquite cover type but is not a PWAA. The dominant vegetative cover types used within the PWAAs included cottonwood/willow, emergent wetland, mesquite, scrub-shrub (Lower Sonoran Desert) and river bottom. River bottom was defined as the active channel and included pool/riffle aquatic areas, and open areas characterized by sand, cobble, and/or gravel. Table 4.3-2, which follows, identifies the baseline PWAAs incorporated in the HGM analysis for this project.

The assessment phase of HGM evaluates the ability of a wetland system to perform a number of functions. In HGM, functional value is defined in terms of Functional Capacity Units (FCUs). An FCU considers both quality (how well a particular wetland performs a particular function) and quantity (acreage of the wetland).

Table 4.3-2. PWAA Description

	Baseline Acres (TY0)
Farms and Croplands - Dairy, Cotton, and Alfalfa	249.7
Existing Buffer Zones - Mesquite, Ironwood, Rabbit brush, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0
Existing Cottonwood-Willow Forests in the Active Channel	69.5
Desert Areas - Bare Earth, Cacti, Rabbit brush, Acacia	961.9
Ditches	56.5
Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.1
Newly Planted Upland Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Rabbit brush, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0
Newly Planted Cottonwood-Willow Forests in the Active Channel	0
Newly Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0
Newly Developed Open Water Areas in the Active Channel	0
Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0
Newly Planted Scrub-Shrublands in the Active Channel	0
Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.5
Parks and Recreation Areas	9.6
Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.6
Existing Sand and Gravel Operations/Extractions in the Active Channel	1,651.6
Existing Scrub-Shrublands in the Active Channel - Rabbit brush, Quailbush, Ironwood, and Saltbush	2,057.1
Existing Soil Cement Areas on the Slopes of the Active Channel	33.9
Existing Residential, Industrial and Transportation Avenues	341.6
TOTAL	5,870.6

The quality of the wetland system's functional performance is measured in terms of a Functional Capacity Index (FCI). An FCI is the ratio of the functional capacity of a wetland under a particular existing, or predicted, condition (rated 0 to 1) and the functional capacity of a wetland under highest sustainable conditions (rated 1). In other words, an FCI indicates how well a particular wetland area actually performs a particular function, compared to how the "best wetland" of the region would perform that same function. The FCI value is then multiplied by the acreage of the PWAA to determine the FCUs provided by the PWAA for a particular

function. Ten functions were analyzed for the Va Shly'ay Akimel project. Annualized FCUs (AAFCUs) for each function were calculated by summing FCUs across all years in the period of analysis and dividing the total by the number of years in the life of the project. Finally, for each alternative, an average of all AAFCUs of all functions was computed by adding the AAFCUs together and dividing by the number of functions (10). The resulting number was then used to compare how the functional capacity or quality of the study area ecosystem would change over time with different alternatives. Existing conditions in the Va Shly'ay Akimel study area were estimated to have a total of 812 AAFCUs (averaged across all functions). Assuming no project is implemented at Va Shly'ay Akimel, the total FCUs are expected to decline to 709 units in 20 years and to 705 units in 50 years.

The HGM analysis report is included as an appendix to the feasibility study.

4.3.4 SPECIAL-STATUS SPECIES

Special-status animals are species in the following categories:

- animals listed or proposed for listing as threatened under the federal Endangered Species Act (ESA) (50 CFR 17.11 [listed animals] and various notices in the Federal Register [proposed species])
- animals listed or proposed for listing as endangered under the federal Endangered Species Act (ESA) (50 CFR 17.11 [listed animals] and various notices in the Federal Register [proposed species])
- animals that are candidates for possible future listing as threatened or endangered under the federal ESA (66 FR 54808, October 30, 2001)
- wildlife species of special concern to the AGFD (Arizona Game and Fish Department 1996)

The following discussions and Table 4.3-3, which follows, summarize the habitat requirements and distribution of the ten special-status wildlife species that potentially occur in the project study area: lowland leopard frog, desert tortoise, Mexican garter snake, bald eagle, peregrine falcon, Yuma clapper rail, cactus ferruginous pygmy owl, western yellow-billed cuckoo, southwestern willow flycatcher, and lesser long-nosed bat. No special-status species have been recorded in the project study area (CH2M HILL et al. 1997).

Table 4.3-3. Special-Status Species That Could Occur or Are Known to Occur in the Va Shly'ay Akimel Study Area

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Lowland leopard frog *Rana yavapaiensis*	--/WC	Occurs below 5,500 feet in elevation, south and west of Mogollon Rim.	Permanent streams, generally avoids ponds; prefers streams with willows and cottonwoods or emergent vegetation.	Predation and competition from non-native fish and amphibians and from stream alteration and flow diversion	The project study area is in the lowland species' geographic range. Areas along the Salt and Rivers appears to be suitable habitat, but there are no recent records.
Desert tortoise *Gopherus agassizii*	--/WC	Occurs across much of Arizona's Sonoran Desert, including the Phoenix area.	Desert areas from 300 to 900 feet with sandy loam to gravelly soils for digging dens; favors cactus scrub habitats with high densities of annual blooms in spring for feeding.	Loss of habitat from urban development, habitat alteration and direct mortality from off-road vehicle use, cattle grazing, and predators, respiratory disease	Small sections of the upland areas in the project study area appear to be potential habitat; could potentially occur in the project study area.
Mexican garter snake *Thamnophis eques*	--/WC	Occurs in permanent marshes in south-central and southeastern Arizona.	Strongly aquatic, and feeds on aquatic animals, including fish and amphibians.	Loss of wetland habitats and because of competition and predation from non-native fish and bullfrogs	Suitable wetland habitat is present along the Salt River; could potentially occur in the project study area.

1426

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Bald eagle *Haliaeetus leucocephalus*	T/WC	Nesting occurs along the Verde and Salt Rivers; also nests along the Agua Fria and Gila Rivers; wintering occurs along rivers and lakes where suitable habitat occurs.	Occurs along large rivers and lakes for nesting and wintering; requires large trees, cliffs, or pinnacles for nesting.	Human disturbance at nesting and wintering sites; loss of suitable nesting sites, and pesticides	Not known to nest in the project study area, although individuals occur in the area as winter visitors and migrants; observed foraging along the rivers in the project area. Open water, marshes, constructed wetlands, and fields in the project study area are suitable foraging habitats.
Yuma clapper rail *Rallus longirostris yumanensis*	E/WC	Occurs in cattail and bulrush marshes along the Colorado River; the lower Gila and Salt Rivers below the Verde/Salt River confluence; and Picacho Reservoir.	Marsh and riparian habitats.	Loss and fragmentation of river marshes; toxic levels of heavy metals, such as selenium, could also have contributed to the species' decline	Salt River support suitable habitat; known to occur in areas of suitable habitat along the Gila River.

1427

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Southwestern willow flycatcher *Empidonax trailii extimus*	E/WC	Nests in dense willow riparian habitats along the lower Big Sandy River, lower Santa Maria River, Bill Williams Delta, upper Gila River, Grand Canyon, and middle Salt River; historically nested along the Salt, Gila, and Agua Fria Rivers.	Riparian forest and scrub habitats.	Has declined for variety of reasons, including habitat loss and fragmentation from flood control projects, development, and intensive grazing; brown-headed cowbird nest parasitism could also have contributed to the species' decline	Habitat quality along the Salt River is considered marginal, because the cottonwood-willow habitat is narrow and fragmented, although still considered suitable for the species; no nesting southwestern willow flycatchers have been observed, although migrating birds have been observed.
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	--/WC	Summer resident only in central and southern Arizona.	Nests in mature cottonwood-willow riparian forests; saltcedar can be a component of their habitat.	Degradation and loss of mature riparian habitat.	Salt and Gila Rivers support suitable habitat; known to occur in areas of suitable habitat along the Gila River.
Cactus ferruginous pygmy owl *Glaucidium brasilianum cactorum*	E/WC	Historically occurred as far north as the confluence of the Salt and Verde Rivers.	Occurs in dessert scrub and riparian areas with mature cottonwood and willows; nests in cavities created by woodpeckers.	Loss of habitat from urban development; competition from other cavity-nesting birds	The are no recent records from the project study area, but small amounts of habitat which could support this species do occur in the project study area.

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Lesser long-nosed bat *Leptonycteris curasoae yerbabuenae*	E/WC	Summer resident of central and southeastern Arizona.	Roosts colonially in large numbers; feeds on agave and saguaro flower nectar and pollen.	Has declined because of human disturbance at breeding and roosting sites and habitat loss; the population appears stable	Habitat quality appears to be low in the project study area; no systematic surveys have been conducted in the project study area; this species was recorded upstream of the Salt River/Gila River confluence, north of the Salt River.

* Status explanations:

Federal

E = listed as endangered under the federal Endangered Species Act.

T = listed as threatened under the federal Endangered Species Act.

-- = no listing.

State

WC = wildlife species of concern in Arizona (Arizona Game & Fish Department).

1429

4.3.4.1 Federally Listed Species

Of the ten special-status species with the potential to occur in the project study area, bald eagle, Yuma clapper rail, cactus ferruginous pygmy owl, southwestern willow flycatcher, and lesser long-nosed bat are federally listed and the western yellow-billed cuckoo is a Candidate for listing.

Bald Eagle

The bald eagle was reclassified as Threatened under the federal ESA in 1995. In July 1999, the bald eagle was proposed for delisting. Bald eagles nest in large trees near lakes and streams, and hunt for waterfowl and fish in wetlands and along rivers and lakes. Bald eagles have been reported nesting along the Salt River east of Phoenix since the 1930s (Witzeman et al. 1997). Bald eagles do not nest in the project study area, although they occur in the area as winter visitors and migrants (Benham-Blair Associates 1980). Bald eagles have been observed foraging along the rivers in the project study area (CH2M HILL et al. 1997). The open water marsh in the project study area may be suitable foraging habitat for bald eagles.

Yuma Clapper Rail

The Yuma clapper rail is federally listed as endangered under the federal ESA and is on the draft review list of the wildlife of special concern in Arizona (Arizona Game and Fish Department 1996). This inland clapper rail occurs in cattail, sedges, and bulrush marshes along the Colorado River, the lower Gila and Salt Rivers below the Verde/Salt River confluence, and Pichacho Reservoir (Arizona Game and Fish Department 1996, Eddelman and Conway 1998). This species has declined because of the loss and fragmentation of river marshes. Toxic levels of heavy metals, such as selenium, could also have contributed to the species' decline (Arizona Game and Fish Department 1996). The Yuma clapper rail is known to occur as a rare and local summer resident in cattail marshes in the Salt River south and west of Phoenix (Witzeman et al. 1997). There is sufficient habitat for this species to occur within the project study area.

Cactus Ferruginous Pygmy-Owl

The cactus ferruginous pygmy-owl is federally listed as endangered under the federal ESA. Historically, the cactus ferruginous pygmy-owl occurred as far north as the confluence of the Salt and Verde Rivers. This species occurs in desert scrub, mesquite bosques, and Sonoran riparian deciduous woodland areas with mature cottonwood and willows. This small owl nests in cavities created by woodpeckers. The species has declined because of urban development, reduction of suitable habitat, and competition from other cavity-nesting birds (Arizona Game and Fish Department 1996, Arizona Game and Fish Department 2001a). No observations of cactus ferruginous pygmy-owls have been recently recorded within 50 miles of the project area (CH2M HILL et al. 1997, Witzeman et al. 1997).

Southwestern Willow Flycatcher

The southwestern willow flycatcher is federally listed as an endangered species under the federal ESA and is on the draft review list of wildlife of special concern in Arizona (Arizona Game and Fish Department 1996). The southwestern willow flycatcher prefers nesting in dense willow riparian habitats and is also found in areas of saltcedar in the Sonoran Life Zone (e.g., the lower Big Sandy River, lower Santa Maria River, Bill Williams Delta, upper Gila River, Grand Canyon, and middle Salt River). Historically, the southwestern willow flycatcher nested along the Salt, Gila, and Agua Fria Rivers (CH2M HILL et al. 1997). Recent statewide surveys indicate that most sites are occupied by fewer than five nesting pairs, which has raised concern over their population status in Arizona. This species has declined for a variety of reasons, including habitat loss and fragmentation resulting from flood control projects, development, and intensive grazing. Brown-headed cowbird nest parasitism may also have contributed to the species' decline (Arizona Game and Fish Department 1996). This species is currently considered an uncommon transient in Maricopa County, with only a few historic summer records (Witzeman et al. 1997). With an area estimation of more than 70 acres of willow, cottonwood/ willow, and willow/saltcedar habitat in the project study area, there is potential for this species to occur.

Western Yellow-billed Cuckoo

This species a candidate for listing as threatened under the federal ESA. In Arizona, the western yellow-billed cuckoo is found locally in streamside cottonwood and willow groves, and prefers to nest in willow or mesquite thickets (Arizona Game and Fish Department 2001b). As many as 13 cuckoo territories were found within the project study area during recent surveys on adjacent project study areas. These territories occurred within or adjacent to the cottonwood/willow riparian areas. The western yellow-billed cuckoo is considered an uncommon local summer resident (Witzeman et al. 1997).

Lesser Long-Nosed Bat

The lesser long-nosed bat is federally listed as endangered under the federal ESA. This bat is a summer resident of central and southeastern Arizona. It roosts colonially in large numbers, occupying mines and caves at the bases of mountains. The lesser long-nosed bat is found in habitats that support agaves, yuccas, saguaros, and organ pipe cacti (Harvey et al. 1999), and feeds mainly on agave and saguaro flower nectar and pollen. The lesser long-nosed bat population has declined because of human disturbance at breeding and roosting sites and habitat loss; however, the population appears stable (Arizona Game and Fish Department 1996). There are records for this species from the Phoenix area, so it could potentially occur in the project study area.

4.3.5 OTHER SENSITIVE SPECIES

Of the ten special-status species with the potential to occur in the project study area, lowland leopard frog, desert tortoise, Mexican garter snake, and peregrine falcon are considered by the State of Arizona to be species of special concern.

Lowland Leopard Frog

The lowland leopard frog was classified as a Category 2 Candidate species in 1988. In 1996, the USFWS changed listing status of "Federal Candidate" species. This classification formerly included three subclassifications: Federal Candidate Category 1, Category 2, and Category 3. During this administrative action, all references to "Category" designations were dropped. All former Category 1 species were now identified as Candidate Species. Species previously listed as a Federal Candidate Category 2 or 3 species were no longer considered Federal candidate species, and so no longer had any Federal protection under "Candidate" listing (Federal Reg., Feb. 28, 1996). In 1996 the USFWS classified all former Category 2 species as "Species of Concern." The lowland leopard frog was listed as wildlife of special concern in Arizona by the AGFD in 1996.

The lowland leopard frog occurs below 5,500 feet in elevation, south and west of the Mogollon Rim (Arizona Game and Fish Department 1996). This species is restricted to permanent streams, and it generally avoids ponds or other aquatic habitats. It usually occurs in streams with willows and cottonwoods or emergent vegetation (bulrushes and cattails) (Stebbins 1954). The central Arizona population appears to be healthy, but the lowland leopard frog has disappeared from the lower Gila River and lower Colorado River system. This species probably has declined for a variety of reasons, including predation and competition from non-native fish and amphibians and from stream alteration and flow diversion (Arizona Game and Fish Department 1988, 1996).

Desert Tortoise

The desert tortoise is listed as wildlife of special concern in Arizona (Arizona Game and Fish Department 1996) and is a federal species of concern. This tortoise occurs across much of Arizona's Sonoran Desert, including the Phoenix area. The Sonoran Desert tortoise population in the Tucson and Phoenix areas has declined because of urban and agricultural development, road construction, wildfires, illegal collection, and use of off-road vehicles in unauthorized areas (Arizona Game and Fish Department 1996).

Mexican Garter Snake

The Mexican garter snake is listed as wildlife of special concern in Arizona (Arizona Game and Fish Department 1996) and is a federal species of concern. This species occurs in permanent marshes in south-central and southeastern Arizona. It is strongly aquatic and feeds on aquatic animals, including fish and amphibians. This garter snake has declined because of the loss of

wetland habitats and competition and predation from non-native fish and bullfrogs (Arizona Game and Fish Department 1996).

Peregrine Falcon

The peregrine falcon is on the draft review list of the wildlife of special concern in Arizona (Arizona Game and Fish Department 1996). Peregrine falcon occurs in small numbers, and is found nesting on cliffs throughout the state. It is found sparsely in migration, and occasionally winters along the Colorado River. The Arizona population of peregrine falcon declined in the 1950s and 1960s and the rest of the U.S. due to DDT contamination. Additionally, increased development forced the peregrine falcon to nest in sub-optimal habitat. (Arizona Game and Fish Department 1998b.) Since the late 1970s, the peregrine falcon has been increasing in the Phoenix area, and is known to nest on cliffs along the Salt River east of the project study area (Phillips et al. 1964, Witzeman et al. 1997.)

4.3.6 FISH AND WILDLIFE COORDINATION ACT

The Fish and Wildlife Coordination Act (FWCA) provides the basic authority for the USFWS' involvement in evaluating impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive equal consideration to other project features. It also requires that federal agencies that construct, license, or permit water resource development projects must first consult with the USFWS (and the National Marine Fisheries Service in some instances) and state fish and wildlife agency regarding the impacts on fish and wildlife resources and measures to mitigate these impacts. Full consideration is to be given to USFWS recommendations (http://www.fws.gov/r9dhcbfa/fwca.htm).

4.3.6.1 Planning Aid Letter

At the request of the Corps, the USFWS has completed a Planning Aid Letter (PAL) dated June 11, 2002 that represent their preliminary evaluation of potential environmental effects and habitat benefits associated with the proposed project. This PAL was developed based on coordination with the Arizona Game and Fish Department, literature research, file reviews and the Corps' Section 905(B) Analysis. A copy of this letter can be found in the FWCA appendix to this EIS (Appendix E).

4.3.6.2 FWCA Report

The USFWS issued a FWCA Section 2(B) report representing their evaluation of the project pursuant to the Fish and Wildlife Coordination Act. Within this report, the USFWS provides comments, including recommendations, on portions of the project that are related to biological resources. This report can be found in Appendix E.

4.3.7 BIOLOGICAL ASSESSMENT

In accordance with Section 7 of the ESA, the Corps has entered into consultation with the USFWS on the impacts of the proposed project on the bald eagle, southwestern willow flycatcher, Yuma clapper rail, cactus ferruginous pygmy-owl, and California brown pelican. As part of the consultation process, the Corps has completed a Biological Assessment, a copy of which can be found in Appendix F. A copy of the Section 7 concurrence letter issued by the USFWS is also included in Appendix F.

4.3.8 SAFE HARBOR AGREEMENT AND CANDIDATE CONSERVATION AGREEMENT

As part of follow-on activities related to the proposed project, the Corps and the project sponsors (SRPMIC and the City of Mesa) will be completing a Safe Harbor Agreement in relation to the southwestern willow flycatcher and Yuma clapper rail, and a Candidate Conservation Agreement in relation to the yellow-billed cuckoo. Information regarding these types of agreements is available on the USFWS website, www.fws.gov.

4.4 CULTURAL RESOURCES

4.4.1 REGULATORY SETTING

There are two principal methods of locating cultural resources. Before starting a project, a records and literature search is conducted at any number of repositories of archeological site records. The search may show that an archeological, or historical survey had been conducted and some cultural resources were identified. That information may be enough to proceed with the significance evaluation stage of the project. If a conclusion is reached that (1) no previous survey had been done, or (2) a previous survey was either out of date or inadequate, the project cultural resources expert, an archeologist, will need to carry out a pedestrian surface survey to determine if any cultural resources are within the proposed project boundaries.

After a cultural resource(s) has been identified during a survey or record and literature search the Federal Agency overseeing the undertaking embarks on a process that involves determining if the cultural resource is eligible for listing in the National Register of Historic Places (National Register). Section 106 of the National Historic Preservation Act mandates this process. The Federal Regulation that guides the process is called 36 CFR 800. For a cultural resource to be determined eligible for listing in the National Register it has to meet certain criteria. The resource has to be either minimally 50 years old or exhibit exceptional importance. After meeting the age requirement, cultural resources are evaluated according to four criteria: a, b, c, and d. The National Register criteria for evaluation as defined in 36 CFR 60.4 are:

> The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and (a) that are associated with events that have made a significant contribution to the broad patterns of our history; or (b) that are associated with the lives of persons significant in our past; or (c) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or (d) that have yielded, or may be likely to yield, information important in prehistory or history.

After a cultural resource has been determined eligible for inclusion in the National Register it is accorded the same level of protection as a property that is included. It then becomes formally known as a "historic property" regardless of age. Historic property status may be applied to individual cultural resources or to a group of cultural resources that are united by a theme or context. The combined historic properties are then designated as either a historic or archeological "district" and the individual elements are called contributors.

Local prehistory and history are summarized here in order to provide a context for further discussion of the known archaeological and historical remains within the project area. The prehistoric overview is summarized from Doyel (1991), and the historic era from Furlong

(1997), Mesa Unified School District (1978), and Zarbin (1997). Other sources are cited as appropriate.

4.4.2 EARLY PREHISTORIC CULTURES

The earliest evidence of man in Arizona dates to the Paleoindian period, beginning near the end of the last Ice Age about 11,000 years ago. Big game was abundant in the wetter, cooler climate of that period, and early human cultures adopted a mobile, hunting- and gathering-based lifestyle. Paleoindian artifacts have been found in southeastern Arizona associated with the remains of mammoth and other extinct Ice Age fauna (Haury et al. 1959). However, no such discoveries have been made in the Salt River Valley.

The subsequent Archaic period, dating between approximately 7000 B.C. and A.D. 150, was characterized by fluctuating climatic conditions, with alternating periods of increased and decreased moisture. Changes in environmental conditions led to changing subsistence strategies for Archaic period populations, with a decrease in big-game hunting and increasing reliance on small game and gathered foods such as fruits, nuts, seeds, and berries. Mobility remained important so that small groups could utilize seasonally-available resources in diverse environmental settings.

The Archaic tradition in southern Arizona is best-known from sites in and around the Tucson basin, and in the river valleys of southeastern Arizona (Mabry 1998). Bruce Huckell (1984:205–209; 1994:3–5) proposes three temporal subdivisions for the Southwestern Archaic. The Early Archaic period (ca. 7000–4800 B.C.) is characterized by simple flaked stone and ground stone tools consistent with a hunting and gathering economy. The Middle Archaic (ca. 4800–1500 B.C.) artifact assemblage is more diverse, and includes several types of projectile points as well as the first appearance of deeply-worn basin metates and stone pestles used for crushing and pounding plant foods. The Late Archaic (ca. 1500 B.C.– A.D. 150) was a transitional period tied to the introduction of maize into the Southwest from Mesoamerica. Mabry (1998:87) suggests that agriculture had spread across the Southwest by about 900 B.C., and that the earliest agricultural villages were established by about 800 B.C. Hunting and gathering remained important, but the adoption of agriculture led to the development of sedentary village life and a host of technological and social innovations associated with this new lifestyle. Evidence from in and around the Phoenix basin suggests Middle and Late Archaic use of the uplands surrounding the valley (Hackbarth 2001; Wright 2002), but relatively few Archaic remains have been found on the valley floor adjacent to the Salt River.

4.4.2.1 The Hohokam

Sometime after about A.D. 100, the Hohokam culture became a recognizable entity in the river valleys of central and southern Arizona. The origins of this sedentary agricultural society are a subject of continuing debate (summarized in Crown 1991), but recent evidence suggests an *in situ* development out of Archaic period patterns (Mabry 1997; Whittlesey 1995) rather than immigration of a Mesoamerican group (Haury 1976). Hohokam villages were typically located

along or near large permanent streams, and were supported by extensive agricultural fields and intricate canal systems. This new settlement/subsistence system was accompanied by the widespread adoption of ceramic technology, pithouse architecture, cremation of the dead, and a variety of other distinctive traits reflected in the archaeological record. The Hohokam are best known from intensive studies at the very large site of Snaketown, along the Gila River about 20 miles south of Phoenix (Gladwin et al. 1937; Haury 1976). The Hohokam chronology established at Snaketown is still in use today, although starting and ending dates—particularly towards the early end of the sequence—remain controversial. A summary of the Hohokam chronology, applying Dean's (1991) dates to the basic Snaketown sequence, is provided in Table 4.4-1. This is followed by a brief discussion of the major characteristics of each period and phase in the Salt River Valley, summarized from Doyel (1991). (It should also be noted that most archaeologists familiar with the Hohokam chronology make a broad distinction between the Classic period and all earlier periods by referring to the Pioneer, Colonial, and Sedentary periods collectively as "the pre-Classic.")

Table 4.4-1. Hohokam Chronology

Period	Phase	Probable Time Range (Years A.D.)
Pioneer	Red Mountain	? to ca. 300
	Vahki	ca. 300 to 500
	Estrella	500s
	Sweetwater	600s
	Snaketown	700s
Colonial	Gila Butte	ca. 775 to 850–900
	Santa Cruz	850–900 to 950–1000
Sedentary	Sacaton	950–1000 to 1100–1150
Classic	Soho	1200 to 1300–1350
	Civano	1300–1350 to ca. 1500

Source: Dean 1991.

4.4.2.2 Pioneer Period (?–ca. 775)

This initial period of Hohokam development appears to involve an *in situ* transition from the Late Archaic lifestyle to a more sedentary, agriculture-dependent way of life. Ceramics first appeared during the Red Mountain phase, and the early plainware assemblages grew to include redwares, red-on-gray, and red-on-buff types. Pithouse architecture became more varied, and villages developed more complex and formal layouts. Burial patterns shifted from predominantly inhumation to predominantly cremation. Hunting and gathering remained important, but the Hohokam also experimented with complex water control systems that made large-scale irrigation agriculture possible. The Snaketown phase, at the end of the Pioneer period, was "a time of rapid change and growing cultural complexity" (Doyel 1991:247) as red-on-buff pottery replaced the earlier red-on-gray styles, ceramic vessel forms and designs

became more diverse, and irrigation systems expanded to make new lands available for settlement and farming. The presence of ceramic figurines, slate palettes, carved stone bowls, and other ritual or ceremonial items suggest growing social complexity during the Pioneer period. The presence of shell jewelry manufactured from species found in the Gulf of California, and trade goods from Mesoamerica and areas to the north and northeast, also indicate that the Hohokam were active participants in a regional exchange network.

4.4.2.3 Colonial Period (ca. 775–950/1000)

This period saw a tremendous expansion in the number, size, type, and complexity of Hohokam sites in and around the Phoenix basin. Villages were generally organized into house clusters centered on public plazas. Large caliche-capped trash mounds, communal pit ovens called *hornos*, and formal cremation cemeteries were also present. Many of the largest villages contained ballcourts, large oval depressions with earthen embankments believed to be associated with a Mesoamerican-derived game. Many smaller villages and limited-use sites associated with subsistence activities were also established during this period. Canal systems were expanded, and there was an increase in the use of dry-farming techniques away from irrigable lands. Red-on-buff ceramic design styles, and trade items such as macaws and copper bells, reflect a strong Mesoamerican influence, although trade with other cultures in northern and eastern Arizona also remained important. By the end of the Santa Cruz phase, Hohokam sites had been established in a wide variety of environmental settings throughout central and southern Arizona. Outlying sites with Hohokam-like characteristics, as far away as the Payson and Prescott areas, may reflect the incorporation of local cultural traditions into the Hohokam interaction sphere.

4.4.2.4 Sedentary Period (950/1000–1100/1150)

This period witnessed an intensification of patterns established during the preceding Colonial period. New villages were established, older villages grew in size, new ballcourts and canals were constructed, and the Hohokam seem to have reached new heights of social and economic complexity reflected in increased, possibly hierarchical distinctions between sites. Red-slipped plainwares, not manufactured since the Pioneer period, also made a reappearance, and the large caliche-capped trash mounds at some villages appear to have evolved into deliberately-constructed "platform mounds" that served as a form of public architecture possibly associated with ceremonial activities. Based on the size and number of villages, the complexity of the settlement/subsistence system, and the extent of Hohokam influence and interaction across a broad region, this period appears in some ways to represent the greatest florescence of the Hohokam culture. Compared to the Colonial period, however, there were relatively few changes in material culture, and Sacaton phase red-on-buff pottery designs are generally less well-executed than earlier styles.

4.4.2.5 Classic Period (1200–ca. 1500)

The Sedentary-to-Classic period transition, while not well understood, appears to have been a time of fundamental changes possibly related to environmental stress. Detailed climatic reconstructions indicate that the Salt River underwent a period of "marked and rapid variation" in streamflows between about A.D. 1200 and 1355 (Nials et al. 1989:69). This would have created difficulties in the operation and maintenance of the irrigation systems upon which the Hohokam were, by then, heavily dependent. It is also known, however, that broad-scale changes in demography, social organization, regional interaction, technological innovations, and sociopolitical systems occurred across most of the prehistoric Southwest during this same time period (Cordell and Gumerman 1989; Gumerman 1994). Environmental factors, while undoubtedly of major importance, should therefore not be considered the only potential agents of change in the Hohokam area.

Most of the familiar Hohokam traits disappeared or underwent radical changes during the Classic period. Many large villages occupied throughout earlier periods (including the site of Snaketown) were abandoned, while others remained viable and even grew in size. New villages were also established, often on the outer edges of expanding canal systems (Howard 1991:5.19). Dispersed, rural populations and small villages aggregated into very large communities, usually located close to the Salt River or some other major stream. Pithouses were largely replaced by surface structures of adobe or masonry arranged in walled compounds or roomblocks. Red-on-buff pottery declined in favor of redwares and polychromes, and inhumations from this period often outnumber cremations. Platform mounds replaced ballcourts as the principal form of public architecture and as the probable focus of integrative and ceremonial activities. Exchange and interaction patterns appear to shift from a Mesoamerican focus to a more northern and eastern orientation, particularly towards the Mogollon culture of upland eastern Arizona and western New Mexico. The appearance of Mogollon-like ceramic and architectural traits in the Hohokam area is often attributed to the Salado culture. The Salado were initially thought to have represented a peaceful "invasion" of the Hohokam homeland by Mogollon peoples (Haury 1945), but recent research suggests that the Salado phenomenon is linked to increased regional interaction, possibly based on a new religious ideology, rather than to the rise of a new culture or the dominance of one culture over another (Crown 1994).

The Classic period has traditionally been divided into two phases, the Soho and the Civano (Dean 1991; Haury 1976). The Hohokam culture, for reasons that may include both environmental and sociopolitical factors, declined throughout the Civano phase and died out by about A.D. 1450. Several recent archaeological projects have nevertheless found evidence for a third phase, termed the Polvorón, following the Civano phase. The Polvorón was a period of decreased population and socioeconomic reorganization for the Hohokam, marked in part by a reversion to pithouse architecture, abandonment or limited reoccupation of Civano phase sites, and a more dispersed settlement pattern (Chenault 2000; Sires 1984). The Polvorón phase is not well-dated, but it appears to fall somewhere between about A.D. 1350 and 1450. This implies that the Civano phase was both earlier and shorter in duration than is suggested by the traditional Hohokam chronology. In any event, the Hohokam had ceased to exist as a cultural entity sometime prior to A.D. 1500.

4.4.2.6 The Protohistoric/Early Historic Period

Little is known about Native American use of the Salt River Valley and adjacent areas during the Protohistoric period, between the Hohokam collapse at about A.D. 1450 and the first extended Spanish explorations of southern Arizona just prior to 1700. The Spanish encountered large groups of Pimas and related peoples in the Tucson Basin and in the Gila River valley south of Phoenix (Doelle 1981), but the Phoenix Basin appeared to have been essentially abandoned. Limited evidence for a very late Hohokam or very early Pima presence has recently been found near Sky Harbor Airport (Bostwick et al. 1996), but no large, permanent settlements are known in this area until the arrival of Anglo settlers in the late 1860s (Luckingham 1989). The Salt River Valley may have served as a buffer zone between the agricultural Piman groups to the south and west, and the hunting-and-gathering Yavapai and Apache groups to the north and east. The Apache, in particular, had a long history of raiding Piman villages, and the Phoenix area may have been a "no man's land" between these warring groups (Hackenberg 1974:132).

4.4.2.7 The Historic Period

Permanent Euroamerican occupation of the eastern Salt River Valley began with the small Hispanic settlement of San Pablo near the base of Tempe Butte in the late 1860s (Furlong 1997). A few years later, Charles T. Hayden established a Salt River crossing, a store, and a flour mill on the river's south bank. This location, first known as Hayden's Ferry, represents the founding of modern-day Tempe. By the end of the nineteenth century, Tempe was home to a normal school predecessor of today's Arizona State University—and was bisected by the Maricopa and Phoenix Railroad, completed in 1887 to link Phoenix with the transcontinental Southern Pacific line at Maricopa (Myrick 1980:498–502). A spur line from Tempe to Mesa was completed in 1895. Thus, early Tempe was important as a farming community, a center for higher education, and as a hub in the regional transportation system. Completion of Roosevelt Dam in 1911 tamed the Salt River and further facilitated settling in the area. Tempe's population consisted of only about 3,000 people as late as 1941. However, following World War II, population boomed with the advent of air conditioning and the influx of veterans attending college on the GI Bill. Subsequent decades saw continued growth, and Tempe's population today exceeds 160,000.

East of Tempe, other communities emerged on both sides of the Salt River. A location known variously as McDowell Crossing, Rowe's Station, and Maryville was established on the north side of the Salt River in the late 1860s (Adams et al. 1992; Granger 1983:388). In 1877, Mormon colonists from the Little Colorado River Valley passed through Maryville and established a new farming community, known as Lehi, on the south side of the river. A later group settled on the higher terrace south of Lehi, establishing the town of Mesa. Maryville was abandoned by 1880, but the Mormon towns thrived with the construction of new irrigation canals. By 1940, Mesa was well-known not only for its rich fields of cotton, alfalfa, lettuce, cantaloupes, grains, dates, and citrus, but also for the presence of an elaborate Mormon temple—one of only seven in the world at that time (Work Projects Administration 1940:350–351). Mesa's population has grown from slightly over 7,000 in 1940 to over 421,000 today.

The Salt River Pima-Maricopa Indian Reservation was established in 1879. The Pimas had migrated into this area from the middle Gila River valley, where upstream diversion of the water by Euroamerican farmers in the 1870s dried up the river and forced the native people to abandon their fields and homes (Spicer 1962). The Salt River provided a more reliable source of water, with no significant upstream users to deplete the flow. Despite the injustices done to them, the Pima traditionally maintained good relationships with Euroamerican groups. In addition to farming their own land, for instance, they assisted the Mormon immigrants in Lehi and Mesa in exchange for a portion of the land, and they provided much of the manual labor for other farmers and settlers in the eastern Salt River Valley. The reservation remains predominantly rural and agrarian today, although it is increasingly hemmed in by urban sprawl. Commercial leases and casinos now supplement Tribal income from the traditional agricultural sources.

Water management has always played a major role in the history of the Salt River Valley, and the present project area is no exception. Some of the earliest historic sites in the vicinity are irrigation canals branching off the Salt River: the Utah Ditch, constructed in Lehi in 1877; the Mesa Canal, built in 1879; and the Tempe Canal, begun in 1871 with numerous later extensions and branches (Aguila 1998). In the early twentieth century, a series of storage dams was constructed on the Salt and Verde rivers, beginning with Roosevelt Dam in 1911 and concluding with Horseshoe Dam in 1946. Controlled releases from the reservoirs were then diverted into canals by Granite Reef Diversion Dam, built just below the confluence of the Salt and Verde rivers in 1908. Two principal canals headed at Granite Reef: the Arizona Canal on the north, and the South Canal on the south. The Arizona Canal was originally dug between 1883 and 1885 to supply water to the north half of the Salt River Valley; it remains the longest (47 miles) and northenmost canal bringing Salt River water to the Phoenix area today (Aguila 1998). The South Canal (sometimes called the Southern Canal) was built between 1906 and 1908 to provide a unified head for all other canals south of the Salt River. These other canals—including the Consolidated Canal and the Tempe Canal—originally headed farther downstream, but these heads were repeatedly damaged by flooding, necessitating frequent repair and reconstruction. The South Canal provided a single, stable head for all existing and future canals irrigating lands south of the Salt River (Aguila 1998). More recently, the Hayden-Rhodes Aqueduct of the Central Arizona Project crossed the Salt River just below Granite Reef Diversion Dam. This aqueduct brings Colorado River water to central and southern Arizona for municipal, industrial, and agricultural uses.

4.4.3 EXPECTED SITE TYPES WITHIN THE PROJECT AREA

Because the Salt River was the only permanent water source in the Salt River Valley, human activities have been concentrated along and near the river for thousands of years. Thus, a broad range of prehistoric and historic resources is known to occur within the project area.

The project area includes, minimally, cultural remains dating from the earliest portion of the Hohokam sequence to the late historic period. For example, the Red Mountain Site, AZ U:10:2 (ASU), is the type site for the Red Mountain phase (ca. A.D. 1–300), which represents a poorly understood transition between the Archaic period and the Vahki phase of the Pioneer period (Morris 1969). This site is still partially intact (Aguila 1998:31), and as one of the oldest known

Hohokam sites in the Salt River Valley it could contain crucial information about the early human cultures of this area. The project area also includes very late (fifteenth century) Hohokam sites, several of which have platform mounds (e.g., AZ U:9:102 [ASM] in Hackbarth et al. 1995). A broad range of other Hohokam sites—canals, limited-activity areas, farmsteads, small and large villages (some with ballcourts), etc.—are also known to exist within the project area. Known historic sites include late nineteenth century and early twentieth century Pima and Euroamerican settlements, canals, roads, and structures.. The very early transitional period represented at the Red Mountain site suggests a pre-Hohokam occupation in the area that may not have been recognized as such by earlier researchers, or that may be buried under later alluvium or obscured by later Hohokam occupations. Recent discoveries of large, complex Archaic period agricultural villages in the Tucson Basin (Mabry 1997) have prompted a debate over whether such sites might exist in the Salt River Valley as well. The irrigable lower terraces adjacent to the Salt River in the eastern portion of the valley (e.g., the Lehi area and portions of the Salt River Pima-Maricopa Indian Reservation) would be likely locales for such sites.

An understanding of project area physiography is important to these patterns, so the pertinent data are briefly reviewed here. Apart from the dry riverbed itself, the project area landscape is dominated by four discrete alluvial terraces that flank the river. These terraces appear to have resulted from Late Cenozoic depositional episodes that were uplifted by tectonic action, and were later eroded through by the rejuvenated river (Péwé 1978). The terraces are listed and described in Table 4.4-2, and should be understood as representing a progression from the lowest, youngest, siltiest soils closest to the river (the Lehi Terrace) to the highest, oldest, most caliche-indurated soils farthest from the river (the Sawik Terrace). These terraces, their relationships, and their distinctive characteristics were crucial factors in both prehistoric and historic land use within the project area. In particular, the presence of good agricultural soils on the Lehi Terrace, and topographic conditions favorable for canal construction, would help determine the type and extent of settlement in the area for many centuries.

Table 4.4-2. Salt River Terraces within the Project Area

Name	Height Above River	Description
Lehi Terrace	5–20 ft	Silty/loamy Holocene soils closest to the river; excellent agricultural soils
Blue Point Terrace	10–80 ft	Gravel and cobbles slightly cemented with caliche. Dissected/ eroded terrace remnant, exposed only upstream from the Lehi area.
Mesa Terrace	10–220 ft	Caliche-indurated gravels, well-exposed except where covered by granitic alluvium from the Usery Mountains. Forms well-defined escarpment in northern Mesa; lower and less prominent in Tempe and on the north side of the river.
Sawik Terrace	50–235 ft	Heavily calichified gravel deposits, fragmentary and only intermittently exposed, most prominently near Granite Reef Dam. Decreases in height to the west, with westernmost portion buried by alluvium.

The archaeological data reveal a strong correlation of Hohokam canals and habitation sites with the edge of the Mesa Terrace. This natural escarpment provided a means, with careful engineering, of "lifting" water to the top of the terrace (i.e., contouring a channel along a horizontal distance such that the channel reaches the mesa top at a lower elevation than the channel's head). This allowed the Hohokam to irrigate new lands 50 feet or more above the riverbed. This patterning suggests high archaeological sensitivity, and a good potential for additional unrecorded sites, along the upper edge of the Mesa Terrace.

The Lehi Terrace contains relatively few known habitation sites, but it does contain numerous canals and small, probably agriculture-related sites. Although the Lehi Terrace would have been vulnerable to occasional flooding (this could be why the villages were located on higher ground), it would also have offered some of the best agricultural land in the valley. Thus, the Lehi Terrace should also be considered an archaeologically sensitive area, particularly for canals and for sites related to agricultural pursuits. As previously noted, this may also be a sensitive area for buried Archaic sites that have few, if any, surface manifestations.

The archaeological data are less clear for the Blue Point Terrace, an intermediate level between the Mesa and Lehi terraces in the portion of the project area east of Lindsay Road. Much of this terrace has been dissected by erosion or covered with granitic alluvium. Pending further data, the Blue Point Terrace should be considered at least moderately sensitive for the presence of unknown cultural resources.

The final and highest formation, the Sawik Terrace, exists solely as a few erosional remnants high above the river near Granite Reef Dam. Any sites in these areas would most likely be associated with limited, temporary use such as collecting cactus fruit or raw material for making stone tools. Archaeological sensitivity is believed to be moderate to low.

4.4.3.1 Records and Literature Search

An initial records and literature search was conducted of the larger overall study area. This study was conducted by Archaeological Research Services, Inc. (ARS)(Wright, et al 2002). The study area for the records search consisted of a 1-mile area on either side of the Salt River, between SR 101 and Granite Reef Dam. As a result of this study, 234 previously recorded sites were identified. These were inventoried from a review of 329 individual cultural resources surveys, test excavations, and data recovery projects. Although several resources have been previously evaluated, or determined to be eligible for the National Register of Historic Places (NRHP), only two were found to be formally listed on the NRHP. These are the Rohrig School and the Lehi School.

Site types inventoried includes a wide range of resources. Prehistoric sites include sparse lithic scatters, agricultural features, canals, habitation sites, limited activity sites, and village sites. Historic period sites include roads, buildings, homesteads, dams, construction camps, and canals.

4.4.3.2 Field Survey

Subsequent to the records and literature search, an intensive archeological field survey was conducted of an additional 1000 acres along the Salt River that had not been previously surveyed. The survey was also conducted by ARS, Inc. (Wright et al. 2003). The areas chosen for survey were generally in areas that might be used for the ecosystem restoration alternatives.

This survey resulted in the identification of 33 historic and prehistoric sites. In addition, three prehistoric canals were identified as potentially present, although no surface indications were noted. Of the 33 sites, 21 of them were evaluated as eligible for the National Register of Historic Places. The remaining 12 could not be evaluated based on survey information alone. See Table 4.4-3 for a brief description of each site and NRHP eligibility evaluation. Eligibility evaluations were based on areas of research potential developed by ARS.

Table 4.4-3. Archaeological Sites Evaluated for NRHP Eligibility in the Va Shly'ay Akimel Ecosystem Restoration Project Class III Cultural Resources Project Area

SRPMIC Site No.	Site Type*	Comments	NRHP Eligible**
60	P: habitation	Extension of previously recorded Hohokam village	Yes
61	P: artifact scatter	Hohokam artifact scatter in plowed field	Indet.
62	M: artifact scatter	Historic Pima/Maricopa artifact scatter and probable habitation site (late 19th/early 20th century) plus Hohokam artifact scatter	Yes
63	M: artifact scatter	Similar to SRPMIC-62, but probably has a more substantial prehistoric component	Yes
64	P: artifact scatter	Hohokam artifact scatter/possible small habitation site	Indet.
65	M: artifact scatter with features	Historic corral and Pima/Maricopa artifact scatter with an earlier Hohokam component	Indet.
66	M: artifact scatter	Mixed Pima/Maricopa and Hohokam artifacts	Indet.
67	H: artifact scatter	Pima/Maricopa artifact scatter	Indet.
68	M: artifact scatter	Mixed Pima/Maricopa and Hohokam artifacts	Indet.
69	M: artifact scatter with features	Hohokam artifact scatter/possible habitation site plus historic tent pads, trash dumps, artifact scatter and rock features of uncertain age	Yes
70	H: artifact scatter with features	Tent pads and trash scatters associated with canal construction	Indet.
71	H: artifact scatter	Historic construction camp with tent pads, trash dumps (early 20th century)	Yes

SRPMIC Site No.	Site Type*	Comments	NRHP Eligible**
72	P: habitation site	Pioneer–Colonial period Hohokam habitation site; type site for the Red Mountain phase; partially excavated in the 1960s by ASU	Yes
73	P: artifact scatter	Tested by ASU in the 1960s; probable Gila Butte phase habitation	Yes
74	P: artifact scatter	Tested by ASU in the 1960s; probable Colonial/Sedentary habitation	Yes
75	P: artifact scatter with features	Hohokam artifact scatter with one cobble structure, one ashy soil stain, and one check dam	Yes
76	M: artifact scatter with features	Probable Hohokam habitation with dense artifact scatter and several roasting features; also historic tent pads and trash scatters	Yes
77	M: artifact scatter with features	Historic tent pads and trash dumps, prehistoric artifact scatter, check dam of uncertain age	Yes
78	H: camp site	Historic tent pad(s) and trash scatter	Indet.
79	H: power plant	Hydropower plant associated with the South Canal; built 1911–1912	Yes
80	M: artifact scatter	Mixed historic and prehistoric artifacts	Yes
81	M: artifact scatter with features	Extensive historic construction camp with tent pads, trash dumps, and structural remains; plus a probable Hohokam habitation area	Yes
82	M: artifact scatter with features	Historic trash dumps, tent pad, and possible grave, plus a prehistoric artifact scatter	Indet.
83	H: trash dump	Trash dump, ca. 1915–1930	Indet.
84	P: artifact scatter with features	Hohokam artifact scatter with rock features and probable roasting features	Yes
85	H: power plant	Hydroelectric plant associated with the Arizona Canal, ca. 1902	Yes
86	P: artifact scatter with features	Extensive Hohokam artifact scatter with numerous rock features and possible structures	Yes
87	P: artifact scatter with features	Extensive Hohokam site with one or more probable habitation areas plus numerous rock features and roasting pits	Yes
88	H: ditch	Historic (1930s or earlier) ditch; 0exact history and function unknown	Indet.
89	P: artifact scatter	Hohokam artifact scatter	Yes
90	P: artifact scatter	Hohokam artifact scatter with one small rock feature	Indet.
91	H: canal	Highland Canal, constructed 1887–1888	Yes

SRPMIC Site No.	Site Type*	Comments	NRHP Eligible**
92	H: canal	Consolidated Canal, may date as early as 1879 but more likely 1891	Yes

* P = prehistoric, H = Historic, M = multicomponent (both prehistoric and historic)

** Yes = National Register eligible; Indet. = indeterminate eligibility, testing or other investigations

Determination of eligibility of indeterminate sites needs to be accomplished prior to groundbreaking activities. Table 4.4-4 identifies possible research questions that could be included in any testing effort for the indeterminate sites noted in Table 4.4-3.

Table 4.4-4. Areas of Potential Research for the Prehistoric and Protohistoric Sites Located in the SRRP Study Area

Site Category*	Areas of Potential Research
Archaic Sites of All Types	Can be used to clarify the type, intensity, seasonality, and timing of pre-ceramic occupation in what would later become a Hohokam "core" area
Red Mountain Phase Hohokam Sites of All Types	So few Red Mountain phase site components have been excavated that there is much to learn about Red Mountain phase settlement patterns, subsistence practices, material cultural traits, architectural styles, social group composition, etc.
Hohokam Ball Court Villages	Data from these sites can be used to test and refine current models about the function of Hohokam ball court villages; in particular, what types of products may have been exchanged at these sites
Hohokam Platform Mound Sites	Data from these sites can be used to assess and refine current models about the evolution and function of Hohokam platform mounds; also, data from these sites can be used to assess the role of platform mounds sites in the larger local communities
Hohokam Non-Irrigation Agricultural Sites	When were these types of features in use? What types of resources were being grown at these sites, and at what level(s) of productivity? To which habitation sites were these sites probably related?
Polvorón Phase Site Components	Since known Polvorón phase site components are still relatively few in number, they can be used to flesh out material culture trait lists; to fine-tune cultural chronologies; and to better reconstruct Hohokam lifeways at this time
Pioneer Period sites of All Types	There are still relatively few excavated pre-Snaketown phase features in the Phoenix area; as such, all Pioneer period site components have the potential to provide important new information about early Hohokam settlement patterns, subsistence practices, social group composition, etc.

Site Category*	Areas of Potential Research
Colonial & Sedentary Period Hohokam Habitation Sites	These sites can be used to refine existing models of, e.g., Hohokam trade practices, subsistence practices, and site structure
Classic Period Hohokam Sites	These sites can potentially provide important information about whether large migrations occurred into the Salt River Valley within the SRRP project area during this time
Hohokam Irrigation Canal Segments	Can provide information about local canal engineering techniques; the amount of potentially arable land; what crops were being grown; what the micro-environments of local canals were like; the temporal distribution of various irrigation canal segments.
Hohokam Field House Sites	What crops were being grown at these sites? When were these sites being used? How does field house architecture compare to existing models? What was the structure of these sites, e.g., where were the farm fields in relation to the other site facilities?
Protohistoric Native American Site Components	Any Protohistoric site component would be extremely important in understanding when and how the Hohokam left and when and how the Pima entered the lower Salt River Valley
Hohokam Limited Activity Sites; Bedrock Grinding Sites; Quarries; Rock Shelters; Rock Art Sites; and Artifact Scatters of All Time Periods	These small sites are potentially of great importance in determining the range and timing of activities that occurred outside habitation sites
Historic Native American Site Components	Comparisons with analogous, contemporary, Euro-American facilities; material culture studies; subsistence studies; settlement studies.
Historic Euro-American Site Components	Can potentially provide information about building construction techniques; early Mormon settlement patterns, subsistence practices, and patterns of cultural interaction

* Site categories listed in bold type are those with particularly high research potential to address current data gaps in the archaeological record

4.4.3.3 Additional Field Survey and Test Excavations

Beginning in November 2003, Statistical Research, Inc. (SRI) conducted a Class III Cultural Resources Survey and archaeological testing of an additional 300 acres on the Salt River Pima-Maricopa Indian Community. SRI completed the survey in December 2003 and submitted a draft report, *A Class III Cultural Resources Survey and Testing Recommendations for the Proposed Salt River Restoration Project, Maricopa County, Arizona* in January 2004. This report summarized the survey results and contained a testing plan for six archaeological sites, SRPMIC 90, 105, 108, 109, 112, and 113.

Additional Archaeological Testing

Only one feature, a historical-period bell-shaped storage pit, was identified in the trench profiles at SRPMIC-109. Excavation of the pit resulted in the recovery of three mid- to late nineteenth century ollas, a small jar, and two bowls. Each of the ollas was capped with a large metal can. A possible stove pipe, a metal spoon, metal cup, and metal pan were also preserved. A small trash scatter rested on the same surface into which the storage pit was dug. Artifacts in this trash scatter included four cans and an intact wine bottle with a push-up base and hand-applied finish.

Testing at SRPMIC-105 was negative. No buried features or artifacts were encountered during the testing. One 20-meter-long, north-south trench was also excavated through a large hummock, but again no buried artifacts or features were exposed.

At SRPMIC-108 all artifacts within the surface collection units were collected, along with a small chipping station. Between 10 and 30 centimeters of sediment were removed and two small shallow pits were exposed. Both pits were excavated. The fill in Feature 15 was ash-stained and collected *en masse* for flotation analysis. Both backhoe trenches were placed on the lower Lehi terrace along the drainage that bisects the site. No artifacts or features were exposed in the southernmost trench. The northernmost trench, however, contained a cultural deposit that is ash-stained and replete with fire-cracked rock. This stratum is best interpreted as a rake-out accumulation associated with a nearby buried roasting pit or horno. One roasting pit, Feature 1, was visible at the surface during a previous survey. It was bisected during testing and contains large amounts of wood charcoal and fire-cracked rock.

Testing of SRPMIC-90 involved the excavation of two 10-meter-long trenches in an artifact concentration at the east end of the site, along with the mechanical scraping of a 5-by-25-meter area in another artifact concentration at the west end of the site. These excavations were placed in areas containing relatively high densities of surface artifacts. A series of 5-by-5-meter surface collection units were placed over the areas to be mechanically excavated. All artifacts within these units were collected. No buried features or artifacts were encountered in the first artifact concentration. Two small, shallow thermal pits, however, were exposed in the 5-by-25-meter mechanical stripping unit placed in the other artifact concentration. Both of these pits were completely excavated and the fill from each of them was collected *en masse* for flotation analysis.

Testing efforts at SRPMIC-112 and 113 focused on determining the age and function of two ditches that could be followed across the west end of the parcel. Each of these ditches was designated a site number during the survey. Backhoe trenches were excavated across both ditches. Styrofoam was found in the bottom of SRPMIC-112 and no subsurface expression of SRPMIC-113 could be found. The styrofoam in SRPMIC-112 rested on the bottom of the ditch only 15–20 centimeters below the modern surface. A large gravel deposit was found to exist immediately beneath both ditches. As such, neither of them would have conveyed water, nor could they have held water for long. SRPMIC-112 and 113, therefore, are considered modern drainage ditches.

Recommendations

Given the results of this testing program, SRI recommend that the information potential of SRPMIC-90, 105, 112, and 113 has been exhausted. The two thermal pits and surface artifacts at SRPMIC-90 are best interpreted as the remains of a small Colonial period farmstead. The residential locus of this site, however, has been destroyed as part of road construction. No buried features were encountered at SRPMIC-105. SRPMIC-112 and 113 were determined to be modern drainage ditches. As such, these sites cannot contribute significantly towards our understanding of past lifeways within the project area. SRI, therefore, recommended that SRPMIC-90, 105, 112, and 113 are ineligible for inclusion in the NRHP.

SRI evaluated SRPMIC-108 and 109 as eligible for listing on the NRHP. A large subsurface deposit of ash-stained soil and fire-cracked rock was identified at SRPMIC-108. This deposit likely represents rake-out debris from a nearby roasting pit or horno. SRI recommended that this part of the site be mechanically stripped and that the feature(s) be excavated. The excavation of a small roasting pit during testing at this site indicates that organic preservation is excellent in this portion of the site. SRPMIC-108 could, therefore, contribute significantly towards our understanding of prehistoric subsistence in the project area.

SRPMIC-109 represents the remains of a small, mid- to late nineteenth century Piman farmstead in Parcel 3. SRI also recommended that this site be mechanically stripped to determine the subsurface limits, structure, and contents of this site. SRPMIC-109 can contribute significantly towards our understanding of historic period Piman pottery production, agricultural activities, and settlement in the project area.

In addition, archival research indicates that several prehistoric canals have been mapped in the project area. No evidence of these canals or associated field systems is evident on the surface or in subsurface excavations conducted by SRI. Their possible existence, however, should be considered during construction, or an effort should be made to locate these features, if there is a data recovery phase.

Consultation to identify traditional cultural properties has yet to be conducted. The SRPMIC would identify these types of resources. Other tribes may also be consulted to obtain their views.

4.5 AESTHETIC RESOURCES

4.5.1 INTRODUCTION

This section describes the existing visual resources and aesthetic conditions in the Va Shly'ay Akimel study area. Photographs (Figures 4.5-1 through 4.5-6) are included to illustrate the baseline conditions in the area. A description of local governmental organizations with jurisdiction in the area is also provided, along with the regulatory setting guiding aesthetic resources in the area.

Please refer to Sections 4.1, "Topography and Geography," 4.2, "Hydrology and Water Resources," and 4.10, "Land Use," for other details on the physical conditions that influence the visual and aesthetic character of the study area.

4.5.2 GENERAL PROJECT SETTING

The study area is located in the eastern portion of Maricopa County, along the Salt River between the City of Mesa and the Salt River Pima-Maricopa Indian Community. The study area is located within a subdivision of the Sonoran Desert referred to as the Lower Colorado River Valley or the microphyllous desert. This area is the largest and most arid subdivision of the Sonoran Desert. Low annual precipitation and high temperatures support relatively sparse vegetation. Characteristic species include blue paloverde, creosote bush, and triangle bursage.

Terrain ranges from hills and rock outcrops north of the study area to alluvium within the river floodplains to the south. Surrounding land within the study area is relatively flat and rural (agricultural and open space, gravel mining) to the north, and urban (residential, agricultural, light industry, commercial, gravel mining, and vacant land) to the south.

The study area includes the floodway and immediately adjacent land uses. The study area is essentially a wide dry wash dominated by large expanses of sand and gravel. The interior floor of the Salt River Valley is comprised of thick layers of alluvium on nearly level or gently sloping surfaces. These soils are sandy to gravelly, but may include areas of finer particles of silt or clay.

4.5.3 GENERAL DESCRIPTION OF THE PROJECT AREA AT PHOTO LOCATIONS

Views of the study area are limited in quality due to sparse development and access points along the banks, gravel quarry operations, and few roadways crossing the river channel. Views within the wash from various photo locations are characterized by diverse channel widths (narrower at Granite Reef Dam on the east, wider at Pima Freeway on the west), and include open water and natural vegetation in the east and dry sand and gravel in the west. This lack of topographic features limits long-range viewing opportunities along the river channels. Toward the eastern end of the study area, the vegetative communities present appear largely undisturbed. The

western end of the study area is dominated by gravel mining operations. Visible degradation of the streambed in the western half of the study area has resulted from dumping of garbage (e.g., household trash, used furniture and appliances, and tires), off-road vehicle use, and gravel mining. Most notably, sand and gravel mining operations within and along the banks of the Salt River in the western half the study area have had a significant effect on visual resources and aesthetic conditions.

Prominent features adjacent to the Salt River include power lines and towers, freeways, urban and rural development, and agricultural fields. Long-distance views include the Usery and Goldfield Mountains to the west and McDowell Mountains to the north.

Figure 4.5-1 shows the locations where photographs were taken throughout the study area. The locations in Figure 4.5-1 are correlated with the photographs shown in Figures 4.5-2 through 4.5-6 and the descriptions below.

4.5.3.1 Pima Freeway

Views of the Salt River from the vicinity of the intersection of the Pima and Red Mountain Freeways are wide open, revealing relatively flat land areas made up of mostly sand, gravel, cobbles, and larger rocks. The Pima and Red Mountain Freeways cross the channel here and are elevated to accommodate crossing during flood flows. To the west of the Pima freeway, views of the channel include shallow, open water with sparse vegetation; to the east of the Pima freeway, views include deeper open water and scattered vegetation, with compacted dirt and gravel areas and little vegetation along the banks. Further east, sand and gravel mining operations dominate the landscape, with operations covering large portions of the north bank and channel bed. Power lines and buildings can be seen on the south side of the channel (Figure 4.5-2).

4.5.3.2 Beeline Highway

Views of the Salt River from the vicinity of Beeline Highway (closest roadway) are relatively broad. The banks of the channel are steeper at this location, with well-defined slopes on both sides. Several areas in this portion of the Salt River are used for illegal dumping of trash and debris. Additional refuse materials have surfaced from the closed landfill located on the northern edge of the channel. Vegetation on the flat dry landscape is sparse in this area, and is dominated by dry grasses. Power lines, buildings, and a new sound wall can be seen on the south side of the channel within City of Mesa boundaries. Sand and gravel mining operations continue within the channel and on both sides of the wash from just east of the Pima Freeway to approximately the center of the study area reach (Figure 4.5-3).

4.5.3.3 Arizona Canal

Views of the portion of the study area located near the center of the reach (the widest section) consist of shallow groundwater recharge ponds. Some vegetation is growing where open water

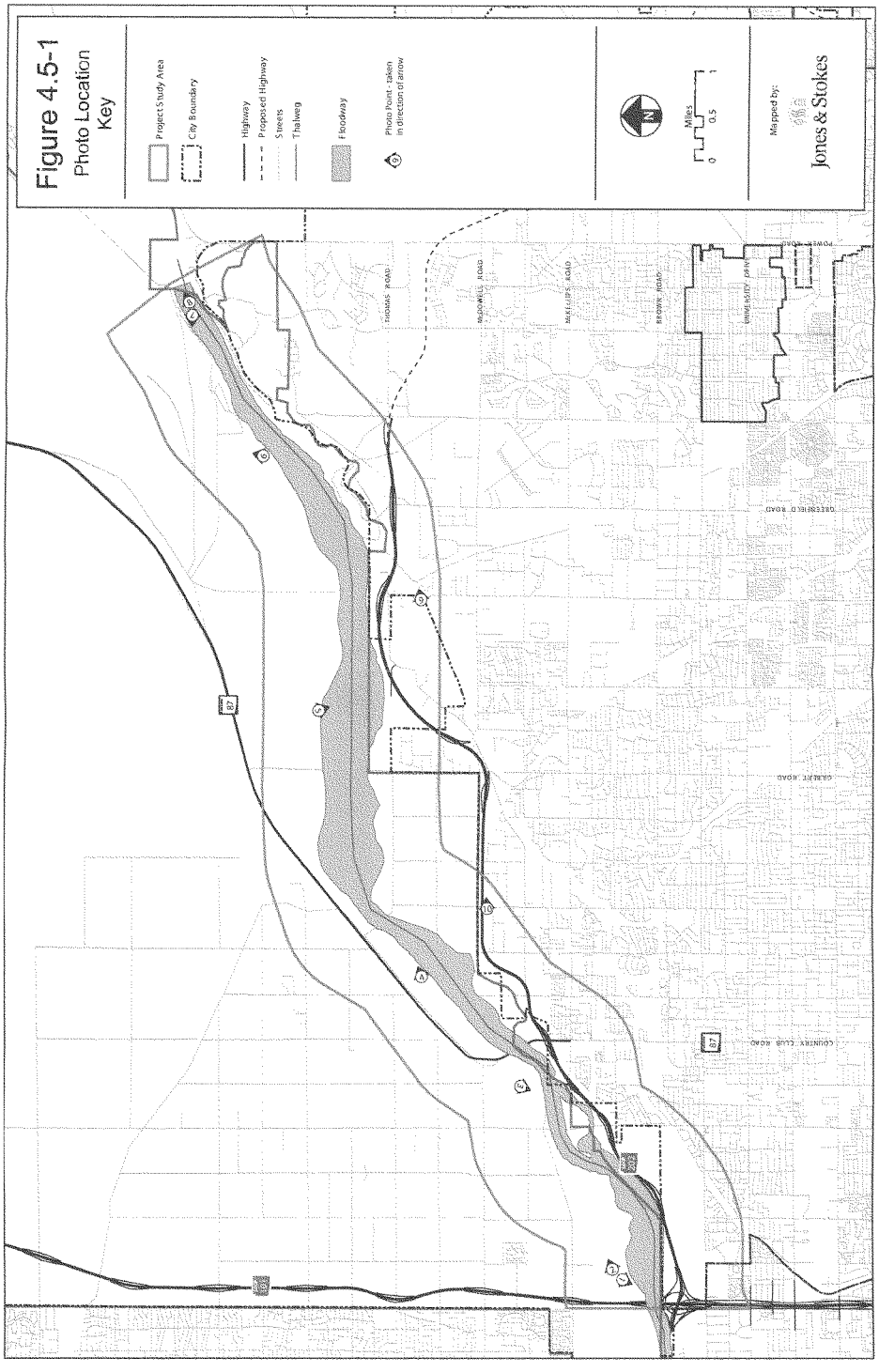


Figure 4.5-1
Photo Location Key
Project Study Area
City Boundary
Highway
Proposed Highway
Streets
Thalweg
Floodway
Photo Point - taken in direction of arrow
N
Miles
0
0.5
1
Mapped by:
Jones & Stokes
THOMAS ROAD
MEKELJIDS ROAD
BROWN ROAD
UNIVERSITY DRIVE
POWER ROAD
GREENFIELD ROAD
GILBERT ROAD
COUNTRY CLUB ROAD
87
28

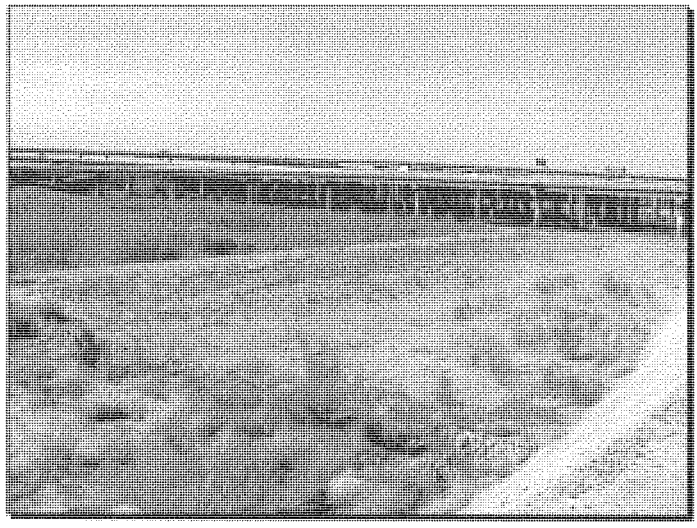


Photo 1: View from the north side of the Salt River near the Pima Freeway (101), looking west. Pima Freeway and Red Mountain Freeway (202) interchange shown in the background.

Photo 2: View from the north side of the Salt River east of the Pima Freeway (101), looking northeast. Gravel mining operations shown in background and detention ponds shown in the foreground.

Jones & Stokes

Figure 4.5-2
Views in the Vicinity of the Pima Freeway

Photo 3: View from the north side of the Salt River south of Cypress Golf Course, looking south. Gravel mining operations shown on right in background.

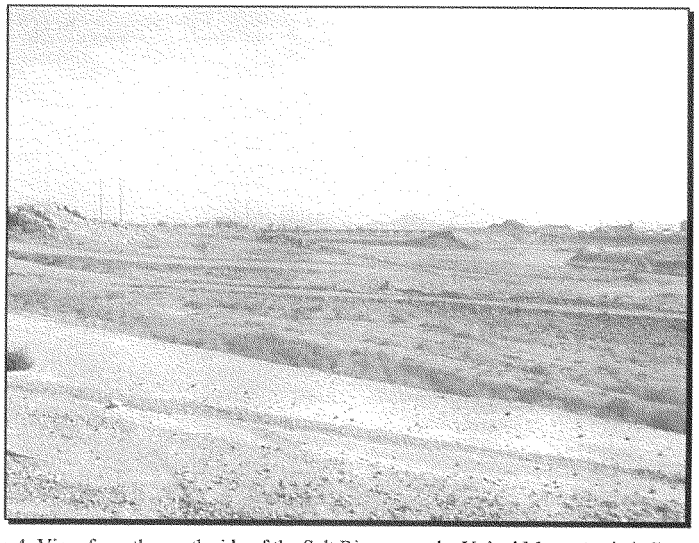


Photo 4: View from the north side of the Salt River near the United Metro Asphalt Company, looking east. Gravel mining operations and Red Mountain Freeway interchange shown in background.

Jones & Stokes

Figure 4.5-3
Views in the Vicinity of Beeline Highway

is found. The south side of the channel is barely visible, and channel banks are almost level with the center portion. Views to the northeast include open space, cactus, and creosote bush, with Red Mountain and the McDowell Mountains visible in the distance (Figure 4.5-4).

4.5.3.4 Granite Reef Dam

Views in this section of the study area are dominated by Granite Reef Dam, a large concrete structure that spans the entire width of the channel. A spillway and control house are located on the northern side of the dam structure. The portion of the study area located just west (downstream) of Granite Reef Dam consists of open channel with sparse vegetation within the channel and along the steep, well-defined banks. The alluvial material within the channel consists of larger grained sand, cobbles, and rocks. Standing water can be seen just below the dam, with open water flowing from the dam's spillway and traveling along the northern portion of the channel for approximately ¼ mile. Vegetation supported by this water can be seen growing along the water's edge. Long-distance views include the Usery Mountains to the east and the McDowell Mountains to the north (Figure 4.5-5).

4.5.3.5 South Canal

Views in the vicinity of the South Canal, along the southern boundary of the project area, are generally unobstructed to the north, east, and west. The visible landscape in these directions typically comprises a broad expanse of alluvial flats in the foreground and middle ground, with generally clear views of the Superstition Mountains directly to the east, the Usery and Goldfield Mountains to the northeast, Red Mountain and the McDowell Mountains to the north, and South Mountain and the Estrella Mountains to the distant west. For the most part, vegetation on the flatlands surrounding the Salt River channel is typical Sonoran desert scrub (creosote bush, bursage, various cacti and upland grasses), with isolated patches of mesquite and cottonwood nearer the river channel. Lands to the south, however, are primarily residential and agricultural, and views are thus dominated by homes, small ranches, livestock paddocks, and a proliferation of introduced trees and shrubs. The eastern portion of the project area south of the SouthCanal, in particular, is distinguished by a large number of orange groves (Figure 4.5-6).

4.5.4 REGULATORY SETTING

Although the proposed project is being undertaken by the Corps, the City of Mesa, Maricopa County, and the Salt River Pima-Maricopa Indian Community (SRPMIC) have jurisdiction over various sections of the study area. Unincorporated lands in the study area would fall within the City of Mesa's sphere of influence. These would likely be annexed by the City, which will have jurisdiction over planning new recreational facilities. Maricopa County visual resource elements are therefore not included in the discussion that follows. Other regulations, plans, goals, and policies related to visual resources and aesthetic conditions pertinent to the Va Shly'ay Akimel study area are described below.

4.5.4.1 City of Mesa

The City of Mesa General Plan defines the direction of growth and the type of development that is desired and expected to occur in Mesa between 2002 and 2025 (City of Mesa 2002). The General Plan is a general guide or blueprint for Mesa's future that presents the community's vision through broad goals and objectives. The City's General Plan acknowledges the importance of visual resources and aesthetic conditions by noting in the vision for Mesa 2025 that "The natural environment is used to enhance the beauty of the community."

The plan also acknowledges the opportunities the Salt River offers for recreation and as a refuge for wildlife. Part of Mesa's vision includes enhancements along the Salt River performed in conjunction with the SRPMIC.

4.5.4.1.1 Parks, Recreation, and Open Space

The Parks, Recreation, and Open Space Element provides the guide for developing the open space system in the City for existing and future residents. The element plans for community connectivity to serve residents through trail corridors, canals, utility corridors, and urban pathways.

The element identifies the following goals objectives and policies relevant to visual resources and aesthetic conditions.

Goal PR-1. Create a balanced, accessible and integrated system of open spaces and recreational opportunities to serve the current and future residents and visitors of the City of Mesa.

Objective PR-1.1. Provide a meaningful network of natural and developed open space areas.

Policy PR-1.1a. Identify lands for potential acquisition to preserve open space for recreational, aesthetic and preservation uses.

Policy PR-1.1b. Coordinate with the Arizona State Land Department for the designation, disposition, and acquisition of state trust lands classified as open space under their management within the three designated planning areas.

Objective PR-1.2. Manage and preserve open space to optimize its use and protection.

Policy PR 1.2a. Develop and implement a Mountain Preserve program at Usery Park Recreation Area that addresses the use and management of dedicated, leased or publicly accessed mountainous and hillside areas.

Policy PR1.2c. Develop a land stewardship program that will protect open space land and natural habitats in the City.

Policy PR1.1e. Encourage the preservation of significant natural areas such as the Salt River corridor to enhance their recreation attraction and aesthetic value.

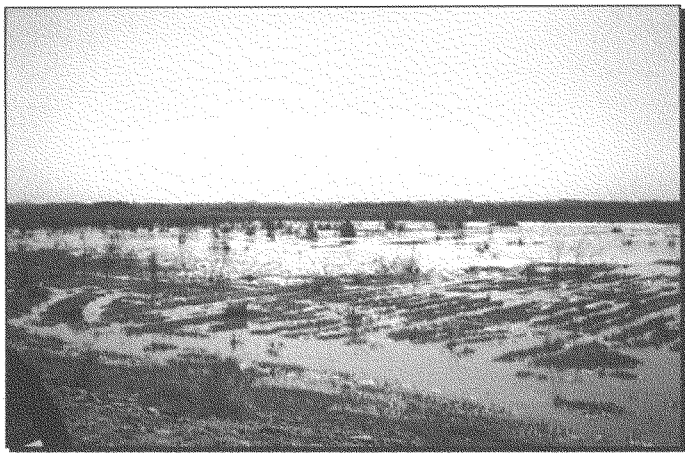


Photo 5: View from the north side of the Salt River at edge of bank, looking south. Groundwater recharge ponds are shown; recharge water is gravity fed from north of Granite Reef Dam via the Southern Canal.

Photo 6: View from the north side of the Salt River, looking northeast. Saguaro cactus and creosote shown in foreground, with Red Mountain in background.

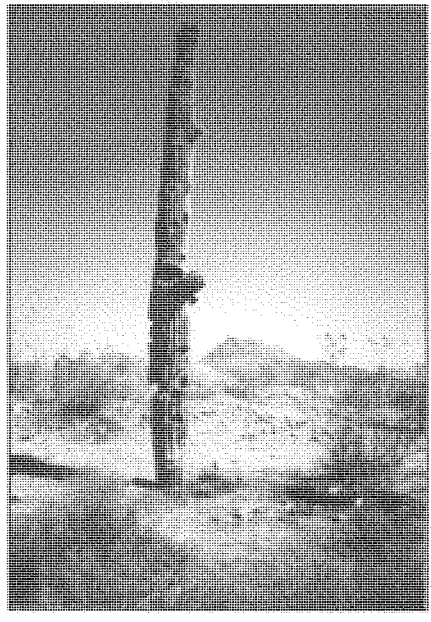


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Figure 4.5-4
Views in the Vicinity of the Arizona Canal

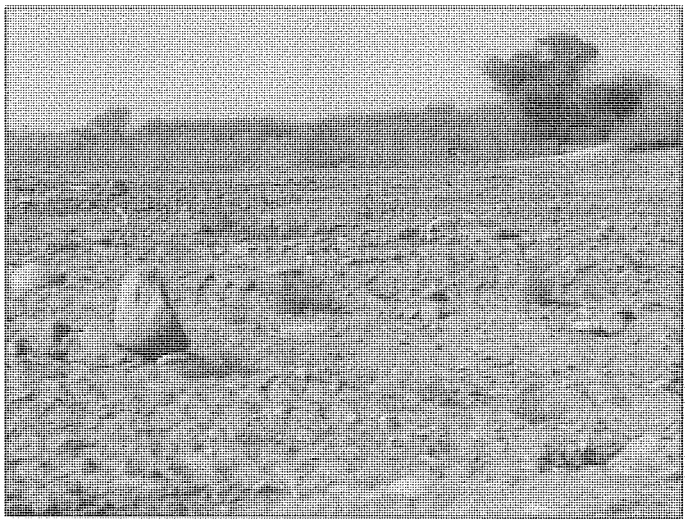

Photo 7: View from the center of the Salt River near Granite Reef Dam, looking west. Dirt access road is shown on the right.

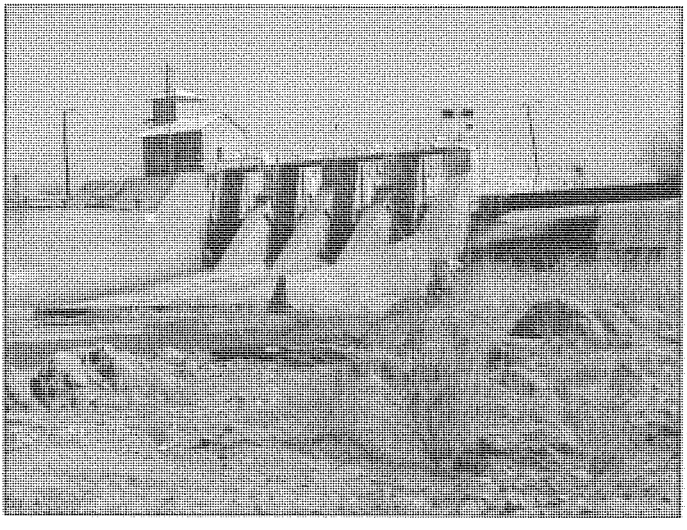

Photo 8: View from the center of the Salt River just below Granite Reef Dam, looking east. Dam control house and spillway are shown.

Jones & Stokes

Figure 4.5-5
Views in the Vicinity of Granite Reef Dam

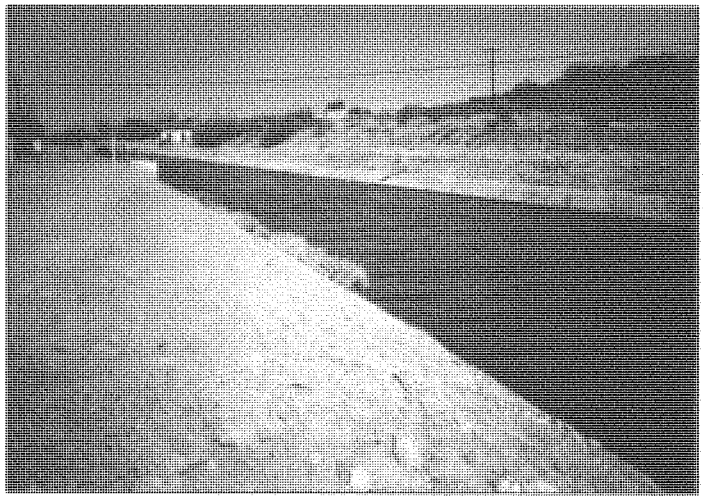

Photo 9: View from the south side of the Salt River on Val Vista Drive, looking east. Southern Canal is shown.

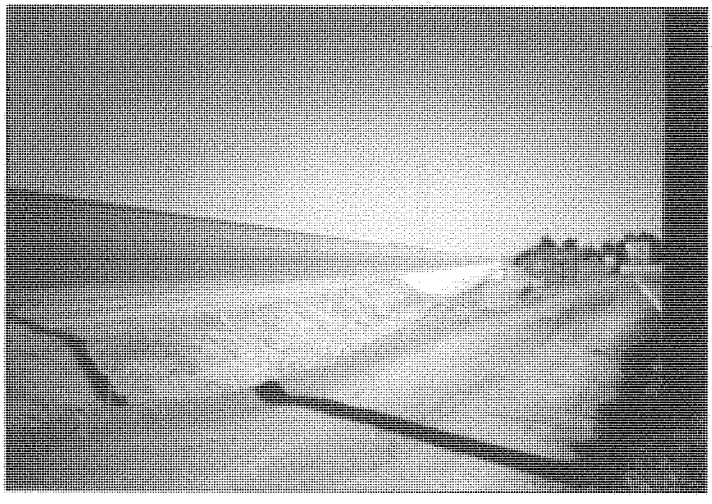

Photo 10: View from the south side of the Salt River at the end of Horne Street, looking east. Sound wall south of the Red Mountain Freeway extension is shown.

Jones & Stokes

Figure 4.5-6
Views in the Vicinity of the City of Mesa

Policy PR 1.2g. Identify natural features in deserts and mountain areas, such as slopes, peaks, ridges, rock outcroppings, stands of vegetation and washes, that could be protected as part of land trusts, as conservation easements, incorporated into developments as design features, or other means of preservation.

Policy PR 1-2h. Encourage preservation in areas with significant environmental features, landforms, and plant communities.

Objective PR 1.3. Maintain where possible the natural aesthetic qualities of the areas that are visually prominent or offer unique settings.

Policy PR 1.3a. Encourage open space areas to align and include prominent natural features to ensure unobstructed view corridors and vistas.

Policy PR 1.3b. Encourage Maricopa County to limit development on Usery Mountain and encourage the City of Mesa to limit development of Spook Hill so the natural attributes remain undisturbed when viewed from adjacent lower elevations.

4.5.4.1.2 Environmental Planning and Conservation

The Environmental Planning and Conservation Element recognizes the importance of a diversity of wildlife and plant communities in maintaining the quality and function of the natural environment. Preservation of corridors is noted as a specific action that can preserve connectivity between wildlife habitats, and the Salt River is one of these primary corridors.

The Environmental Planning and Conservation Element identifies the following goals, objectives, and policies relevant to visual resources and aesthetic conditions:

Goal EPC-3. Provide for the protection and wise use of the resources of the natural environment in the City of Mesa

Objective EPC-3.2. Promote the protection, enhancement, and establishment of native vegetation and plant species.

Policy EPC-3.2c. Promote restoration and revegetation of disturbed areas with native plant species so that disturbed areas, over a reasonable amount of time, match the plant densities of the undisturbed setting.

Policy EPC-3.2d. Recognize and protect areas of significant natural vegetation (such as areas along washes, natural spring areas or on slopes) that are advantageous to the increased densities of the native vegetation.

Objective EPC-3.3. Ensure that new development recognizes limitation associated with the natural features of the land, including slopes, unstable soils, and floodplains.

Policy EPC-3.3d. Require that ridgelines remain as undeveloped natural open space.

Policy EPC-3.3e. Encourage, where feasible, the maintenance of retained washes and new drainage channels in a "natural" desert character. Solutions may include landscaping with native rock and plant materials, contouring, and preservation of existing natural features.

Policy EPC-3.3h. Promote, where applicable, minimum site grading to encourage integration with the natural contours of the land.

4.5.5 SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

The SRPMIC is considered a sovereign nation and is not under the regulatory or political jurisdiction of any of the local governments in the area or the U.S. federal government. The tribal community does not have any established regulations or plans for visual resources and aesthetic conditions.

4.6 AIR QUALITY

4.6.1 INTRODUCTION

This section describes the existing climate, meteorology, and ambient air quality in the region of the study area, along with the regulatory requirements associated with the management of air pollutants.

4.6.2 CLIMATE AND METEOROLOGY

The climate in central Maricopa County, including the study area, is characteristic of the Sonoran Desert, with hot summers, mild winters, and annual average precipitation totals of approximately 8 inches. Figures 4.6-1 and 4.6-2 present monthly precipitation totals and temperature means, respectively, summarized from data obtained from the National Climatic Data Center On-Line Data Access System for the Phoenix Sky Harbor International Airport long-term monitoring station. Average and median monthly precipitation totals calculated for 1960-1995 are provided in Figure 4.6-1. The long-term annual average and median rainfall for this period are 7.99 inches and 7.62 inches, respectively. (CH2M HILL et al. 1997.) Data gathered for meteorological conditions in the survey area during 2001 and the first quarter of 2002 were downloaded from Arizona Meteorological Network's Internet site and are shown in Table 4.6-1 below (Arizona Meteorological Network 2002).

Table 4.6-1. Meteorological Summary for Survey Area, 2001-2002

Month/Year	Average Temperature (°F)	Average Relative Humidity (%)	Average Wind Speed (mph)	Total Rainfall (inches)
2001				
January	50	63	2.6	1.71
February	54	56	2.9	0.62
March	62	49	2.9	0.74
April	68	41	3.6	0.83
May	83	27	3.8	0.06
June	89	26	3.8	0.00
July	91	37	3.7	0.45
August	90	40	3.4	0.62
September	86	35	3.2	0.11
October	74	41	2.7	0.00
November	63	47	2.7	0.14
December	49	58	2.5	0.72
2002				
January	51	45	2.5	0.01
February	56	35	2.7	0.00

Source: Arizona Meteorological Network 2002.

Data from the Phoenix Encanto monitoring station were used because this monitoring station is the closest one to the study area. These data indicate that the rainfall during 2001 was 6.0 inches, which is below average.

Figure 4.6-2 presents the monthly average, maximum, and minimum temperatures for 1960-1995. The minimum average temperature is 44 degrees Fahrenheit (°F) in January and the maximum average temperature is 85.6°F in July (CH2M HILL et al. 1997). Monthly average temperatures for 2001 and the first quarter of 2002 downloaded from Arizona Meteorological Network's Internet site are shown in Table 4.6-1. Data from the Phoenix Encanto monitoring station were used because this monitoring station is the closest to the study area. The minimum average temperature in 2001 and the first quarter of 2002 was 49°F, and occurred during December 2001 (Arizona Meteorological Network 2002). The maximum average temperature for this same period was 91°F, and occurred in July 2001.

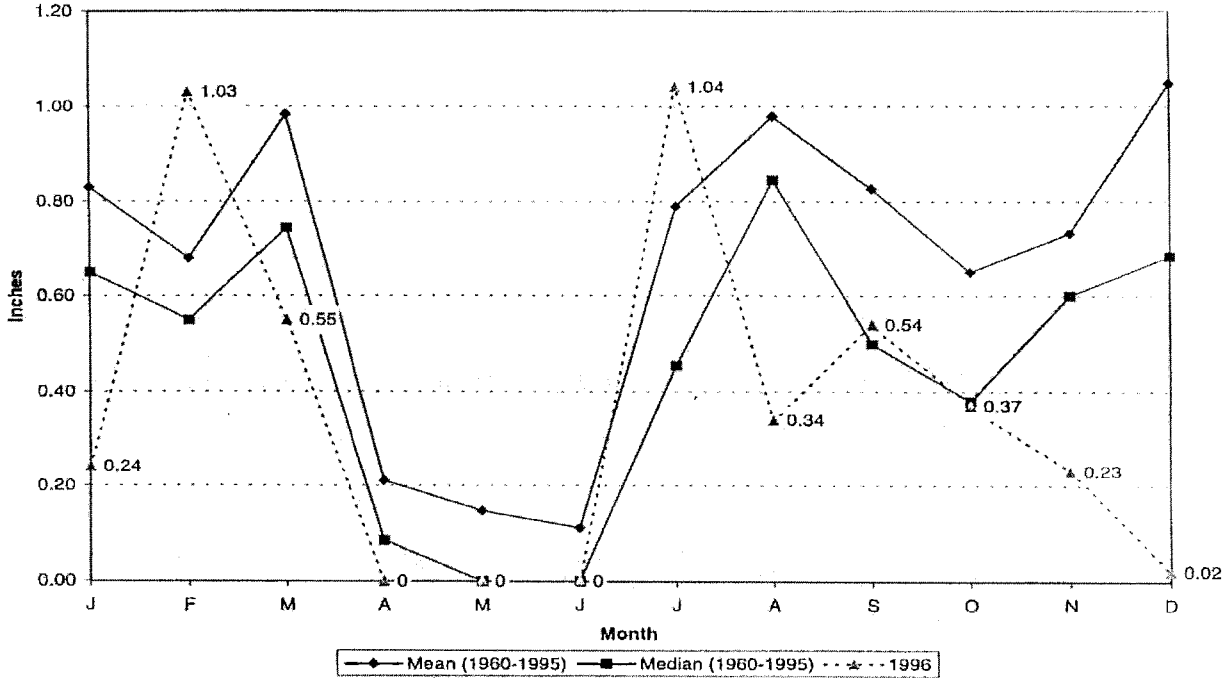

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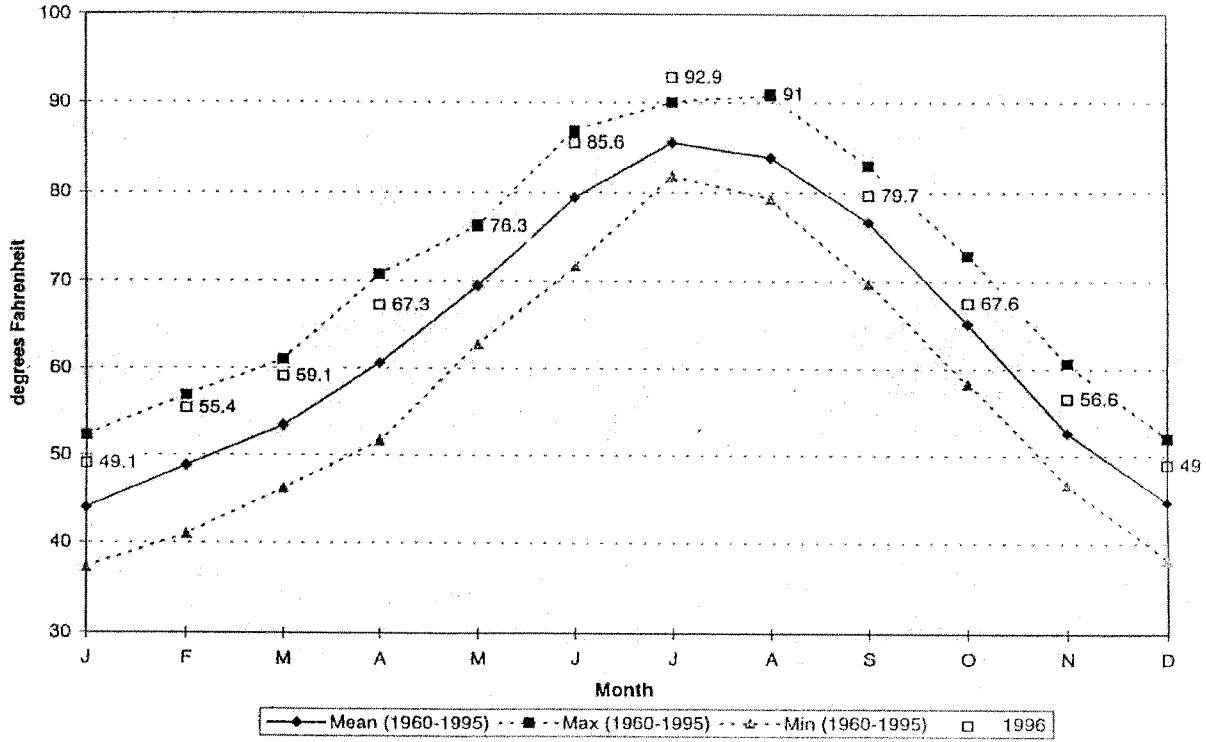
Figure 4.6-1
Monthly Total Precipitation, Phoenix, Arizona, 1960-1996



Jones & Stokes

Figure 4.6-2
Monthly Mean Temperature, Phoenix, Arizona, 1960-1996

4.6.3 EXISTING AIR QUALITY

4.6.3.1 Criteria Pollutants

Air quality is evaluated by measurement of ambient concentrations of pollutants that are known to have deleterious effects. The Environmental Protection Agency (EPA) has promulgated primary and secondary National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM10), ozone (O_3), sulfur dioxide (SO_2), and lead. Primary standards are adopted to protect public health, while secondary standards are adopted to protect public welfare (Arizona Department of Environmental Quality 2000). States are required to adopt ambient air quality standards that are at least as stringent as the federal NAAQS. The ADEQ is responsible for regulating air quality in the state and has adopted the federal NAAQS as state standards. These standards are presented in Table 4.6-2. Table 4.6-3 summarizes some of the health effects associated with each of the six criteria pollutants. Tables 4.6-2 and 4.6-3 appear on the following pages.

Table 4.6-2. State and Federal Ambient Air Quality Standards

Pollutant	Average Time	Primary Standard	Secondary Standard
Carbon monoxide (CO)	1 hour	35.00 ppm	NS
	8 hour	9.00 ppm	NS
Nitrogen dioxide (NO_2)	Annual	0.053 ppm	0.053 ppm
Particulate matter (PM10)	24 hour	150 $\mu g/m^3$	150 $\mu g/m^3$
	Annual	50$\mu g/m^3$	50$\mu g/m^3$
Ozone (O_3)	1 hour	0.12 ppm	0.12 ppm
	3 hour	NS	1300 $\mu g/m^3$ (0.5ppm)
	24 hour	365 $\mu g/m^3$ (0.14 ppm)	NS
Sulfur dioxide (SO_2)	Annual	80 $\mu g/m^3$ (0.03 ppm)	NS
Lead	Calendar quarter	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

Notes:
NS = No standard
ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter

Source: Arizona Department of Environmental Quality 1998.

Table 4.6-3. Health and Welfare Effects of Criteria Air Pollutants

Pollutant	Health and Welfare Effects
Carbon monoxide (CO)	Impairs the ability of blood to carry oxygen in the body. Cardiovascular system is primarily affected, causing angina pain in persons suffering from cardiac arterial disease. Affects other mammals in a similar manner.
Nitrogen dioxide (NO_2)	Impairs the respiratory system, causing a high incidence of acute respiratory diseases. Preschool children are especially at risk. Damages certain plants and materials. Degrades visibility because of its brownish color and its conversion to nitrate particles. Nitrate particles are also a major component of acid deposition.
Particulate matter (PM10)	Causes irritation and damage to the respiratory system, resulting in difficult breathing, inducement of bronchitis, and aggravation of existing respiratory diseases. Also, certain polycyclic aromatic hydrocarbons in PM10 are carcinogenic. Individuals with respiratory and cardiovascular diseases, children, and elderly persons are at greatest risk. Secondary effects include soiling, damaging materials, and impairment of visibility. PM10 also is associated with acid deposition, which damages materials, plants, and trees and acidifies surface waters, thereby harming aquatic life.
Ozone (O_3)	Damages the respiratory system, reducing breathing capacity and causing chest pain, headache, nasal congestion and sore throat. Individuals with chronic respiratory diseases are especially susceptible to ozone. Injures certain plants, trees, and materials.
Sulfur dioxide (SO_2)	Aggravates, asthma, resulting in wheezing, shortness of breath, and coughing. Healthy persons exhibit the same responses at higher exposures. Asthmatics and atopic individuals are the most sensitive groups, followed by those suffering from bronchitis, persons with emphysema, bronchiectasis, cardiovascular disease, the elderly, and children. Damages certain plants and materials. Impairs visibility and contributes to acid deposition because of its conversion to sulfate particles.
Lead	Damages cardiovascular, renal, and nervous systems, resulting in anemia, brain damage, and kidney disease. Preschool age children are particularly susceptible to brain damage effects. Similar effects are observed in other mammals.

Source: Arizona Department of Environmental Quality 1998.

The ADEQ and Maricopa County Environmental Services Department, Air Quality Division, operate a countywide network of air pollution monitoring stations in the study area (U.S. Army Corps of Engineers 1997). The air quality monitoring station nearest the study area is the Mesa monitoring station (near Broadway Road and Alma School Road); data from this site provide a general profile of the ambient air quality in the area. Table 4.6-4 below presents the concentrations of ambient pollutants recorded in 2000 through 2001, as well as the number of days the ambient concentrations exceeded the federal and state ambient air quality standards.

Table 4.6-4. Ambient Air Quality Monitoring Data from Mesa Monitoring Station

Pollutant Standards	2000	2001
Ozone (O_3)		
Maximum 1-hour concentration (ppm)	0.102	0.093
No. Days Standard Exceeded		
NAAQS (1-hour) > 0.12 ppm	0	0
Carbon Monoxide (CO)		
Maximum 8-hour concentration (ppm)	4.3	2.9
Maximum 1-hour concentration (ppm)	8.0	4.6
No. Days Standard Exceeded		
NAAQS (8-hour) ≥ 9.0 ppm	0	0
NAAQS (1-hour) ≥ 35 ppm	0	0
Particulate Matter (PM_{10})		
Maximum 24-hour concentration ($\mu g/m^3$)	126	98
Average arithmetic mean concentration ($\mu g/m^3$)	37	30
No. Days Standard Exceeded		
NAAQS (24-hour) > 150 $\mu g/m^3$	0	0

Source: Maricopa County Environmental Services Department, Air Quality Division, 2002.

As of July 1, 1997, EPA had revised two standards, those for O_3 and PM10, to ensure a more effective and efficient protection of public health and the environment. These revised standards are an 8-hour O_3 standard of 0.08 parts per million (ppm), a 24-hour standard for PM2.5 (particulate matter with a diameter of 2.5 microns or smaller) of 65 micrograms per cubic meter ($\mu g/m^3$) and an annual PM2.5 standard of 15 $\mu g/m^3$ (Arizona Department of Environmental Quality 2000).

Areas with air quality that does not meet these standards are designated by EPA as "nonattainment areas." Several areas within Arizona have been designated by EPA as nonattainment areas. Once an area has been designated as a nonattainment area, a state

implementation plan (SIP) must be developed to demonstrate the measures that will be undertaken in the area to reduce the pollutant levels to meet the air quality standards. The Phoenix area has been designated by EPA as a nonattainment area for CO, O_3, and PM10 (Arizona Department of Environmental Quality 2000). Maricopa County was reclassified as a "serious" CO and PM10 nonattainment area in June 1996, and was classified as a "serious" nonattainment area for O_3 in February 1998 (Arizona Department of Environmental Quality 2000). The Maricopa Association of Governments is currently preparing or has prepared SIPs to address the control of nonattainment criteria pollutants (Arizona Department of Environmental Quality 2000). No nonattainment areas for lead or oxides of nitrogen are within Arizona (Arizona Department of Environmental Quality 2000).

4.6.3.2 Toxic Air Contaminants

In addition to criteria pollutants, other regulated pollutants include toxic air contaminants (TACs), which are suspected or known to cause cancer, genetic mutations, birth defects, or other serious illnesses in exposed people. TACs are not regulated by the federal or state ambient air quality standards, but are addressed by the National Emission Standards for Hazardous Air Pollutants (NESHAPs) and Title III of the 1990 Clean Air Act Amendments (U.S. Army Corps of Engineers 1997).

The concentrations of toxic pollutants are determined by the level of emissions at the source and the meteorological conditions encountered as these pollutants are transported away from the source. Thus, impacts from toxic pollutant emissions tend to be site specific and their intensity is subject to constantly changing meteorological conditions. The worst meteorological conditions that affect short-term impacts (low wind speed, highly stable air mass, and constant wind direction) occur relatively infrequently in the Phoenix metropolitan area (U.S. Army Corps of Engineers 1997).

4.6.4 REGULATORY SETTING

Federal, state, and regional agencies have established standards and regulations addressing air pollutant emissions that may affect proposed projects.

4.6.4.1 Federal and State Regulations

The following federal and state regulatory considerations may apply to the project and the alternatives.

- The federal Clean Air Act of 1970, which directs the attainment and maintenance of NAAQS for six "criteria" pollutants, including CO, O_3, particulate matter, sulfur oxides, oxides of nitrogen, and lead.

- The 1977 Clean Air Act, which enacted legislation to control seven air toxic pollutants. EPA adopted the NESHAPs contained in the Act, which were designated to control emissions of hazardous air pollutants to prevent adverse health effects in humans.
- The 1990 amendments to the Clean Air Act, which determine standards for attainment and maintenance of the NAAQS (Title I), motor vehicles and reformulation (Title II), hazardous air pollutants (Title III), acid deposition (Title IV), operating permits (Title V), stratospheric ozone protection (Title VI), and enforcement (Title VII).
- EPA's New Source Review (NSR) and Prevention of Significant Deterioration (PSD) regulations.

4.6.4.2 Federal Conformity Requirements

Federal projects are subject to either the Transportation Conformity Rule (40 Code of Regulations [CFR], Part 51, Subpart T), which applies to federal highway or transit projects, or the General Conformity Rule (40 CFR Part 51, Subpart W), which applies to all other federal projects. Because the proposed action is not a federal highway or transit project, it is subject to the General Conformity Rule.

The purpose of the General Conformity Rule is to ensure that federal projects conform to applicable SIPs so that they do not interfere with strategies employed to attain the NAAQSs. The rule applies to federal projects in areas designated as nonattainment areas for any of the six criteria pollutants for which the EPA has established NAAQSs and in some areas designated as maintenance areas. The rule applies to all federal projects except:

- programs specifically included in a transportation plan or program that is found to conform under the federal transportation conformity rule,
- projects with associated emissions below specified *de minimis* threshold levels, and
- certain other projects that are exempt or presumed to conform.

The project study area is in a nonattainment area for federal ozone, CO, and PM10 standards. The applicable *de minimis* thresholds are 50 tons per year (tpy) of reactive organic gases and nitrogen oxides, 100 tpy of CO, and 70 tpy of PM10. If the Va Shly'ay Akimel project would result in total direct and indirect emissions in excess of the *de minimis* emission rates, it must be demonstrated that the emissions conform with the applicable SIP for each affected pollutant. If emissions would not exceed the *de minimis* levels, and are not regionally significant, the project is presumed to conform and no further analysis or determination is required.

4.6.4.3 Regional and Local Regulations

Maricopa County has jurisdiction for air quality within Maricopa County. The Va Shly'ay Akimel project study area is located within Maricopa County, and emissions that would result from the construction and maintenance of the Va Shly'ay Akimel project are therefore subject to

Maricopa County rules and regulations. The rules and regulations of this agency are designed to achieve defined air quality standards that are protective of public health (U.S. Army Corps of Engineers 1997). To that purpose, they limit the emissions and permissible impacts of emissions from projects, and specify emission controls and control technologies for each type of emitting source to ultimately achieve the air quality standards (U.S. Army Corps of Engineers 1997). The construction contractor will be required to obtain appropriate air permits for this project.

The most important air quality regulation applicable to this project is Maricopa County Rule 310, which requires all construction activities to use stringent control measures to minimize fugitive dust emissions. The mitigation measures described in Section 5.6 include the anticipated requirements under Rule 310.

4.7 NOISE

4.7.1 INTRODUCTION

This section describes the existing noise setting in the vicinity of the Va Shly'ay Akimel study area, including noise sources and the regulatory setting for noise. General information about noise is also provided.

4.7.2 GENERAL NOISE SETTING

A noise environment consists of a base of steady background noise that is derived from many distant and indistinguishable noise sources, combined with sound from individual local sources. In the study area, these local sources include frequent aircraft overflights, traffic noise from streets and freeways in the area, industrial use, and sand and gravel mining operations along the study area.

4.7.2.1 Description of Noise Characteristics

Noise is measured on the decibel (dB) scale, which quantifies sound intensity. Because the human ear is not equally sensitive to all frequencies within the entire spectrum, noise measurements are weighted more heavily within those frequencies of maximum human sensitivity in a process called "A-weighting." The human ear can detect changes in sound levels of approximately 3 A-weighted decibels (dBA) under normal conditions. Changes of 1 to 3 dBA are typically noticeable under controlled conditions, whereas changes of less than 1 dBA are only discernable under controlled, extremely quiet conditions. A change of 5 dBA is typically noticeable by the general public in an outdoor environment. Background information on noise characteristics is included in Appendix G.

Noise may be generated from a point source, such as a piece of construction equipment, or from a line source, such as a road containing moving vehicles. Noise attenuates (decreases) with distance at a rate of 6 dB per doubling of distance for a point source and 3 dB per doubling of distance from a line source. The rate at which noise attenuates can also be affected by the type of terrain over which the noise passes. For an acoustically soft site, such as undeveloped areas, open space, and vegetated areas, noise from a line source attenuates at a rate of 4.5 dBA per doubling of the distance. These rates represent the extremes, and most areas contain a combination of hard and soft elements, with the noise attenuation falling somewhere between these two attenuation factors. Objects that block the line of sight attenuate the noise source if the receptor is located within the "shadow" of the blockage, such as behind a sound wall. If a receptor is located behind the wall but has a view of the source, the wall will do little to attenuate the noise. Additionally, a receptor located on the same side of the wall as the noise source may experience an increase in the perceived noise level because the wall will reflect noise back to the receptor, possibly compounding the noise.

Time variation in noise exposure is typically expressed in terms of the average energy over time (called L_{eq}), or alternatively, as a statistical description of the sound level that is exceeded over some fraction of a given observation period.

4.7.2.2 Effects of Noise

High noise levels can interfere with a broad range of human activities in a way that degrades public health and welfare. Such activities may include:

- speech communication in conversation and teaching,
- telephone communication,
- listening to television and radio,
- listening to music,
- concentration during mental and physical activities,
- relaxation, and
- sleep.

Interference with listening situations can be determined in terms of the level of the environmental noise and its characteristics. The amount of interference in nonlistening situations often depends on factors other than the physical characteristics of the noise. These may include attitude toward the source of an identifiable noise, familiarity with the noise, characteristics of the exposed individual, and the intrusiveness of the noise.

4.7.2.3 Noise Sources

The Va Shly'ay Akimel study area is located in a mixed setting containing both urbanized areas and semi-rural areas. The study area has a moderate activity levels and several sources of adverse noise. The principle sources of noise in the study area are sand and gravel mining operations. This is the largest contributor of ambient noise in the area. Automobiles traversing on SR 202 and SR 101 are another contributor of ambient noise in the area. Traffic noise in the area may be characterized as moderately loud. Aircraft departing from and entering Phoenix Sky Harbor Airport contribute to the ambient noise in the study area. The airport is not within the immediate vicinity of the study area, though the study area runs generally parallel to the airport's takeoff and approach zone. However, because aircraft produce intense noise and pass over the area at relatively low altitudes, these aircraft are considered to be moderate noise sources.

Talley Industries, located south of the project site, is another source of noise in the study area. Talley Industries occasionally detonates explosives left over from the manufacture of ejection seats. This noise is not continuous and therefore is not considered to be significant.

4.7.2.4 Sensitive Receptors

The study area contains residential and agricultural land uses. Sensitive receptors for noise in the study area consist of residential uses located to the south of the river channel and a few scattered houses on the north side of the river channel.

4.7.3 REGULATORY SETTING

4.7.3.1 Federal and State Standards and Regulations

EPA has identified the relationship between noise levels and human response. EPA has determined that over a 24-hour period, a L_{eq} of 70 dBA will result in some hearing loss. Interference with activity and annoyance will not occur if exterior levels are maintained at an L_{eq} of 55 dBA and interior levels at or below 45 dBA. Although these levels are relevant for planning and design and are useful for informational purposes, they are not land use planning criteria because they do not consider economic cost, technical feasibility, or the needs of the community.

In addition to the L_{eq} limitations discussed above, in accordance with 24 CFR 51, Subpart B, "Noise Abatement and Control," EPA set 55-dBA day-night average sound level (L_{dn}) as the basic goal for residential noise intrusion. However, other federal agencies, in consideration of their own program requirements and goals, as well as the difficulty of actually achieving a goal of 55-dBA L_{dn}, have settled on the 65-dBA L_{dn} level as their standard. At 65-dBA L_{dn}, activity interference is kept to a minimum, and annoyance levels are still low. It is also a level that can realistically be achieved.

The federal government regulates occupational noise exposure common in the workplace through the Occupational Health and Safety Administration (OSHA) under EPA. Noise exposure of this type is dependent on work conditions and is addressed through a facility's or construction contractor's health and safety plan. With the exception of construction workers involved in facility construction, occupational noise is irrelevant to this study and is not further addressed in this document.

4.7.3.2 Regional and Local Standards and Regulations

Local governmental jurisdictions are responsible for regulating noise within their respective political boundaries. Specific noise regulations are discussed in the respective zoning ordinances for each of the local jurisdictions, where applicable.

Maricopa County

Maricopa County does not have a noise ordinance. Noise-producing aspects of new projects and existing development fall under the jurisdiction of individual cites in which a given development is located. On October 20, 1997, the County adopted the Maricopa County Comprehensive Plan,

which contains a noise element. The Comprehensive Plan states that due to increased highway traffic, air traffic, construction, and industrial and commercial activities brought about by growth and development, noise has become an increasing concern to both the public and governmental agencies. The Comprehensive Plan sets forth Objectives and Policies to reduce or eliminate sources of noise, including unnecessary traffic (Maricopa County Planning and Development Department 1997).

City of Mesa

The City of Mesa Noise Ordinance sets forth the City policy regarding noise-producing activities and associated constraints on such activities. The ordinance limits the amount of noise that may be produced by various land use activities, vehicles, and construction, and limits the amount of noise that may be produced in areas adjacent to hospitals, schools, and churches. For construction noise, limitations are placed on the time of day that noise-generating construction activities can occur and further limits the days on which these activities can occur (City of Mesa 2000).

Salt River Pima-Maricopa Indian Community

The Community does not have a noise ordinance regulating noise within the Va Shly'ay Akimel study area. However, the creation of excessive noise considered detrimental to the life or health of any individual or in disturbance of the public peace and welfare is not permitted. Noise issues are handled on a case-by-case basis, and all projects on Community lands require a permit for construction (Thompson pers. comm.).

4.8 SOCIAL AND ECONOMIC RESOURCES (INCLUDING ENVIRONMENTAL JUSTICE)

4.8.1 INTRODUCTION

This section presents information regarding the social and economic resources that exist in the vicinity of the study area. A description of the population characteristics, including population, ethnicity, housing trends, local industries, and employment rates is provided below. In addition, environmental justice issues are presented. The data and associated tables and figures presented in this section are based on information obtained from the 2000 U.S. Census Bureau surveys for Maricopa County (County) and for the tracts adjacent to the Salt River in the vicinity of the study area. Additional information regarding population- and housing-growth forecasts and other demographic projections for the County and local municipalities was obtained through the Maricopa Association of Governments (1997) and Arizona Department of Economic Security (1997 and 2000) web sites.

Information regarding employment, personal income, and educational attainment was obtained from the 2000 Census database. In this socioeconomic section of this report, the term *study area* refers to the group of census tracts that exist within or extend into the study area. Whenever possible, the 2000 census information has been supplemented by the most current information available from the online database of the City of Mesa (2002).

4.8.2 GENERAL SOCIOECONOMIC SETTING

4.8.2.1 Population

The southern portion of the study area lies in the City of Mesa, Arizona, which has a total population of 421,614 (City of Mesa 2002), and the northern portion lies in the Salt River Indian reservation, which has a total population of 6,403. Table 4.8-1, "Population and Household Characteristics in the Vicinity of the Study Area," shows the 2000 population and household and family structure for the County and the study area. In 2000, the population in the County totaled 3,072,149 people (U.S. Census Bureau 2000). The Maricopa Association of Governments (MAG) projects that the County's population will grow to approximately 3,709,566 by 2010, and to approximately 4,516,090 by 2020, increases of 637,417 and 1,443,941 people, respectively (Maricopa Association of Governments 2002). The population living in the census tracts in the study area makes up approximately 1.7% of the total County population. The average population of the tracts within the study area is 4,741 persons (U.S. Census Bureau 2000).

Table 4.8-1. Population and Household Characteristics in the Vicinity of the Study Area

Jurisdiction	Population	Number of Households	Persons per Household	Number of Families	Persons per Family
Maricopa County	3,072,149	1,133,048	2.71	763,110	3.21
Study Area	52,153	13,973	3.73	9,362	4.20

Source: U.S. Census Bureau 2000

4.8.2.2 Ethnicity

Table 4.8-2, "Ethnic Population Characteristics in the Vicinity of the Study Area," shows the ethnic makeup of the County and the study area in 2000. The approximate population breakdown of the County by ethnicity is: 66.2% white, 24.8% Hispanic, 3.5% African American, 1.5% American Indian and Alaskan Native, 2.1% Asian, 0.1 % Native Hawaiian or other Pacific Islander, 0.1% other races, and 1.6% two or more races (U.S. Census Bureau 2000).

Table 4.8-2. Ethnic Population Characteristics in the Vicinity of the Study Area

Jurisdiction	White	Black or African American	American Indian or Alaskan Native	Asian	Native Hawaiian or other Pacific Islander	Other	Hispanic or Latino	Two or more Races
Maricopa County	2,034,530	108,521	45,703	64,562	3,725	4,086	763,341	47,681
Percent of County Total	66.2%	3.5%	1.5%	2.1%	0.1%	0.1%	24.8%	1.6%
Va Shly'ay Akimel Study Area	44,812	1,823	4,447	1,179	102	767	16,791	1,685
Percent of Study Area Total	62.6%	2.5%	6.2%	1.6%	0.1%	1.1%	23.4%	2.4%

Source: U.S. Census Bureau 2000

The ethnic composition of the study area resembles but does not mirror that of the County as a whole. Most notably, the population of American Indian and Alaskan Natives is approximately 4.7% greater in the study area than in the County as a whole. The approximate population breakdown in the study area is: 62.6% white, 23.4% Hispanic, 2.5% African American, 6.2% American Indian and Alaskan Native, 1.6% Asian, 0.1% Hawaiian and Pacific Islander, 1.1% other races, and 2.4% two or more races (U.S. Census Bureau 2000).

4.8.2.3 Housing

The housing within the study area is characterized by urban, rural residential, and rural farming. Table 4.8-3, "Housing Occupancy Rates in the Vicinity of the Study Area," shows the housing data for the County and study area for 2000. The County had a total of 1,250,231 housing units, of which 1,132,886 (90.6%) were occupied. MAG projects that the County will have approximately 1,490,212 housing units by the year 2010, and approximately 1,824,979 by 2020. On the local level, MAG predicts that the City of Mesa, in which approximately 2% of the study area is located, will have approximately 194,762 housing units by 2010, and approximately 241,532 by 2020 (Maricopa Association of Governments 1997).

Table 4.8-3. Occupancy Rates in the Vicinity of the Study Area

Jurisdiction	Households	Housing Units	Occupied Housing Units	Occupancy (in percentage)
Maricopa County	1,133,048	1,250,231	1,132,886	90.6%
Study Area	13,973	15,486	13,969	90.2% (avg.)
Percentage of County Total	1.2%	1.2%	1.2%	

Source: U.S. Census Bureau 2000

The study area had a total of 15,486 housing units and 13,973 households, with an average occupancy rate of 90.2 %. The study area includes approximately 1.2% of the housing within the County and generally has a slightly lower occupancy rate than the County as a whole (U.S. Census Bureau 2000).

Table 4.8-4, "Housing-Unit Type and Housing-Unit Median Value in the Vicinity of the Study Area," shows that in 2000, 13,516 housing units (87.3% of the total housing units within the study area) were located in urban areas within the study area, while 1,970 housing units (12.7%) were located in rural areas (66 on farms and 1,904 on non-farmland). In the County, approximately 1,212,724 housing units (97.0% of the total housing units of the County) were located in urban areas, and approximately 37,507 housing units (3.0%) were located in rural areas. The housing units within the study area had a median value of $72,945, while those in the County had a median value of $122,000 (U.S. Census Bureau 2000).

Table 4.8-4. Housing-Unit Type and Housing-Unit Median Value in the Vicinity of the Study Area

	Rural		Urban		Median Unit Value
Urban	Farm	Non-Farm	Inside	Outside	Median Value
Maricopa County	493	37,014	1,193,574	19,150	$122,000
Study Area	66	1,904	13,516	0	$72,945

Source: U.S. Census Bureau 2000

4.8.2.4 Employment

According to the Arizona Department of Economic Security (ADES), approximately 1,553,900 people were employed in Maricopa County in 2000, with employment expected to continue to grow in the region. Employment opportunities in the Phoenix-Mesa metropolitan area are expected to expand to 2,086,543 jobs by 2008; this would represent an 8-year increase of 532,643 jobs (2000–2008). In January 2002, the total civilian labor force in the County was 1,586,600, of which 1,501,000 were employed. Table 4.8-5, "Industry Employment in Maricopa County, January 2002," shows that there are 1,501,000 people currently employed in the County (Arizona Department of Economic Security 2002), a slight decrease from 2 years ago.

Table 4.8-5. Industry Employment in Maricopa County, January 2002

Jurisdiction	
Maricopa County	
Total Civilian Labor Force	1,586,600
Total Unemployment	85,600
Total Employment	1,501,000
Non-Farm Employment	1,528,500
Goods Producing	258,900
Mining and Quarrying	1,000
Construction	112,500
Manufacturing	145,400
Service Producing	1,269,600
Transportation, Communication, and Public Utilities	82,200
Trade	374,400
Financial, Insurance, and Real Estate	125,300
Government	

Jurisdiction	
Federal	19,700
State and Local	171,300

Source: Arizona Department of Economic Security (2002)

* Adjusted to the Current Population Survey (CPS 2002) to reflect place of residence. BENCHMARK YEAR 2001 QUARTER 1

Table 4.8-6, "Occupational Employment in the Vicinity of the Study Area," shows the major employment sectors within the County and study area for 2000 and the number of people employed in each sector. Approximately 1,427,292 people were employed in the County, and 18,490 people were employed in the study area. The two largest employment sectors in the County were Management/Professional and Sales/Office Occupations, which employed 33.9% and 29.7% of the work force, respectively. The largest employment sector in the study area was Sales/Office Occupations, which employed 25.9% of the work force, but the second largest was Production, Transportation, and Material Moving Occupations, which employed 19.6% of the work force. The third and fourth largest employment industries in the County as a whole were Service Occupations and Production, Transportation, and Material Moving Occupations employing 14.6% and 11.0 % of the work force, respectively. In the study area, the third and fourth largest employment sectors were Management/Professional Occupations and Service Occupations, employing 19.1% and 19.0% of the work force, respectively. The study area accounts for approximately 1.3% of the countywide employment for workers above 16 years of age (U.S. Census Bureau 2000).

Table 4.8-6. Occupational Employment in the Vicinity of the Study Area

Occupational Category	Number of Employees	Percent of Total
Maricopa County		
Management, professional, and related occupations:	483,582	33.9%
Management, business, and financial operations occupations:	209,597	14.7%
Management occupations, except farmers and farm managers	137,342	9.6%
Farmers and farm managers	1,553	0.1%
Business and financial operations occupations:	70,702	5.0%
Business operations specialists	34,441	2.4%
Financial specialists	36,261	2.5%
Professional and related occupations:	273,985	19.2%
Computer and mathematical occupations	43,317	3.0%
Architecture and engineering occupations:	38,728	2.7%
Architects, surveyors, cartographers, and engineers	28,634	2.0%

Occupational Category	Number of Employees	Percent of Total
Drafters, engineering, and mapping technicians	10,094	0.7%
Life, physical, and social science occupations	8,609	0.6%
Community and social services occupations	17,201	1.2%
Legal occupations	15,058	1.1%
Education, training, and library occupations	66,776	4.7%
Arts, design, entertainment, sports, and media occupations	27,471	1.9%
Healthcare practitioners and technical occupations:	56,825	4.0%
Health diagnosing and treating practitioners and technical occupations	39,718	2.8%
Health technologists and technicians	17,107	1.2%
Service occupations:	208,498	14.6%
Healthcare support occupations	20,623	1.4%
Protective service occupations:	28,056	2.0%
Fire fighting, prevention, and law enforcement workers, including supervisors	14,238	1.0%
Other protective service workers, including supervisors	13,818	1.0%
Food preparation and serving related occupations	68,582	4.8%
Building and grounds cleaning and maintenance occupations	50,917	3.6%
Personal care and service occupations	40,320	2.8%
Sales and office occupations:	423,504	29.7%
Sales and related occupations	179,982	12.6%
Office and administrative support occupations	243,522	17.1%
Farming, fishing, and forestry occupations	5,327	0.4%
Construction, extraction, and maintenance occupations:	149,539	10.5%
Construction and extraction occupations:	91,502	6.4%
Supervisors, construction and extraction workers	12,137	0.9%
Construction trades workers	78,914	5.5%
Extraction workers	451	0.0%
Installation, maintenance, and repair occupations	58,037	4.1%
Production, transportation, and material moving occupations:	156,842	11.0%
Production occupations	85,055	6.0%
Transportation and material moving occupations:	71,787	5.0%
Supervisors, transportation and material moving workers	2,364	0.2%
Aircraft and traffic control occupations	3,485	0.2%

Occupational Category	Number of Employees	Percent of Total
Motor vehicle operators	36,116	2.5%
Rail, water and other transportation occupations	2,831	0.2%
Material moving workers	26,991	1.9%
Total (for the 6 Major Categories):	1,427,292	-
Study Area		
Management, professional, and related occupations:	3,523	19.1%
Management, business, and financial operations occupations:	1,548	8.4%
Management occupations, except farmers and farm managers	963	5.2%
Farmers and farm managers	100	0.5%
Business and financial operations occupations:	485	2.6%
Business operations specialists	226	1.2%
Financial specialists	259	1.4%
Professional and related occupations:	1,975	10.7%
Computer and mathematical occupations	334	1.8%
Architecture and engineering occupations:	217	1.2%
Architects, surveyors, cartographers, and engineers	99	0.5%
Drafters, engineering, and mapping technicians	118	0.6%
Life, physical, and social science occupations	56	0.3%
Community and social services occupations	141	0.8%
Legal occupations	100	0.5%
Education, training, and library occupations	647	3.5%
Arts, design, entertainment, sports, and media occupations	155	0.8%
Healthcare practitioners and technical occupations:	325	1.8%
Health diagnosing and treating practitioners and technical occupations	144	0.8%
Health technologists and technicians	181	1.0%
Service occupations:	3,522	19.0%
Healthcare support occupations	338	1.8%
Protective service occupations:	402	2.2%
Fire fighting, prevention, and law enforcement workers, including supervisors	174	0.9%
Other protective service workers, including supervisors	228	1.2%
Food preparation and serving related occupations	1,136	6.1%
Building and grounds cleaning and maintenance occupations	1,064	5.8%

Occupational Category	Number of Employees	Percent of Total
Personal care and service occupations	582	3.1%
Sales and office occupations:	4,786	25.9%
Sales and related occupations	1,492	8.1%
Office and administrative support occupations	3,294	17.8%
Farming, fishing, and forestry occupations	225	1.2%
Construction, extraction, and maintenance occupations:	2,809	15.2%
Construction and extraction occupations:	1,697	9.2%
Supervisors, construction and extraction workers	167	0.9%
Construction trades workers	1,510	8.2%
Extraction workers	20	0.1%
Installation, maintenance, and repair occupations	1,112	6.0%
Production, transportation, and material moving occupations:	3,625	19.6%
Production occupations	1,975	10.7%
Transportation and material moving occupations:	1,650	8.9%
Supervisors, transportation and material moving workers	50	0.3%
Aircraft and traffic control occupations	18	0.1%
Motor vehicle operators	774	4.2%
Rail, water and other transportation occupations	58	0.3%
Material moving workers	750	4.1%
Total (for the 6 Major Categories):	18,490	-

In Maricopa County, 1,877,045 people are expected to be employed by the year 2010, and 2,212,889 people are expected to be employed by 2020. Although employment predictions are not available specifically for the study area, the City of Mesa is expected to have 214,936 persons employed by 2010, and 264,158 persons employed by 2020 (Maricopa Association of Governments 1997).

4.8.2.5 Income

Table 4.8-7, "Median Income in Maricopa County and the Vicinity of the Study Area," shows median household income for residents within Maricopa County and the study area for the year 2000. The median household income for the County was $45,358, whereas the median household income for the study area was $33,417 (U.S. Census Bureau 2000).

Table 4.8-7. Median Income in Maricopa County and in the Vicinity of the Study Area

Jurisdiction	Median Household Income
Maricopa County	$45,358
Study Area	$33,417 (avg.)

Source: U.S. Census Bureau 2000

4.8.3 ENVIRONMENTAL JUSTICE

In 1994, The President of the United States issued Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. The objectives of the executive order include developing federal agency implementation strategies, identifying minority and low-income populations where proposed federal actions could have disproportionately high and adverse human health and environmental effects, and encouraging the participation of minority and low-income populations in the NEPA process.

There are two types of data that must be reviewed to evaluate environmental justice effects: minority populations and income levels. Minority data for census tracts located within the study area were obtained from the recent 2000 census. Countywide statistics were reviewed to determine the percentage of the population not classified as Caucasian and the percentage classified as Hispanic. Using the county average for comparison, each of the census tracts in the study area was evaluated to determine whether the minority and/or Hispanic population percentages were greater than the county average. If a census tract percentage exceeded the county average, the tract was evaluated for environmental justice effects based on its minority population. Figure 4.8-1 shows the locations of the census tracts that meet this criterion and are evaluated for environmental justice impacts in this EIS.

The second criterion for an environmental justice analysis is income. Income data were obtained from the 2000 census and used in this analysis. To determine the locations of low-income populations, county income data were reviewed to determine the countywide percentage of households that have incomes below poverty levels. Then, the individual census tracts were evaluated to determine the percentage of households within the tract that have incomes below poverty levels. If a census tract percentage exceeded the county average, the tract was included in the analysis based on income levels. Figure 4.8-2 shows the locations of the census tracts that meet this criterion and are evaluated for environmental justice impacts in this EIS

Figure 4.8-1
Minority Populations
Project Study Area
City Boundaries
SRP-MIC
Thalweg
Canal
Highway
Local Roads
2000 Census block groups as compared to Maricopa County average for minority population as ratio of total population.
Block group has higher ratio than Maricopa County of minority population.
Block group has equal or lower ratio than Maricopa County of minority population.
0
0.5
1
Miles
Mapped by:
Jones & Stokes
INDIAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HIGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STANLEY DRIVE
NEBA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
87
202
60
101

Figure 4.8.2
Low Income Populations
Project Study Area
City Boundaries
SRP-MIC
Thalweg
Canal
Highway
Local Roads
2000 Census block groups as compared to Maricopa County average for population below poverty level (11.7%) as ratio of total population.
Block group has higher ratio than Maricopa County (> 11.7%) for population below poverty level
Block group has equal or lower ratio than Maricopa County (<= 11.7%) for population below poverty level
N
0
0.5
1
Miles
Mapped by:
Jones & Stokes
NOAN SCHOOL ROAD
THOMAS ROAD
MCDOWELL ROAD
MCKELLIPS ROAD
BROWN ROAD
POWER ROAD
RECKER ROAD
HAGLEY ROAD
GREENFIELD ROAD
VAL VISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STANLEY DRIVE
MESA DRIVE
COUNTRY CLUB DRIVE
ALMA SCHOOL ROAD
DOBSON ROAD
60
87
202

4.9 TRANSPORTATION

4.9.1 INTRODUCTION

This section discusses the transportation system that exists within the vicinity of the Va Shly'ay Akimel study area. A general description of the physical system is provided, along with current roadway conditions and the regulatory setting.

4.9.2 TRANSPORTATION SETTING

The Va Shly'ay Akimel project proposes restoration of a 14-mile reach of the Salt River extending from Granite Reef Dam to the SR 101/202 interchange. The dominant mode of transportation for this area is the automobile. Along this reach of the Salt River, there are four bridged crossings (including the interchange) and one at-grade crossing. Nearly all local streets and arterials near the Salt River form a north-south, east-west grid roadway network. Exceptions to this grid include the Beeline Highway (SR 87) and SR 202.

4.9.2.1 Interstate Highways

There are no interstate highways within 5 miles of the project study area. The nearest interstate highway is I-10, which is approximately 5 miles west of the SR 101/202 interchange.

4.9.2.2 State Highways

There are three state highways near the study area: SR 87, SR 101, and SR 202. SR 87 is also known as the Beeline Highway north of the Salt River and as Country Club Drive south of the Salt River. According to Arizona Department of Transportation (ADOT) staff, SR 87 is no longer an ADOT right-of-way through Mesa and Chandler (Catchpole pers. comm.). From the north, SR 87 parallels the Salt River in a southwesterly direction until it reaches the Country Club Drive alignment, at which point the roadway bears due south, crosses the Salt River, and becomes Country Club Drive. The crossing at the Salt River is a bridged, four-lane crossing. ADOT lists the Average Daily Traffic (ADT) volumes for the segment of SR 87 between McKellips Road and McDowell Road at 17,700 vehicles per day (ADOT 2002). The Level of Service (LOS) was listed as LOS B in 1996; however, no recent LOS data are available.

SR 101 is also known as the Pima Freeway and is a north-south freeway. SR 101 has a bridged crossing of the Salt River on the west end of the study area. The Pima Freeway is a six- to eight-lane freeway, with the majority of it being six lanes. Near the Va Shly'ay Akimel study area, SR 101 has on/off ramps at 8th Street in Mesa and at McKellips Road, McDowell Road, Indian School Road, and Chaparral Road along the west boundary of the Salt River Pima-Maricopa Indian Community (SRPMIC). ADOT lists the ADT volume for the segment of SR 101 between McKellips Road and McDowell Road at 134,000 vehicles per day (ADOT 2002). SR 202 is also

known as the Red Mountain Freeway and is an east-west freeway that generally parallels the south side of the Salt River in the study area. SR 202 is presently under construction. As of July 2000 it was open from SR 101 to Gilbert Road. In January 2003, the 4.5-mile stretch opened from Gilbert Road to Higley Road. As it continues eastward, the SR 202 alignment diverges from the Salt River, and is thereby outside the Va Shly'ay Akimel project area. East of Power Road, SR 202 turns south to intersect US 60 and continue as the Santan Freeway. The Red Mountain Freeway is a six-lane freeway, with on/off ramps at Dobson Road, Alma School Road, McKellips Road, Country Club Drive, Gilbert Road, McDowell Road, Thomas Road, Val Vista Drive, Greenfield Road, and Higley Road. ADOT lists the ADT volume for the segment of SR 202 between Dobson Road and McKellips Road at 94,000 vehicles per day (ADOT 2002).

Level of Service (LOS) Concept

The roadway system's ability to accommodate traffic demand is typically controlled and limited by the capacity of the intersections. Intersection capacity analysis is, therefore, a principal tool used in traffic engineering to determine the adequacy of a system to meet traffic demands.

Beginning in 1965, LOS concept has been used in traffic engineering to describe the quality of traffic flow and the degree of congestion a driver can expect. The concept defines the near-capacity condition as LOS "E," while a free-flow condition under which a driver would experience very little or no delay is defined as LOS "A." Capacity analysis is the procedure used to compare the forecast traffic volume with the theoretical carrying capacity of an intersection. The results of the capacity analysis provide an estimator of the quality of flow for that intersection.

Based on peak-hour turning movement counts, the LOS at each signalized intersection is calculated using methodologies as presented in Chapter 16 of the *Highway Capacity Manual 2000*, published by the Transportation Research Board. The capacity analysis methodologies for unsignalized intersections are outlined in Chapter 17 of the same document. For signalized intersections, LOS is based on control delay per vehicle, measured in seconds. Table 4.9-1 outlines the LOS concept for signalized intersections:

Table 4.9-1. Roadway Segment Level of Service

Level of Service	Control Delay per Vehicle (sec/vehicle)
A	≤ 10.0
B	> 10.0 and ≤ 20.0
C	> 20.0 and ≤ 35.0
D	> 35.0 and ≤ 55.0
E	> 55.0 and ≤ 80.0
F	> 80.0

Three key segments of highway had LOS statistics for 1996, but no more recent LOS data were available. The segment of SR 87 between McKellips Road and McDowell Road was listed as LOS B in 1996. The segment of SR 101 between McKellips Road and McDowell Road was listed as LOS C in 1996. The segment of SR 202 between Dobson Road and McKellips Road was listed as LOS A in 1996; SR 202 currently extends to Higley Road.

4.9.2.3 Local Roadway Network

The study area is elongated east-west and generally follows the Salt River floodplain (Figure 4.9-1). Several local roadways parallel the river, while others cross the river in a north-south direction. Nearly all local streets and arterials near the Salt River form a north-south, east-west grid roadway network. Typically, arterial roadways in Maricopa County have an ultimate section of six lanes with a left-turn lane or a raised median. Where it is required and possible, the City of Mesa will widen arterial sections to include three through lanes in each direction with dual left-turn lanes and one right-turn lane at intersections (Foy pers. comm.).

Tables 4.9-2 and 4.9-3 list major arterial roadways in the project area and their available present ADT volumes for the City of Mesa and the SRPMIC, and future estimated volumes for City of Mesa roadways.

Table 4.9-2. City of Mesa ADT Volumes

Location	2001 ADT (1,000s)	2025 ADT (1,000s)
University Drive, west of Dobson Road	26	29
University Drive, west of Alma School Road	27	31
University Drive, west of Country Club Drive	33	34
University Drive, west of Mesa Drive	38	39
University Drive, west of Stapley Drive	35	35
University Drive, west of Gilbert Road	35	35
University Drive, west of Lindsay Road	28	29
University Drive, west of Val Vista Drive	27	27
University Drive, west of Greenfield Road	22	23
University Drive, west of Higley Road	19	21
University Drive, west of Recker Road	NA	20
University Drive, west of Power Road	NA	19
Brown Road, west of Mesa Drive	31	33
Brown Road, west of Gilbert Road	24	30

Location	2001 ADT (1,000s)	2025 ADT (1,000s)
Brown Road, west of Lindsay Road	28	29
Brown Road, west of Val Vista Drive	25	26
Brown Road, west of Greenfield Road	24	26
Brown Road, west of Higley Road	22	26
Brown Road, west of Recker Road	24	26
Brown Road, west of Power Road	21	28
McKellips Road, west of Country Club Drive	53	NA
McKellips Road, west of Mesa Drive	61	52
McKellips Road, west of Stapely Drive	53	51
McKellips Road, west of Gilbert Road	50	51
McKellips Road, west of Lindsay Road	44	46
McKellips Road, west of Val Vista Drive	37	40
McKellips Road, west of Greenfield Road	29	34
McKellips Road, west of Higley Road	26	31
McKellips Road, west of Recker Road	26	29
McKellips Road, west of Power Road	17	29
McDowell Road, west of Lindsay Road	16	22
McDowell Road, west of Val Vista Drive	17	22
McDowell Road, west of Greenfield Road	17	22
McDowell Road, west of Higley Road	18	22
McDowell Road, west of Recker Road	18	20
McDowell Road, west of Power Road	11	18
Dobson Road, north of University Drive	13	18
Alma School Road, north of University Drive	26	33
Country Club Drive, north of University Drive	36	40
Country Club Drive, north of Brown Road	35	39
Country Club Drive, north of McKellips Road	31	NA
Mesa Drive, north of University Drive	21	25
Mesa Drive, north of Brown Road	15	20
Mesa Drive, north of McKellips Road	4	15
Stapely Drive, north of University Drive	25	25
Stapely Drive, north of Brown Road	17	18

Location	2001 ADT (1,000s)	2025 ADT (1,000s)
Stapely Drive, north of McKellips Road	1	NA
Stapely Drive, north of McDowell Road	0.3	NA
Gilbert Road, north of University Drive	24	26
Gilbert Road, north of Brown Road	22	22
Gilbert Road, north of McKellips Road	11	18
Lindsay Road, north of University Drive	25	26
Lindsay Road, north of Brown Road	19	19
Lindsay Road, north of McKellips Road	12	13
Val Vista Drive, north of University Drive	18	22
Val Vista Drive, north of Brown Road	13	20
Val Vista Drive, north of McKellips Road	7	18
Val Vista Drive, north of McDowell Road	1	12
Greenfield Road, north of University Drive	19	22
Greenfield Road, north of Brown Road	14	16
Greenfield Road, north of McKellips Road	7	12
Greenfield Road, north of McDowell Road	6	10
Higley Road, north of University Drive	28	38
Higley Road, north of Brown Road	22	34
Higley Road, north of McKellips Road	19	30
Higley Road, north of McDowell Road	5	22
Recker Road, north of University Drive	12	16
Recker Road, north of Brown Road	15	18
Recker Road, north of McKellips Road	13	19
Recker Road, north of McDowell Road	7	19
Recker Road, north of Thomas Road	3	NA
Power Road, north of University Drive	30	40
Power Road, north of Brown Road	22	32
Power Road, north of McKellips Road	16	25
Power Road, north of McDowell Road	9	18
Power Road, north of Thomas Road	4	NA

Source: City of Mesa 2002

Table 4.9-3. Salt River Pima-Maricopa Indian Community ADT Volumes

Location	2001 ADT (1,000s)
Chaparral Road, east of 92nd Street	2.2
Camelback Road, east of Dobson Road	0.3
Camelback Road, east of Alma School Road	0.6
Camelback Road, east of Mesa Drive	0.2
Indian School Road, east of 92nd Street	2.7
Indian School Road, east of Alma School Road	2.3
Indian School Road, east of Extension Road	2.2
Thomas Road, east of 92nd Street	1.3
Thomas Road, east of Extension Road	1.1
Thomas Road, east of Stapely Drive	0.6
92nd Street, north of McKellips Road	2.7
92nd Street, north of McDowell Road	0.4
92nd Street, north of Thomas Road	0.3
92nd Street, north of Camelback Road	0.1
Alma School Road, north of McDowell Road	1.8
Alma School Road, north of Thomas Road	1.6
Alma School Road, north of Camelback Road	0.8

Source: Salt River Pima-Maricopa Indian Community 2001

The following table (Table 4.9-4) lists available intersection LOS for arterial roadways in Mesa.

Table 4.9-4. Mesa Arterial Intersection LOS

Location	2001 Intersection Peak Hour LOS	
	AM	PM
University Drive/Dobson Road	E	E
University Drive/Alma School Road	C	D
University Drive/Country Club Drive	E	E
University Drive/Mesa Drive	D	D

Location	2001 Intersection Peak Hour LOS	
	AM	PM
University Drive/Stapley Drive	E	E
University Drive/Gilbert Road	F	F
University Drive/Lindsay Road	F	F
University Drive/Val Vista Drive	B	D
University Drive/Greenfield Road	D	F
University Drive/ Higley Road	F	F
University Drive/ Power Road	E	E
Brown Road/ Mesa Drive	F	F
Brown Road/Stapley Drive	F	F
Brown Road/ Gilbert Road	F	F
Brown Road/ Lindsay Road	F	F
Brown Road/ Val Vista Drive	F	F
Brown Road/ Greenfield Road	F	F
Brown Road/ Higley Road	F	F
Brown Road/ Recker Road	D	E
Brown Road/ Power Road	E	E
McKellips Road/ Country Club Drive	C	F
McKellips Road/ Mesa Drive	C	C
McKellips Road/ Stapely Drive	D	D
McKellips Road/ Gilbert Road	F	F
McKellips Road/ Lindsay Road	F	F
McKellips Road/ Val Vista Drive	F	F
McKellips Road/ Greenfield Road	E	F
McKellips Road/ Power Road	F	C
McDowell Road/ Recker Road	C	F
McDowell Road/ Power Road	B	C

Source: City of Mesa 2002

The SRPMIC 2001 Transportation Plan does not list current roadway or intersection LOS. The report lists roadway segments that are anticipated to be failing by the year 2020. The LOS analysis for roadway segments is based on a traffic volume-to-capacity ratio, with the LOS E ratio being 0.91 to 1.00 and the LOS F ratio being greater than 1.01. The year 2020 failing arterial roadway segments identified in the SRPMIC Transportation Study include:

- Alma School Road from McKellips Road to Indian School Road,
- Mesa Drive from SR 87 to Indian School,
- Gilbert Road from SR 87 to Shea Boulevard,
- McKellips Road from SR 101 to SR 87,
- McDowell Road from SR 101 to SR 87,
- Thomas Road from Dobson Road to SR 87,
- Indian School Road from Dobson to Mesa Drive, and
- SR 87 from Center Street to Gilbert Road.

Four local roadways cross the Salt River in the study area; one crosses the river at grade, while the others have bridges spanning the floodplain. These roadways are:

- Alma School Road (bridge),
- Country Club Drive/SR 87 (bridge),
- Gilbert Road (bridge), and
- McKellips Road (at grade).

4.9.2.4 Railroads

No railroad lines cross the Salt River within the study area.

4.9.2.5 Airports

Two airports operate near the study area. These include Phoenix Sky Harbor International Airport and Mesa Falcon Field Municipal Airport. Phoenix Sky Harbor International Airport is 6 miles to the west of the study area. This airport handles both commercial and Air National Guard aircraft. Mesa Falcon Field Municipal Airport is located on the southeast corner of McDowell Road and Greenfield Road in Mesa, approximately ½ mile south of the southern boundary of the project study area.

4.9.3 REGULATORY SETTING

The Va Shly'ay Akimel project could potentially affect local roadway conditions, access, and through traffic flow. It may be necessary to obtain encroachment permits or similar legal agreements from the respective public agencies responsible for the numerous roadways through the study area. Such permits would be needed for any location where an activity would occur physically within the right-of-way of a public road. The regulatory setting of the transportation network in the area is guided by numerous governmental and political jurisdictions, which would be responsible for issuing such permits. Throughout the study area, these agencies include the

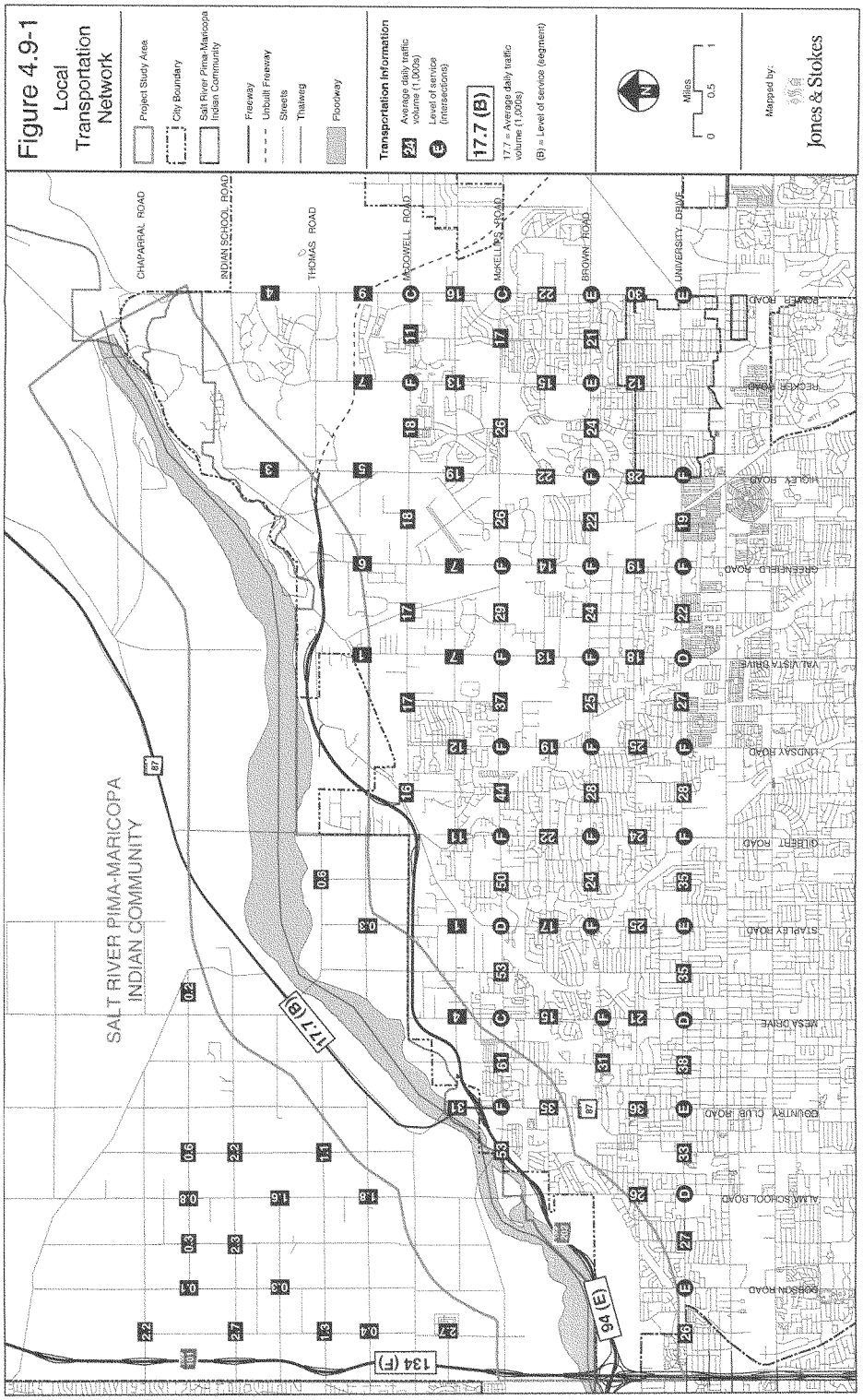


Figure 4.9-1
Local Transportation Network
Project Study Area
City Boundary
Salt River Pima-Maricopa Indian Community
Freeway
Unbuilt Freeway
Streets
Thalweg
Floodway
Transportation Information
Average daily traffic volume (1,000s)
Level of service (intersections)
17.7 (B)
17.7 = Average daily traffic volume (1,000s)
(B) = Level of service (segment)
Miles
0
0.5
1
Mapped by:
Jones & Stokes
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
CHAPARRAL ROAD
INDIAN SCHOOL ROAD
THOMAS ROAD
McDOWELL ROAD
McKELLIPS ROAD
BROWN ROAD
UNIVERSITY DRIVE
POINSETTIA ROAD
HIGLEY ROAD
GREENFIELD ROAD
VALVISTA DRIVE
LINDSAY ROAD
GILBERT ROAD
STANLEY ROAD
MESA DRIVE
COUNTRY CLUB ROAD
ALMA SCHOOL ROAD
GOSSON ROAD
87
202 (E)
101 (E)
134 (F)
17.7 (B)
94 (E)

City of Mesa, SRPMIC, Maricopa County Department of Transportation, ADOT, and the Federal Aviation Administration.

4.10 LAND USE

4.10.1 INTRODUCTION

This section describes the existing land uses and recreational opportunities in the vicinity of the Va Shly'ay Akimel study area. A discussion of the various planning organizations with jurisdiction in the area is provided, along with information on the regulatory setting for future development projects in the area.

4.10.2 LAND USES IN THE PROJECT STUDY AREA

The proposed Va Shly'ay Akimel project activities will occur primarily within the Salt River floodplain. The general area is characterized by relatively flat topography, and there are a variety of land uses throughout the study area.

The land use pattern is made up of a patchwork of jurisdictional and political boundaries between the City of Mesa (the City), unincorporated areas of Maricopa County (the County), and the Salt River Pima-Maricopa Indian Community (SRPMIC). Remnant County islands are located in two locations within the study area and are completely surrounded by the City and the SRPMIC. These lands are within the City's sphere of influence and would likely be annexed by the City as growth and development reaches the area.

Several gravel mining operations are located along the Salt River, with processing operations occurring along its banks. The river contains a large groundwater recharge basin in the central portion of the study area, just east of North Gilbert Road.

The land area north of the Salt River is generally within the SRPMIC reservation. Upland areas south of the river are generally within the City's jurisdiction, but islands of unincorporated areas of the County are also present. A clear contrast is evident between the rural and open character of the upland areas north of the river, within the SRPMIC reservation, and the more urbanized area south of the river, within the City's sphere of influence.

Created by Executive Order in 1879, the SRPMIC consists of 52,600 acres, located 15 miles northeast of the City of Phoenix. The SRPMIC is home to nearly 6,000 enrolled members representing two pre-American Sovereign Indian tribes, the Pima and Maricopa. The SRPMIC maintains 19,000 of its acres as natural preserve. The secondary land use is agriculture, which supports a variety of crops, including cotton, melons, potatoes, brown onions, and carrots (Salt River Pima-Maricopa Indian Community 2002). The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands. Gravel mining and processing, two closed landfills, and other industrial operations have a significant influence on land use patterns in the western portion of the study area that is located along the north banks of the river. Other land uses are scattered intermittently throughout the area along the north banks of the river, including a shooting range, a recreational vehicle park, private farms, and a commercial golf course.

The west and central portions of the study area south of the river and within the City's sphere of influence are largely made up of very low-density rural residential uses to higher-density suburban residential uses. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern portion of the study area. The south banks of the river are also scattered with gravel mining and processing operations.

4.10.3 REGULATORY SETTING

Although the proposed project is being undertaken by the U.S. Army Corps of Engineers (Corps), the State, County, City, and SRPMIC have jurisdiction over planning and development decisions within their respective political boundaries in the study area. Regulatory requirements and future growth policies for these organizations are identified within several different planning documents. The regulatory setting for each of these organizations is presented below.

4.10.3.1 State of Arizona

In recent years, the State of Arizona adopted growth management legislation, known as "Growing Smarter" and "Growing Smarter Plus," in response to concerns about the rates of population growth in communities throughout the state. This legislation requires all cities in Arizona to update their General Plans. These laws were enacted to improve the way cities plan for future growth, expansion, and redevelopment by

- reforming local planning and zoning procedures,
- increasing citizen participation in growth and planning issues, and
- adjusting State Land Trust policies to preserve open space and enhance conservation.

City and county plans are required to include new elements and/or modify existing elements. Additionally, each municipality must coordinate their plan with other plans in the region. The Growing Smarter Act mandates five new elements to be added to municipal plans:

16. Open Space
17. Growth Areas
18. Environmental Planning
19. Cost of Development
20. Water Resources

The Act provides for increasing public participation, as well as modifying existing procedures regarding adoption, re-adoption, and amendments to the General Plan. Written procedures must be in place to provide for:

- Public participation,
- Public hearings, and
- Consultation with school districts, public utilities, associations of governments, and public land management agencies.

The State Land Department is also required to prepare a conceptual land use plan, with an annual 5-year disposition or development plan for all trust lands located in urban areas, and it must identify lands projected for sale, lease, reclassification, or rezoning over each period.

The 2000 legislation requires that voters ratify new community plans at least once every 10 years. If a proposed new plan fails to receive a sufficient number of votes, the existing plan remains in effect. Minor amendments to an existing plan must be approved by the City Council.

During the 2002 legislative session, HB 2601 was introduced to address issues with the Growing Smarter legislation that were identified by stakeholders statewide through the efforts of the Growing Smarter Oversight Council. The bill was signed by Governor Jane Hull on May 6, 2002. The amendments included:

- An extension of the deadline for the adoption of updated General or Comprehensive Plans. Given their population size categories, Mesa, as a municipality over 75,000 persons and Maricopa, as a county over 125,000 persons were allowed one additional year to 12/31/02.
- Clarification of language regarding the water resources element. A new requirement was added that included an analysis of how the demand from future projected growth will be served by the legally and physically available supplies or a plan to obtain additional necessary supplies. Also, ADWR is now included in the review and comment process on all water resources elements.
- Revises the requirements for the 60-day review period. The time frame for the review and comment period by affected entities is now at least 60 days prior to the notice of hearing by the planning commission.

4.10.3.2 Maricopa County

Portions of the study area are within unincorporated areas of the County and are governed by County planning and development activities.

4.10.3.2.1 Maricopa County Comprehensive Plan

As required by state law, Maricopa County prepared a comprehensive plan "to conserve the natural resources of the County, to ensure efficient expenditure of public funds, and to promote the health, safety, convenience, and general welfare of the public" (Maricopa County 1997). The plan provides a guide for decisions made by the planning and zoning commission and the board of supervisors concerning growth and development. In response to Growing Smarter/Growing Smarter Plus, Maricopa County achieved certification of portions of its 1997 plan as compliant

with the legislation. Complete compliance with Growing Smarter/Growing Smarter Plus required the addition of some elements, accomplished in 2002. One of the new elements, "Environmental Effects," contains some goals, objectives, and policies pertinent to the project

The County lands within the study area are designated as a "General Plan Development Area" on the County's land use map. These areas are defined as unincorporated areas that are likely to be annexed by a city or town in the future and are included in an adopted municipal general plan. As is the case within the study area, these areas often include many of the unincorporated lands that are either surrounded by a jurisdiction or surrounded by a strip annexation. The County will take into consideration the general plans of municipalities within these areas to guide decision making under the following circumstances: 1) the municipal plan has been updated in the previous five years; and 2) the municipality can demonstrate that residents, property owners, and improvement districts from the unincorporated areas in the specific planning area have been involved in the planning process (Maricopa County 1997). The City of Mesa General Plan meets these criteria and is discussed later in this chapter.

The Salt River itself is identified as "Proposed Open Space" on the land use map. This designation recognizes that natural resources and open spaces are important to the quality of life in the county and, if acquired, are intended to be planned and managed to protect, maintain, and enhance their intrinsic value for recreational, aesthetic, and biological purposes. Additionally, the General Plan provides that public access should be protected and preservation shall be encouraged. When combined with Dedicated Open Space lands, the Proposed Open Spaces are intended to establish an interconnected system of protected natural open spaces, corresponding to regionally significant mountains, rivers, washes, upland desert, and cultural resources in unincorporated areas of the County (Maricopa County 1997).

The County's size and environmental diversity is greater than many states, and it provides a complex natural ecosystem. As part of the overriding vision for the County, protection of the unique desert environments is identified among the top priorities. The Maricopa County Comprehensive Plan focuses on maintaining and improving the physical environment, natural resource conservation, and other environmental considerations. Additionally, the plan recognizes the importance of creating, improving, and conserving natural habitat and open space to increase biological diversity. River and wash policies include discouraging development within 100-year floodplains, maximizing wildlife habitat and native vegetation along waterways, and developing management principles to protect the natural riparian habitat of the region (Maricopa County 1997).

The Maricopa County Comprehensive Plan is arranged in a series of elements, each containing a series of goals, objectives, and policies used to define development standards and to guide public investment and public and private decision-making (Maricopa County 1997). Listed below are several goals and policies in the Maricopa County Comprehensive Plan (both 1997 and 2002 additions) that are relevant to the proposed project.

Land Use Element (Maricopa County 1997)

Goal: Promote efficient land development that is compatible with adjacent land uses, is well integrated with the transportation system, and is sensitive to the natural environment.

Objective L10: Promote the balance of conservation and development.

Policy L10.1: Encourage the preservation of environmentally sensitive areas through the transfer of development rights, density transfers, or other suitable techniques.

Objective L11: Promote an interconnected open space system.

Policy L11.1: Determine, encourage, and support techniques for acquisition and maintenance for open space.

Policy L11.3: Encourage the protection of ridgelines, foothills, significant mountainous areas, wildlife habitat, native vegetation, and riparian areas.

Transportation Element (Maricopa County 1997)

Goal: Promote an efficient, cost-effective, integrated, accessible, environmentally sensitive, and safe countywide multi-modal system that addresses existing and future roadway networks and promotes transit, bikeways, and pedestrian travel.

Environmental Element (Maricopa County 1997)

Goal 1: Promote development that considers adverse environmental impacts on the natural and cultural environment, preserves highly valued open space, and remediates areas contaminated with hazardous materials.

Objective E4: Encourage the protection of habitat.

Policy E4.4: Explore incentives to preserve habitat.

Policy E4.5: Explore methods to acquire lands classified as priority habitat areas as part of an open space plan.

Objective E5: Promote the protection and preservation of riparian areas.

Policy E5.1: Encourage site evaluation and classification of riparian areas as required by the Corps 404 permit program or by other state or federal laws, regulations, and/or guidelines.

Policy E5.2: Consider incentives and options for preservation.

Environmental Effects Element (Maricopa County 2002)

Goal 1: Encourage development that considers environmental impacts on air quality, water quality, and sensitive plant and wildlife species, as well as the impacts that noise exposure has on health and quality of life.

Goal 3: Encourage development that minimizes environmental hazards.

Objective E2: To help improve water quality, encourage development that minimizes land disturbance to reduce soil erosion and sedimentation in rivers, streams, and washes.

Policy E2.1: Encourage development that minimizes blading, cutting, and filling.

Policy E2.2: Encourage development that minimizes disturbance of the natural desert environment and utilizes native soils, plants, and existing topography.

Objective E4: Encourage protection and preservation of sensitive plant and wildlife habitat and riparian areas within the framework of state and federal laws, regulations, and guidelines.

Policy E4.1: Encourage protection of plants identified by the Arizona Native Plant Law.

Policy E4.2: Encourage protection of all endangered and threatened plants and wildlife designated on the Endangered Species List for Maricopa County.

Policy E4.3: Encourage the development of corridors linking established and proposed open space areas to allow migration of wildlife and encourage biodiversity of species.

Objective E7: Encourage development that protects air quality, water quality, and water resources; that minimizes soil and waterway disturbance; that mitigates noise problems; and that preserves historic resources.

Policy E7.1: Promote development that minimizes grading and blading of the landscape.

Policy E7.2: Promote development that emphasizes protection of waterways.

4.10.3.3 City of Mesa

The City of Mesa General Plan was adopted by City Council on June 24, 2002 and passed by the voters in the City election of November 5, 2002. It provides a vision and guide to the community's citizens, businesses, and officials as the community grows and develops in the future (City of Mesa 2002). The General Plan defines seven subareas that have particular features or land use issues for consideration in the land use plan. Some portions of the city, including some of the areas within the study area, are not within a defined subarea. Those subareas that overlap the study area include, from west to east, Mesa Grande, Lehi, and Falcon Field.

The vision of the Mesa 2025 General Plan is to provide for a prosperous and economically balanced community, to address the need for future housing and employment opportunities, and to support Mesa as a sustainable community in the 21st century. While 2025 is a reference year used for some purposes in the General Plan, the General Plan's Land Use Plan map presents "buildout" land use rather than the prospective land use in a particular future year.

Each element includes Goals, Objectives, and Policies. Several goals and policies in the Mesa General Plan that may be relevant to the proposed project are listed below under the title for the General Plan Element in which they appear. The pertinent elements are Parks, Recreation, and Open Space and Environmental Planning and Conservation.

Environmental Planning and Conservation Element

This element addresses the quality of the environment and the conservation of natural resources. It also addresses the protection of Mesa's historic sites and structures. It combines the provisions of the Environmental Planning Element and the Conservation Element as required by the Arizona Growing Smarter Statute.

The following goals, objectives, and policies of the Environmental Conservation Element are relevant to the proposed project:

Goal EPC-3: Provide for the protection and wise use of the resources of the natural environment in Mesa.

Objective EPC-3.1: Maintain connections between wildlife habitats by identifying and protecting corridors for unimpeded movement.

Policy EPC-3.1a: Establish sufficient trails, wildlife corridors, and other linear linkages between large open space areas.

Policy EPC-3.1b: Require an effective means for the safe and uninterrupted movement of wildlife through open space corridors at all infrastructure and roadway crossings.

Policy EPC-3.1c: Encourage the design of walls and fences to not disrupt natural wildlife movement patterns and design all infrastructure and roadways to minimize the impact on wildlife corridors.

Policy EPC-3.1e: Design public recreational spaces to be wildlife-friendly whenever possible.

Policy EPC-3.1f: Promote enhanced landscaping along washes and wildlife corridors to promote the use of such areas by native wildlife.

Policy EPC-3.1g: Encourage the establishment of open space lands that restrict and/or limit human use to protect significant plant and animal habitats.

Policy EPC-3.1h: Encourage the preservation of a system of linkages, connections, and gateways between significant open spaces and significant animal and plant habitats.

Objective EPC-3.2: Promote the protection, enhancement, and establishment of native vegetation and plant species.

Policy EPC-3.2c: Promote the restoration and re-vegetation of disturbed areas with native plant species so that the disturbed area, over a reasonable amount of time, matches the plant densities of the undisturbed setting.

Policy EPC-3.2d: Recognize and protect areas of significant natural vegetation (such as areas along washes, natural spring areas, or on slopes) that are advantageous to the increased densities of the native vegetation.

Objective EPC-3.3: Ensure that new development recognizes limitations associated with the natural features of the land, including slope, unstable soils, and floodplains.

Policy EPC-3.3k: Restrict development in floodplains and floodways according to FEMA designations.

Parks, Recreation, and Open Space Element

The City of Mesa is committed to providing meaningful parks and open spaces through a variety of recreational venues, both passive and active, for all residents to enjoy. This element describes the goals, objectives, and policies that will meet these needs. Specific details are contained in the Parks and Recreation Master Plan.

The following goals, objectives, and policies of the Recreation Element are relevant to the project:

Goal PR-1: Create a balanced, accessible, and integrated system of open spaces and recreational opportunities to serve the current and future residents and visitors of the City of Mesa.

Objective PR-1.1: Provide a meaningful network of natural and developed open space areas.

Policy PR-1.1a: Identify lands for potential acquisition to preserve Open Space for recreational, aesthetic and preservation uses.

Policy PR-1.1c: Strive to acquire open space acreage as defined in Table 9.1 and further described in the Parks and Recreation Master Plan.

Objective PR-1.2: Manage and preserve open space to optimize its use and protection.

Policy PR-1.2b: Continue to create a plan for securing use licensing and maintaining a dedicated trail system with SRP assistance.

Policy PR-1.2e: Encourage the preservation of significant natural areas such as the Salt River corridor to enhance their recreation attraction and aesthetic value.

Policy PR-1.2f: Limit development in the areas that may pose natural or manmade environmental hazards such as steep slopes and flood plains.

Policy PR-1.4a: Encourage the development of innovative specialty parks to provide new recreation opportunities. An example of this includes linear pedestrian/bicycle/open space systems in the floodways and utility corridors throughout the City.

Objective PR-1.5: Promote an interconnected open space network that responds to local and regional needs.

Objective PR-1.6: Coordinate open space plans, related improvements and implementation strategies with neighboring jurisdictions, stakeholders and user groups.

Policy PR-1.6a: Coordinate the provision of river trail linkages with Maricopa County, the Flood Control District of Maricopa County, the Town of Gilbert, and the Cities of Chandler, Tempe and Scottsdale.

Policy PR-1.6b: Work with Maricopa County and other appropriate agencies and stakeholders to identify and preserve or protect environmentally sensitive areas and open space sites within new annexation areas of the City.

Objective PR-2.4: Strive to establish pedestrian connections between open space and parks.

Policy PR-2.4a: Through the Parks and Recreation Master Plan, integrate drainage and utility easements into the circulation plan.

Objective PR-2.6: Require that useable open space and recreational facilities be an integral part of all residential planned area developments.

Policy PR-2.6a: Encourage park designs that promote integration with surrounding demographics and land uses, provide pedestrian connections to adjacent neighborhoods, and contribute to the neighborhood's character and identity.

4.10.3.4 Salt River Pima-Maricopa Indian Community

The SRPMIC is considered a sovereign nation and is not under the regulatory or political jurisdiction of any of the local governments in the area or the U.S. federal government. All land use activities are guided by the SRPMIC's established procedures and activities. The SRPMIC adopted a general development plan in December 1988. The land uses in the project area include agriculture, commercial, industrial, natural resources, open space, public use, and residential. The SRPMIC does not have specific land use regulatory mechanisms, but has generally zoned portions of the SRPMIC along the Salt River as natural resources, agriculture, open space, and industrial use areas.

4.11 RECREATION

4.11.1 INTRODUCTION

This section presents the existing recreational opportunities in the vicinity of the Va Shly'ay Akimel study area. A discussion of the planning organizations with jurisdiction in the area is provided along with information on the regulatory environment guiding recreational facilities in the area.

The project study area (Figure 4.11-1) is located within the boundaries of the following local government jurisdictions: Maricopa County, the City of Mesa, and the Salt River Pima-Maricopa Indian Community (SRPMIC). Remnant County islands, which are completely surrounded by the City of Mesa and the SRPMIC, are located in two locations within the study area. These lands are within the City of Mesa's sphere of influence and would likely be annexed by the City as growth and development reaches the area.

There are few regional recreational facilities in the vicinity of the project study area. Papago Park is located just north of the Salt River in eastern Phoenix and western Tempe. It includes about 1,400 acres bounded on the north by Oak Street, on the south by State Highway 202, on the west by 52nd Street and on the east by 68th Street. The park includes: rock formations dating back 15 million years, ramadas, picnic facilities, three fish ponds stocked with rainbow trout and channel catfish, a baseball stadium, a softball complex, volleyball courts, a zoo, botanical gardens, a state historical museum, two golf courses, an archery shooting range, nature trails, and restrooms.

Maricopa County provides a countywide system of trails; the primary component of which is the Sun Circle Trail. The Sun Circle Trail, when completed, will encircle the Phoenix metropolitan area (Maricopa County 1982). The Sun Circle Trail will provide opportunities for hiking, horseback riding, and bicycling.

North and east of the study area are the McDowell, Goldfield, and Usery Mountains. Some of the recreational uses in these areas include fishing, camping, hiking, biking, and horseback riding.

4.11.2 EXISTING RECREATION ENVIRONMENT

4.11.2.1 Maricopa County

The area within and surrounding SRPMIC lands and the City of Mesa, does not currently have any significant dedicated riparian habitat areas with supporting recreation facilities. Dedicated open space exists in the form of regional parks, wilderness areas, wildlife areas, and passive open space that provide recreation and visual resources for the residents of the area (Maricopa County 1997). Primary recreation areas in Maricopa County include the following:

National Trails Systems

- North Mountain Trail: consisting of 9 miles of trails located in northwest Phoenix.
- South Mountain Trail: consists of 14 miles of desert trails in the center of South Mountain Park, providing for hiking and horseback riding.
- Sun Circle Trail: 110 miles of urban to open desert trails forming a loop around the Phoenix metropolitan area for hiking and bicycling.
- Squaw Peak Trail: includes 1.2 miles of urban wilderness area.

State Parks

- Painted Rocks State Park: 140-acre historical park located 15 miles west of Gila Bend.
- Lost Dutchman State Park: 300 acres of desert park on the Apache Trail located near the Maricopa/Pinal County border that includes picnic facilities, restrooms, and 35 campsites.

BLM Lands

- Greenbelt Resource Conservation Area located south of Buckeye: includes hunting and hiking.

State Game and Fish Department

- Black Canyon Shooting Range: includes 1,290 acres located 20 miles north of Phoenix.
- Base and Meridian: 173 acres of wildlife habitat located 3 miles south of Cashion.
- Gila River Wildlife Area: 6,896 acres of wildlife habitat extending from Avondale to the Gillespie Dam.

Major Water Bodies

- Apache Lake Marina: located 35 miles east of Phoenix in Maricopa and Gila County.
- Bartlett Lake: Maricopa County (35 miles northeast of Phoenix).
- Canyon Lake: Maricopa County (30 miles east of Phoenix).
- Lake Pleasant: Maricopa and Yavapai County (25 miles north of Phoenix).
- Saguaro Lake: Maricopa County (25 miles east of Phoenix).

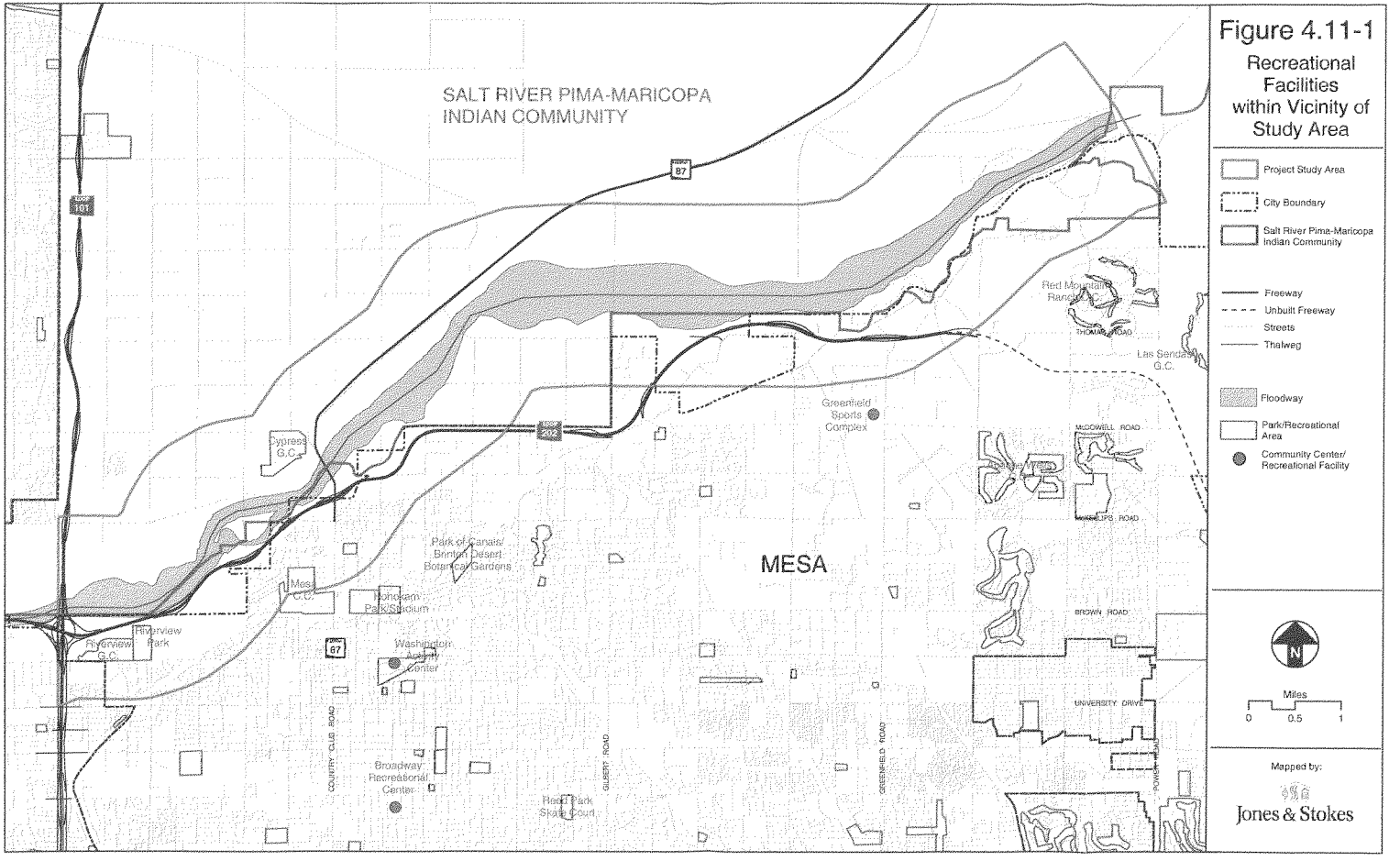


Figure 4.11-1
Recreational Facilities within Vicinity of Study Area

Maricopa County

- Estrella Regional Park: 18,000 acres located 3 miles south of Goodyear.
- Thunderbird Park/Adobe Dam
- Cave Buttes Recreation Area

4.11.2.2 City of Mesa

Within the City of Mesa there are approximately 55 traditional park sites. Mesa Parks are classified into four groups based on size, service area, typical recreation facilities provided, and public emphasis. The four groups are neighborhood parks, community parks, district parks, and specialized facilities/areas. In addition to parks, the City also has seven recreation centers and sports complexes (Broadway Recreation Center, Gene Autry Sports Complex, Hohokam Stadium, Jefferson Gym/Recreation Center, Red Mountain Multigenerational Center, Reed Park Skate Court, Washington Activity Center. Recreational facilities within the City also include 13 public swimming pools, as well as special facilities (such as museums and stadiums). The closest recreational facilities to the Va Shly'ay Akimel study area is the Riverview Golf Course and Riverview Park; both located near the west end of the study area in the City of Mesa. Riverview Golf Course is located at 2202 W. 8th Street and is a regulation nine-hole course. Riverview Park is located at 2100 W. 8th Street and comprises soccer fields, four lighted softball fields, playground, restrooms, two lighted basketball courts, hard-surface volleyball court, and a lake within a 51-acre area (City of Mesa 2001).

In the project study area, the existing streambed consists primarily of a dry wash with no recreational facilities or public access for recreation.

Tempe Town Lake

Another recreational feature downstream from the project study area in the City of Tempe is the Tempe Town Lake. The 220-acre Tempe Town Lake is contained within the Salt River flood channel using inflatable dams, a water pump system, and slurry walls. Resorts, restaurants, retail shops, and a marina are planned for the neighboring areas.

Rio Salado Project

The Rio Salado Project is a planned recreational and habitat restoration project that will restore the Salt River to a more natural state. The recreational elements associated with this project would include trails, scenic overlooks, interpretive centers, gathering areas, parking, restrooms, and shade structures. Activities along the project area would include bird watching, hiking, biking, and equestrian uses, wildlife observation, and fishing. The Rio Salado project is located downstream from the project study area.

4.11.2.3 Salt River Pima-Maricopa Indian Community

No parks that fall within the jurisdiction of the SRPMIC were observed within the Va Shly'ay Akimel study area. However, the Cypress Golf Course and a recreational vehicle park and shooting range are located within 1/4 mile of the study area.

4.11.3 REGULATORY ENVIRONMENT

Maricopa County, the City of Mesa, and SRPMIC have jurisdiction over respective planning and development decisions in the study area. Unincorporated land in the study area falls within the City of Mesa's sphere of influence and would likely be annexed by the City, which would have jurisdiction over planning new recreational facilities.

4.11.3.1 Maricopa County

Portions of the study area are within unincorporated Maricopa County. The Maricopa County Comprehensive Plan contains goals and policies related to recreation facilities (Maricopa County 1997.

The Comprehensive Plan seeks to establish a network of protected open spaces that correspond to regionally significant mountains, rivers, washes, and upland deserts. Parks and recreation facilities are a form of secured open space that provide the foundation of a coordinated outdoor recreation system and contribute to the County's quality of life. Existing publicly owned recreation areas include neighborhood and community parks, Maricopa County regional parks (largest county park system in the country), State Game and Fish lands, and a municipal mountain preserve. These lands provide recreational opportunities within or near urbanized areas. The Comprehensive Plan recommends acquisition of open space to meet the passive and active recreation needs of the region's population.

Dedicated open space areas are those areas that are under public ownership (except state trust land) that have unique environmental and physical qualities. These areas include mountains and foothills, rivers and washes, canals, significant desert vegetation, wildlife habitat, and cultural resources. Within Maricopa County, dedicated open space exists in the form of regional parks, wilderness areas, wildlife areas and the Tonto National Forest. Dedicated open space currently comprises approximately 2,000 square miles, with another 650 square miles of proposed open space in the unincorporated areas of the county. Open space provides recreation and visual resources for the residents of Maricopa County. The Maricopa County Comprehensive Plan transportation element contains the following goal related to recreational facilities:

Goal: Promote an efficient, cost-effective, integrated, accessible, environmentally sensitive, and safe countywide multimodal system that addresses existing and future roadway networks, as well as promotes transit, bikeways, and pedestrian travel.

4.11.3.2 City of Mesa

The City of Mesa General Plan defines the direction of growth and the type of development that is desired and expected to occur in Mesa between 2002 and 2025 (City of Mesa 2002). The General Plan is a guide for Mesa's future development that presents the community's vision through broad goals and objectives.

The City of Mesa's Parks and Recreation Division developed a Parks and Recreation Plan to provide more detailed analysis of the City's recreation and open space needs for the future. The plan was completed in August 2002 and the goals, objectives and policies contained therein were incorporated into the City's General Plan.

The general park standards the City developed and identified are listed below in Table 4.11-1.

Table 4.11-1. City of Mesa Park Standards

Type of Facility	Description	Park Size	Service Radius/Siting Criteria
Neighborhood Park	Serves the recreational and social focus of the neighborhood	3-15 acres (3 acres min.)	½ mile
Neighborhood Park/School	Can fulfill the space requirements for other park classes	3-15 acres	½ mile (Elem./Jr. High School) 3 miles (High School) Determined by location of school enrollment boundary
Community Parks		15-40 acres	3 miles Serves two or more neighborhoods
Urban Paths and Trails	Open space linkages for parks within the community	Varies, based on resource availability and opportunity	Varies
Metro Parks	Serves as a special use park, typically for sports and/or signature facilities	40-200 acres	2-3 miles
Regional Park	Serves the entire community with a significant level of park space dedicated to active and passive users	200+ acres	Entire city

Source: City of Mesa 1996

Several goals and policies in the Mesa General Plan that may be relevant to the proposed project are provided below under the respective General Plan Elements.

Transportation Element

Goal T-1. Provide a balanced, multi modal transportation system for the City of Mesa that supports the safe and efficient movement of people and goods.

Objective T-1.4. Create a comprehensive system of bicycle facilities, programs, and services.

Policy T-1.4b. Develop an interconnected network of shared use paths along canal banks, utility easements, and roadway rights-of-way to link open spaces, parks, recreational facilities, and schools throughout the City and into adjacent jurisdictions.

Recreation Element

Goal PR-1. Create a balanced, accessible and integrated system of open spaces and recreational opportunities to serve the current and future residents and visitors of the City of Mesa.

Objective PR-1.1. Provide a meaningful network of natural and developed open space areas.

Policy PR-1.1c. Strive to acquire open space acreage as defined in Table 9.1 [Table 4.11-1 above] and further described in the Parks and Recreation Master Plan.

Objective PR-1.2. Manage and preserve open space to optimize its use and protection.

Policy PR-1.2b. Continue to create a plan for securing use licensing and maintaining a dedicated trail system with SRP assistance.

Objective PR-1.4. Enhance recreational opportunities through the multi-purpose use of open space resources.

Policy PR-1.4a. Encourage the development of innovative specialty parks to provide new recreation opportunities. An example of this includes linear pedestrian/bicycle/open space systems in the floodways and utility corridors throughout the City.

Environmental Planning and Conservation Element

Goal EPC-3. Provide for the protection and wise use of the resources of the natural environment in the City of Mesa

Objective EPC-3.1. Maintain connections between wildlife habitats by identifying and protecting corridors for unimpeded movement.

Policy EPC-3.1a. Establish sufficient wildlife trails, corridors, and other linear linkages between large open space areas.

Policy EPC-3.1e. Design public recreational spaces to be wildlife-friendly whenever possible.

Policy EPC-3.1g. Encourage the establishment of open space lands that restrict and/or limit human use to protect significant plant and animal habitats.

Policy EPC-3.1h. Encourage the preservation of a system of linkages, connections, and gateways between significant open spaces and significant animal and plant habitats.

Economic Development Element

Goal ED-3. Utilize the competitive advantages of the City and region to promote Mesa as a community where people may live, learn work, shop, and play.

Objective ED-3.4. Maintain a well-rounded community in terms of recreational, cultural, educational, and health care opportunities.

Policy ED-3.4a. Support the expansion of the City's parks and recreation system and facilities.

4.11.3.3 Salt River Pima-Maricopa Indian Community

The Salt River Pima-Maricopa Indian Community is considered a sovereign nation and is not under the regulatory or political jurisdiction of any of the local governments in the area or the U.S. federal government. All land use activities are guided by the tribal community's established procedures and regulations. The tribal community does not have any established regulations or plans for recreational facilities.

4.12 PUBLIC HEALTH AND SAFETY

4.12.1 INTRODUCTION

This section describes the existing environmental conditions in the Va Shly'ay Akimel study area relating to public health and safety, including hazardous and toxic materials. In addition, the various regulations relating to the handling and use of hazardous materials are described.

4.12.2 GENERAL PROJECT SETTING

The Salt River is a terraced, low-gradient river. Historically, its flow has been directed by development, dating back to Native American use of the river for irrigation. Presently, the Salt River is mostly a dry riverbed whose flow is dependent on large storm events, treatment plant releases, or upstream dam releases.

Depth to groundwater ranges from 120 feet below land surface near the SR 101/202 interchange to 350 feet below land surface near Power Road. The direction of flow is highly variable; however, groundwater flow is generally to the west-southwest (Arizona Department of Water Resources 1992). Soil types in the Salt River are porous sands, gravel, and rounded cobbles. The primary modern use of the Salt River is for extreme flood event flood control.

The land uses in the vicinity of the Salt River between the SR 101/202 interchange and Power Road are sand and gravel quarries, commercial developments, and residential developments on the south side of the river and residential developments, sand and gravel quarries, and landfills on the north side of the river.

The soils and water in the riverbeds are potentially subject to contamination from several sources, including discharge from stormwater systems that may carry metals, grease, and oils of minimal toxicity; overland flows that may transmit sediment and fertilizers; leachate from landfills within the riverbed; and point-source dumping by the general public.

The City of Mesa collects and discharges untreated stormwater from its streets and gutters into the Salt River. City ordinances do not allow gutters and storm sewers to be used for any purpose other than stormwater. The Environmental Protection Agency (EPA) issued the City a permit for this activity. Under this permit, the City of Mesa is obligated to sample and test the stormwater (City of Mesa 2002). According to City of Mesa staff, the stormwater is tested throughout the system for 26 pollutants (Mendelzon pers. comm.).

A City of Mesa wastewater treatment plant (Northwest Water Reclamation Plant) is located on the south side of the river, just east of the SR 101/202 interchange. The City of Mesa treats and releases municipal wastewater from this plant into the Salt River under a National Pollutant Discharge Elimination System (NPDES) permit issued by EPA. Under this permit, Mesa must submit an annual report with analytical results of sampling (City of Mesa 2002). The 1999 annual report indicates that the plant had no discharges that violated applicable EPA or local

standards (City of Mesa 1999). Additionally, City staff indicated that there had not been any violations in 2000 or 2001 (Draper pers. comm.).

Portions of the Salt River are used as illegal dumping sites for commercial and residential refuse and other materials. Domestic refuse, as well as construction debris, is common within the area. Dumping could result in potential sources of contamination.

Mosquitoes are also a health concern in the study area. The ecological characteristics in the study area provide an ideal environment for mosquito infestation. Mosquitoes are a public health concern because of their potential to spread disease. Maricopa County Vector Control monitors mosquitoes along the Salt River primarily during the summer months. Monitoring methods include carbon dioxide traps set twice each month (Ramirez pers. comm.).

4.12.3 REGULATORY SETTING

The principal federal regulatory agency for hazardous waste is the EPA. In Arizona, the Arizona Department of Environmental Quality (ADEQ) is responsible for implementing federal regulations throughout the state. Federal law requires state regulations to be at least as stringent as federal regulations.

4.12.3.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, was passed by Congress in 1980 to facilitate the cleanup of the nation's toxic waste sites. In 1986, Congress amended CERCLA by issuing the Superfund Amendment and Reauthorization Act (SARA), Title III (community right-to-know laws). Title III states that past and present owners of land contaminated with hazardous substances can be held liable for the entire cost of cleanup, even if the material was dumped illegally when the property was under different ownership.

There are three primary databases for CERCLA: the EPA National Priorities List of Superfund Sites (NPL), the Arizona Water Quality Assurance Revolving Fund (WQARF), and the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). The results of database searches for NPL, WQARF, and CERCLIS are shown below. Except where noted, the searches were conducted for the entire study area as defined at the beginning of this chapter.

4.12.3.2 National Priorities List

The EPA publishes the NPL, which lists federal Superfund sites in Arizona that are under investigation or remediation by EPA for known soil or groundwater contamination. There are no NPL sites within the specified search area (Environmental FirstSearch 2002).

4.12.3.3 Water Quality Assurance Revolving Fund

The ADEQ Office of Waste Programs maintains information for WQARF study areas. The WQARF program is the state equivalent to the federal Superfund, which funds cleanup projects resulting from the release of hazardous materials into the environment. There are no identified WQARF sites within the search area (Environmental FirstSearch 2002).

4.12.3.4 Comprehensive Environmental Response, Compensation, and Liability Information System

CERCLIS is the EPA's database of current and potential Superfund sites currently or previously under investigation under CERCLA. There are two CERCLIS sites within the project study area, which are described in Table 4.12-1 (Environmental FirstSearch 2002).

Table 4.12-1. CERCLIS Sites

Facility	Location	Status
North Center Street Landfill	End of N. Center Street at the Salt River	NFRAP
Busby Metals	522 W. McKellips Road	NFRAP

NFRAP – No Further Remedial Action Planned by ADEQ or EPA

Source: Environmental FirstSearch 2002

4.12.3.5 Solid Waste Landfills

A review of the ADEQ databases for active and inactive municipal solid waste landfills, rubbish landfills, private solid waste landfills, closed solid waste landfills, and private disposal facilities required to report to ADEQ (under Section 37, Chapter 315, Laws 1991, House Bill 2121) identified three such facilities (Table 4.12-2) that are within ½ mile of the Salt River flow centerline (Environmental FirstSearch 2002).

Table 4.12-2. Landfills

Facility	Location	Status
City of Mesa Landfill (North Center Street Landfill)	NEC, Center Street and Lehi Road	Closed
Salt River/Pima Tribe (Tri-City) Landfill	1 mile north of McDowell Road on the SR 87	Closed
Allied Concrete Landfill	SEC, Center Street and Lehi Road	Closed

Source: Environmental FirstSearch 2002

Other sources omit specific reference to the "Allied Concrete Landfill" that ADEQ lists and identify the solid waste landfills within the project study area as:

1. Tri-City (sometimes "Tri-Cities") Landfill
2. North Center Street Landfill (owned by SRPMIC),
3. North Center Street Landfill (owned by City of Mesa), and
4. Cypress (sometimes "Old Tri-City," "Old Tri-Cities," or "Country Club") Landfill.

Mr. Dick Jeffries, Manager of the Planning and Permitting Unit of ADEQ's Solid Waste Section, noted there is little standardization in how landfills are named. Furthermore, because landfills were not formally regulated prior to the 1991 passage of Subtitle D of RCRA (40 CFR 257-258), many gaps and/or inaccuracies are known to exist in the historical record (Jeffries pers. comm.). It is likely that the "Allied Concrete Landfill" and the "North Center Street Landfill" owned by the City of Mesa are one and the same.

For the purposes of this report, the four landfills listed above will be uniformly referred to as the Tri-City Landfill, North Center Street Landfill (SRPMIC), North Center Street Landfill (City of Mesa), and Cypress Landfill. The locations and conditions of these landfills are discussed in greater detail in the sections below. It should be noted, however, that waste from illegal "wildcat" dumps and/or dumps that preceded the historical record may be encountered throughout the project area.

Tri-City Landfill

The Tri-City Landfill, located in Township 2 North, Range 5 East, Section 34 of the Gila and Salt River Baseline and Meridian, comprises approximately 217 acres. The landfill is bounded to the north by the Beeline Highway (SR 87) and an SRP methane gas power generation station, to the south by the Salt River channel, by the Union Rock and Materials Corporation aggregate processing facility to the southwest, and by undeveloped land to the east.

The site, which is owned by the SRPMIC, operated from 1972 until October 1993. According to the *Final Closure Report and Postclosure Maintenance Plan: Tri-Cites Landfill and North Center Street Landfill* (CH2M HILL 1994), the landfill site was originally excavated for gravel deposits to a maximum depth of approximately 50 feet below the river channel surface and is now estimated to contain approximately 40 million cubic yards of waste and daily cover soil. The waste received consisted of residential household waste, commercial construction and demolition materials, landscaping and yard cleanup waste, and some inert soil, asphalt, and concrete. Methane gas that develops in the landfill is currently directed via a collection system to the gas power generation station that adjoins the property to the north.

The Tri-City Landfill site is underlain by several feet of gravelly silt followed by nearly continuous zones of cobbly sandy gravel, occasionally separated by lenses of clean sand or silty

sand. Although the water table may rise nominally during late winter or spring flows, depth to groundwater is generally between 150 and 200 feet. While the landfill site does not contain a bottom barrier or liner, no obvious indicators of landfill leachate have been identified from groundwater quality analyses (CH2M HILL 1994). This is considered consistent with the significant depth to groundwater in the immediate vicinity and the fact that low annual rainfall tends to minimize production of leachate.

The Tri-City Landfill was closed and capped in 1994. CH2M HILL developed the closure plan; the actual boundaries of the landfill were determined by test pit excavations conducted by SHB-Agra; and Simons, Li & Associates served as design engineer for bank protection measures placed along the river channel. The landfill site was "hard-banked" with cement-stabilized alluvium (CSA), commonly referred to as "soil cement," to alleviate chances for a flood event to expose or wash out landfill materials. The selected bank protection slope was extended 10–15 feet below the river channel and upward at a slope of 1:1 to the elevation of a 100-year flood event, plus 3 feet of freeboard. The thickness of the CSA layer is approximately 5.6 feet.

Existing daily cover soil at the Tri-City Landfill varied in depth from 2–15 feet. In compliance with Subtitle D of RCRA, Part 258, Subpart F, at closure the landfill was covered with an 18-inch barrier layer of compacted silty/clayey soil that meets strict ASTM D698 permeability requirements. The barrier soils were then graded to promote runoff and topped by a 1-foot vegetative layer (Subtitle D specifies a minimum of 6 inches) of sandy loam that was later hydroseeded with grasses. As the waste materials contained in the Tri-City Landfill decompose, the site is expected to continue to settle over an approximately 30-year period following closure, or until approximately the year 2024. Settling is expected to be uneven across the site, which will necessitate periodic additions of cover soil to discourage ponding of water and consequent percolation. (CH2M HILL 1994.)

North Center Street Landfill (SRPMIC)

The North Center Street Landfill, located in Township 1 North, Range 5 East, Section 3, covers approximately 35 acres. It is bounded by the Salt River channel on the north, undeveloped SRPMIC land to the west, the City of Mesa Police Department firearms training range to the southwest, Vulcan/CalMat to the south, and undeveloped SRP-owned land to the east. The North Center Street Landfill operated from 1979 until it was closed in 1980, and is estimated to contain approximately 3 million cubic yards of waste and cover soil. The waste received consisted of residential household waste, commercial construction and demolition materials, landscaping and yard cleanup waste, and some inert soil, asphalt, and concrete. (CH2M HILL 1994.)

Like the Tri-City Landfill, the North Center Street Landfill site was originally excavated for gravel deposits for use in construction and concrete aggregates. Its maximum depth is estimated at 40 to 50 feet below the river channel surface, and it too is unlined. The North Center Street Landfill received final closure at the same time (1994) and in a manner similar to that of the Tri-City Landfill. Unlike the Tri-City site, however, methane gas collected at North Center Street Landfill is burned off in a process known as flaring.

North Center Street Landfill (City of Mesa)

According to the Phase I Environmental Site Assessment completed by Liesch Southwest (2002), the site of the City of Mesa Police Department firearms training range adjacent to the North Center Street Landfill owned by the SRPMIC was originally used for disposal of waste by the City of Mesa, dating back at least to the 1960s. The site has since been developed with two classroom buildings, an office, and armory, a storage yard for miscellaneous vehicles and equipment, and a car impoundment lot. The embankments of the five currently operating target ranges appear to have been constructed of fill soil material that includes a large percentage of waste debris. The landfill beneath is thought to predate the Tri-City and Cypress Landfills. No information is currently available regarding its total acreage, depth, volume, or contents.

Cypress Landfill

The Cypress Landfill is located north of the Salt River channel and south of the Cypress Golf Course between Alma School Road and Country Club Drive. No information is currently available regarding its total acreage, depth, volume, or contents. The Cypress Landfill operated from at least the early 1960s to approximately 1980. The facility was never permitted and, to date, no closure plans have been initiated. The site is known to contain contaminants, although precise information regarding the nature of the contamination is unavailable. According to Liesch Southwest (2002), the site was investigated in 1990 by Ecology and Environment, Inc. at the request of USEPA. The investigation was conducted in response to the visible presence on the surface of 60–65 drums in various stages of decay. Fourteen of these drums were removed under emergency procedures through the ADEQ WQARF program. The contents of the other drums may have leached into the ground or groundwater. The SRPMIC have indicated they would like to clean up the site for future development and are in the process of requesting funding for a USEPA Brownfield Pilot Project study for this site. (Liesch Southwest 2002).

4.12.3.6 Arizona Leaking Underground Storage Tank List

The ADEQ Office of Water Quality maintains a list of reported leaking underground storage tanks (LUSTs). Based on a search of this database, there are 22 reported leaking underground storage tanks at 11 sites within the search area. A LUST designated as "Closed" has been remediated to the ADEQ's satisfaction. Of the 22 reported LUSTs within ½ mile of the river centerline, three remain open and one of the open LUSTs has likely impacted groundwater (Environmental FirstSearch 2002). These sites are listed in Table 4.12.3 below.

Table 4.12-3. LUST Sites

Facility	Location	Status
Travizo Hay Company	1747 N. Alma School Road	1 Open
ADOT Mesa Maintenance	2409 N. Country Club Drive	2 Open – likely groundwater contamination
AZ Department of Public Safety	2409 N. Country Club Drive	1 Closed
Bingo Hall/Ray Station	2345 N. Country Club Drive	1 Closed
Circle K	1150 W. McClellan	1 Closed
Sunward Materials/BCW	1564 N. Alma School Road	1 Closed
Karl Watkins	2116 N. Country Club Drive	1 Closed
Conteras Contractors	2110 N. Country Club Drive	7 Closed
Chandler Ready Mix Materials	3250 E. Lehi Drive	5 Closed
Cashway Concrete & Materials	650 W. McKellips Road	1 Closed
Valley Wide Contracting Co. Inc.	620 W. McKellips Road	1 Closed

Source: Environmental FirstSearch 2002

4.12.3.7 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) directs EPA to administer a regulatory program that extends from the manufacturing of hazardous waste to its disposal; the law regulates the generation, transportation, treatment, storage, and disposal of hazardous waste at all facilities and sites in the nation. RCRA was amended in 1984 by the Hazardous and Solid Waste Act, which affirmed and extended the "cradle-to-grave" system of regulating hazardous wastes.

Under RCRA, EPA maintains a list of facilities involved in the generation, transport, treatment, storage or disposal of hazardous waste. There are three separate databases: RCRA Corrections Log; RCRA Treatment, Storage, and Disposal Facilities (TSD); and RCRA Generators. For RCRA Correction Log and RCRA TSD facilities, the search was conducted for the project study area. For RCRA generators the search distance was ¼ mile from the river flow centerline. Table 4.12-4 shows the listed sites (Environmental FirstSearch 2002).

Table 4.12-4. RCRA Sites

Facility	Location	Status
RCRA Correction Sites		
Talley Defense Systems, Inc.	4111 and 4301 N. Higley Road	Listed violations & regulatory enforcement actions
RCRA TSD Sites		
Talley Defense Systems, Inc.	4111 and 4301 N. Higley Road	TSD
RCRA Generator Sites		
Statewide Environmental Services	1747 N. Alma School Road	No Longer Regulated
Blue Circle West Leasing	1564 N. Alma School Road	Generates < 100 kg/month
New West Materials	1540 N. Alma School Road	Generates < 100 kg/month

Source: Environmental FirstSearch 2002

4.12.3.8 Occupational Safety and Health Administration

Occupational Safety and Health Administration (OSHA) is the primary federal agency responsible for worker safety in the handling and use of chemicals in the workplace. The employer is required to monitor worker exposure to listed hazardous substances and notify workers of exposure. OSHA regulations specify requirements for employee training, availability of safety equipment, accident-prevention programs, and hazardous substance exposure warnings.

4.12.3.9 Vector Control

Maricopa County Department of Environmental Services, Vector Control Division and the Arizona State Department of Health Services, Office of Infectious Disease Services, Vector-Borne and Zoonotic Disease Section are the agencies primarily responsible for control of mosquitoes and other animal vectors in the project area.

4.12.4 POTENTIAL FOR RECYCLING AND/OR RE-USE OF NON-TOXIC FILL MATERIALS

Certain non-toxic materials used or excavated during project construction may have the potential to be recycled and/or re-used. An analysis of potentially recyclable materials present within the project study area has been conducted based on information contained in the Va Shly'ay Akimel Phase I Environmental Site Assessment (Liesch Southwest 2002). Jones & Stokes contacted representatives of Maricopa County, the City of Mesa, and the SRPMIC to identify requirements

for recycle and re-use of fill and/or construction materials. An inventory of recycle facilities in the vicinity of the project area is presented in Table 4.12-5.

Table 4.12-5. Recycle Facilities

Facility	Contact Name & Title	Address	Material Accepted	Recyclable	Costs
Johnson Steward Johnson	Laron Dewitt, General Manager	1132 W. McLellan Rd. Mesa, AZ 85201	Concrete and asphalt	No, Disposal only.	Unknown
Maricopa County Solid Waste Department	Lisa Mwale, Waste Tire Coordinator	2801 W. Durango St., Phoenix, AZ 85009	Tires	No, Transfer station only.	Non-residents are free. $140/ ton for off-road tires.
Mesa Materials	Patti Southway, Sales Rep	3410 N. Higley Rd. Mesa, AZ 85215	Broken asphalt only	Yes	$15/load (10-wheeler truck) or $25/load (larger than 10-wheeler truck)
Salt River Landfill	Randy Watkins, Compliance & Recycling Coordinator	13602 N. Beeline Highway Scottsdale, AZ 85256	Greenwaste and large appliances	Yes	$34/ton (discount for some cities)
Salt River Sand and Rock	Donna Casillos, Sales Rep	Dobson and McKellips Rd. Scottsdale, AZ 85256	Concrete and asphalt	No, Disposal only.	$20/load (10-wheeler truck) and $30/load (larger than 10-wheeler truck)

CHAPTER 5. ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION AND ALTERNATIVES

This section describes the environmental effects associated with the no-action alternative and each of the action alternatives. A brief discussion of the approach and methodology for performing the analysis is provided. The results of the analysis, both direct and indirect, are also included in this section. The environmental effects are described separately for each resource area and project alternative. For impacts that are substantial and adverse, mitigation measures have been provided. Although some short-term impacts will occur as a result of project construction and temporary site disturbance, the long-term impacts are expected to be beneficial because the major focus of the action alternatives is to increase vegetation and wildlife habitat in the project study area.

5.1 GEOLOGY AND TOPOGRAPHY

5.1.1 APPROACH AND METHODOLOGY

Geology and topography impact assessments in or near the project area focus on soil and erosion potential. The Natural Resources Conservation Service classifies soil with erosion hazards of slight, moderate, high, very high, and severe, establishing the significance criteria. These classifications are based on slope, climate, vegetation, and the physical/chemical characteristics of the soil. In addition to direct and indirect impacts, both short-term and long-term construction-related effects and longer term and permanent effects were also considered. The significance determination was based on past field experience with similar restoration projects.

Other evaluated impacts include geomorphologic impacts, impacts due to seismic activity, and impacts to prime and unique farmlands. Geomorphologic impacts assessed potential changes to existing landforms and possible effects on the hydrologic functionality and associated shifts of the river channel.

As discussed in Section 4.1, "Geology and Topography," seismic activity is not considered a concern in the project area. No active faults are known to occur on or near the project site, so no direct impacts related to surface rupture are anticipated. Seismic activity is very low in the region of the proposed project. Seismic impacts related to ground motion are also not anticipated.

Although prime farmland is in the vicinity of the project location, no farmland will be adversely affected by any of the proposed action alternatives. Section 1540(b) of the Farmland Protection Act, 7 U.S.C. 4201(b), states that the purpose of the Act is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. All project impacts will be confined to the banks of the Salt River, therefore not converting any farmland to nonagricultural uses.

Operation and Maintenance (O&M) activities for the proposed action will include repair work after major flooding events; dredging and reconstruction may be required in the restoration areas.

5.1.2 ENVIRONMENTAL IMPACTS

5.1.2.1 No Action

Under the No-Action Alternative, the existing topography would remain relatively unaffected. Landforms would remain approximately the same, although large-scale flood events will continue to change the floodplain. Areas within the channel that are currently subject to erosion will continue to erode at current rates. Additionally, ongoing human encroachment and gravel mining will continue to adversely affect river channel profile and planform. In the short-term ongoing gravel mining within the project area will cause upstream headcutting, sediment trapping within the gravel pits and reduction in downstream sediment transport, and associated downstream channel bed and bank erosion. No short-term impacts on geology or topography are associated with the restoration and enhancement of the river corridor. Long-term impacts of the No-Action Alternative could include an increase in the potential for wind-related soil erosion from continued decreased water availability. This could result in a substantial decrease in vegetative cover over time.

5.1.2.2 Alternative F

Activities under this alternative include the creation of irrigation and drainage ditches throughout the project area, spillways, bank armors, constructed wetlands, a low-flow channel, a grade control structure west of Gilbert Road at the center point of the old Gilbert Quarry, and a water distribution channel. Many of the procedures involve several forms of reshaping, including excavation and grading. These restoration measures will occur at multiple sites designated throughout the project area.

Impact: Minor Geomorphologic Changes in the River Channel

Under Alternative F, the geomorphologic character of the existing landscape will be permanently altered due to the many reshaping procedures planned for the project. River bottom areas will undergo surface reshaping, which includes moving soil to fill depressions or remove unwanted mounds. In addition, soils will be imported to various areas to provide the necessary environment for new vegetation. Clay, mixed gravel, and cobble layers will be placed in areas of proposed wetland habitats. The current wind erosion potential will likely be reduced, except for the initial construction-related effects.

The addition of a Surface Braided Irrigation Network (SBIN), 2–3 feet wide and 6 inches deep, will change the existing water runoff pattern. It will affect the erosion and deposition within the channel; however, it is unlikely to cause functional changes in the river channel's current erosion and deposition patterns. The river channelization will create a low-flow channel that is free to migrate. Erosion potential may change due to the channel's ability to migrate. Continued

quarrying at the Higley Plant has the potential to increase the rate of downstream sediment deposition in Reach 7, thereby decreasing the bedload material downstream in Reach 6. The lack of bedload material may affect the stability of the river channel in Reach 6. However, these potential geomorphologic changes are considered less than significant.

Mitigation Measure: No mitigation required.

Impact: Beneficial Changes to the River Channel

Armoring the south bank, east of Gilbert Road, will reduce erosion as well as provide bank stabilization and soil protection for new vegetation. Further east along the south bank, the berm of coarse rock will help prevent further erosion. Between Alma School Road and Country Club Road, the south bank will be reinforced with soil cement to prevent further erosion as well as possible damage to SR 202. The grade control structure will help stabilize the river system and help protect the river channel from headcutting. This is considered a beneficial effect.

Mitigation Measure: No mitigation required.

5.1.2.3 Alternative N

Under Alternative N, the channel alterations will be substantially similar to those of Alternative F. Habitat configurations and reshaping measures will remain relatively the same, with the exception that no bank stabilization, spillways, or river channelization will occur. The different reshaping measures will result in minor variations in the geomorphologic changes to the river channel. These changes and their impacts are consistent with those of Alternative F.

5.1.2.4 Alternative O (Preferred Alternative)

Modifications for Alternative O will be similar to descriptions set forth in Alternative F. However, as described in Alternative N, no bank stabilization, spillways, or river channelizations will occur. The different reshaping measures will result in minor variations in the geomorphologic changes to the river channel, which are consistent to the changes and impacts outlined in Alternative F.

5.1.2.5 Alternative E

Changes to the river channel will be very similar in scope to the modifications described for Alternative F. The primary difference is the location, quantity, and configuration of habitat areas that would be constructed in the channel and on the adjacent bank areas. Under this alternative, the configuration of habitats is restricted to Sonoran Desert vegetation. The different reshaping measures will result in minor variations in the geomorphologic changes that would occur. However, for the purposes of this assessment, these changes and their impacts are consistent with those of Alternative F.

5.1.2.6 Alternative A

Alternative A is considerably similar to Alternative E with regard to the geomorphologic changes that would occur. This alternative is restricted to Sonoran Desert vegetation, limiting the reshaping methods for an irrigation system to SBIN. As a result, the only reshaping procedures for Alternative A are the SBIN and the old Gilbert Quarry. In addition, bank stabilization by means of bank armoring is not included as a restoration measure. The impacts associated with this alternative are less than significant.

5.2 HYDROLOGY AND WATER RESOURCES

5.2.1 APPROACH AND METHODOLOGY

This section describes the impacts of the various alternatives to hydrology and water quality within the study area. These impacts were determined through inspection of the plans for each alternative and a review of the construction and restoration aspects of each alternative. Impacts on surface hydrology were evaluated to determine whether the implementation of the alternative would result in substantial alteration of watercourses or in stream channels. Additionally, impacts were analyzed to determine if the alternative would exacerbate flooding in currently flood-prone areas or create new potential for flooding or flood damage. Groundwater hydrological impacts were analyzed to determine whether an alternative would result in a substantial loss or change in groundwater resources within the area.

Water quality impacts were evaluated to determine whether construction or operation of an alternative would result in degradation of existing or future water quality, resulting in the potential for violations of existing water quality standards. The analysis focuses on turbidity and sedimentation associated with construction and restoration activities and the potential for water quality impacts caused by accidental spills of fuels or solvents during construction.

The project alternatives, including the recommended plan (preferred alternative), Alternative O, were also evaluated to ensure compliance with the Guidelines established under the Federal Pollution Control Act (Clean Water Act) Amendments of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), legislation collectively referred to as the Clean Water Act. These guidelines, referred to as the Section 404(b)(1) Guidelines or "Guidelines," are the substantive criteria used in evaluating discharges of dredged or fill material under Section 404 of the Clean Water Act. Fundamental to the Guidelines is the precept that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern."

The Guidelines require that, except as provided under §404(b)(2), "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have significant adverse environmental considerations." A "practicable alternative" is defined as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes," and include both on- and off-site alternatives.

The results of the evaluation identified short-term construction-related impacts on water quality (e.g., turbidity, stormwater pollutants, accidental fuel spills), hydrology (e.g., increases in water surface elevations), and wildlife (e.g., disturbance). No long-term impacts were identified. The evaluation also identifies best management practices (BMPs) and mitigation measures that will

be implemented during construction to avoid and/or minimize any short-term impacts. Based on the evaluation and the inclusion of mitigation measures to address short-term impacts, the project has been determined to be in compliance with the Guidelines. A more detailed description of the Clean Water Act, Section 404(b)(1) compliance evaluation is provided in Appendix A.

5.2.2 ENVIRONMENTAL IMPACTS

5.2.2.1 No Action

Under the No-Action Alternative, existing flooding and flood damage will continue at approximately the same level of magnitude and frequency. Water quality is expected to decline slightly as the watershed continues to urbanize. Erosion and sedimentation processes would continue at current rates and degrees of magnitude.

5.2.2.2 Alternative F

Impact: Temporary Adverse Effects on Water Quality during Project Construction

Project construction and restoration activities proposed under this alternative include grading, site preparation for vegetation planting, channel excavation and reshaping, and the installation of bank stabilization, and grade control features. These activities as well as O&M activities such as sediment removal will result in soil disturbance and have the potential to cause temporary discharges of soil and sediment into the river channel. Soil discharged into the river channel may increase turbidity, stimulate algal growth, increase sediment deposition, and adversely affect aquatic organisms. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure HWR-1.

Mitigation Measure HWR-1: Implement Erosion Control Measures

The Corps and their contractors shall implement erosion control measures throughout the construction period and during implementation of O&M activities to minimize erosion and sediment input into the river. The Corps will oversee implementation of erosion control measures. The contractor selected for the project shall:

- conduct construction and O&M activities during the dry season;
- conduct all construction work in accordance with site-specific construction plans that minimize the potential for increased sediment inputs to the river;
- divert concentrated runoff away from channel banks;
- minimize vegetation removal;
- identify with construction fencing all areas that require clearing, grading, revegetation, or reshaping and minimize areas to be cleared, graded, reshaped or otherwise disturbed;

- grade and stabilize spoils and stockpile sites to minimize erosion and sediment input to the river;
- implement erosion control measures as appropriate to prevent sediment from entering the river channel or other watercourses to the extent feasible, including the use of silt fencing or fiber rolls to trap sediments and erosion control blankets to protect channel banks;
- mulch disturbed areas as appropriate and plant with appropriate species as soon as practicable after disturbance; and
- avoid operating equipment in flowing water by using temporary cofferdams or other suitable structures to divert flow around the channel and bank construction areas.

Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials During Project Construction

Project construction and restoration activities could result in accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents). Hazardous substances that enter the river channel could have temporary adverse effects on water quality and aquatic organisms. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

The Corps and their contractors shall prepare a spill prevention and response plan that regulates the use of hazardous and toxic materials, such as petroleum-based fuels and lubricants for construction equipment. The Corps will oversee development and implementation of a stormwater pollution prevention plan. Elements of the plan will ensure that:

- workers are trained to avoid and manage spills;
- construction and maintenance materials are prevented from entering the river channel;
- all spills are cleaned up immediately and appropriate agencies are notified of any spills and of the cleanup procedures employed;
- staging and storage areas for equipment, materials, fuels, lubricants, solvents, and other possible contaminants are located at least 100 feet away from the river's normal high-water area;
- vehicles are removed from the river's normal high-water area before refueling or lubricating;
- vehicles are immediately removed from the work area if they are leaking; and
- equipment is not operated in flowing water (if necessary, suitable temporary structures can be installed to divert water around in-channel work areas).

Impact: Changes in 100-year Water Surface Elevations

Channel reshaping and vegetation planting activities proposed under Alternative F have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. As part of the project planning process, the Corps conducted modeling (HEC-RAS) to analyze changes in hydraulic conditions associated with implementation of the project alternatives. Hydraulic modeling conducted for Alternative F demonstrated increases in water surface elevations in the lower and middle project reaches (Reaches 3, 4, 5, and 6) associated with the establishment of cottonwood/willow and wetland vegetation in the main channel. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-3.

Mitigation Measure HWR-3: Identify Changes in 100-year Floodplain

The Corps will conduct additional hydraulic analyses to identify changes in the 100-year floodplain associated with increased surface water elevations and assess the potential for flooding and flood damage in the lower and middle reaches of the project area. If it is determined that implementation of this alternative will increase the potential for flood-related damages, the Corps will modify the low-flow channel design and/or implement any additional design changes necessary to reduce water surface elevations in the affected reaches of the project area.

Impact: Beneficial Changes in Flooding Frequency and Severity

The construction of bank stabilization features and the excavation of a low-flow channel proposed under Alternative F have the potential to change 100-year water surface elevations and reduce the potential for flooding in the project area. Hydraulic modeling conducted by the Corps as part of the planning process demonstrated decreases in water surface elevations in the lower and middle reaches of the project area (Reach 2 and the upper segment of Reach 5) associated with the new low-flow channel and projected future gravel mining activities. This is considered a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Changes in Groundwater Hydrology

Irrigation water sources proposed under Alternative F consist primarily of surface water SRPMIC agricultural return flows, and surplus agricultural water and stormwater runoff from the Hennessey, Evergreen, and Tempe Drains. However, the Alternative includes the construction of one new groundwater well. Irrigation water will be pumped from this new well and diverted to planting areas through distribution channels or pipelines during times when surface water sources are not available. Because groundwater will only be used intermittently, and because

groundwater in sufficient quantity is available to supply water wells within the project area, it is unlikely that the installation of a new well and the intermittent pumping of groundwater for irrigation purposes will impact nearby wells. However, because groundwater resources are carefully controlled in Arizona, the installation of a new well and the pumping of groundwater will require permits for the withdrawal of irrigation water. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-4. This alternative is not anticipated to alter the groundwater hydrology and water delivery system above Granite Reef Dam.

Mitigation Measure HWR-4: Obtain Permits for Groundwater Withdrawal

The Corps will work with the appropriate agencies to obtain the permits necessary for the construction of a new groundwater well and the withdrawal of appropriate amounts of groundwater that is needed for irrigation purposes.

Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water

Under Alternative F, SRPMIC agricultural return flows, surplus agricultural water and stormwater runoff from the Hennessey, Evergreen, and Tempe Drains, treated effluent from the City of Mesa wastewater treatment plant, and discharge from local storm drains will be diverted into newly constructed distribution channels and pipelines for irrigation purposes. These water sources may contain contaminants (e.g., VOCs, metals, ions, nutrients, herbicides) that could have adverse effects on water quality and aquatic organisms. In general because of their sources, irrigation return flows and surplus agricultural water are of relatively high quality and are suitable for use as irrigation for restoration plantings. Additionally, as these are existing discharges to the river, the water quality of these sources is currently regulated under permits held by the local sponsors (SWPPP and AZ Pollutant Discharge Elimination System). The effluent discharged from the City of Mesa wastewater treatment plant currently meets aquifer recharge standards, surface water quality standards and NPDES requirements so it is also suitable for irrigation use. However, because stormwater discharges represent runoff from urban, rural, and agricultural areas, water quality varies greatly based on land use and the magnitude, duration, and timing of storm events. Sediment and pollutants tend to accumulate between storm events and the highest concentrations of pollutants are often washed into rivers, creeks, and streams during "first flush" events. However it is difficult to assess potential adverse effects on water quality associated with the use of stormwater for irrigation as only limited water quality data is available for the project area. A review of existing water quality data showed that storm water runoff exceeded applicable standards for five trace metals including total recoverable lead, and dissolved copper, cadmium, silver, and zinc (Knight Piésold 2003). Because of the lack of existing data related to stormwater quality, this impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

The local sponsors will develop a stormwater quality sampling plan and conduct sampling and analyses to identify potential contaminants and adverse effects on water quality associated with using stormwater as an irrigation source for restoration plantings. If the analyses show that constituents exceed applicable water quality standards, the local sponsors will develop a stormwater monitoring plan and identify measures and implement water quality improvement measures (e.g., scheduling of irrigation withdrawals to avoid "first flush" events; installing detention basins, treatment swales, or other facilities to pre-treat stormwater; and/or identify other irrigation sources).

5.2.2.3 Alternative N

Impact: Temporary Adverse Effects on Water Quality during Project Construction

Under Alternative N, potential adverse effects on water quality associated with construction and O&M activities (e.g., soil disturbance and temporary discharges of soil and sediment) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-1.

Mitigation Measure HWR-1: Implement Erosion Control Measures

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials during Project Construction

Under Alternative N, potential adverse effects on water quality associated with accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

Same as described above.

Impact: Changes in 100-year Water Surface Elevations

Channel reshaping and vegetation planting activities proposed under Alternative N have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. Hydraulic modeling conducted by the Corps for Alternative N demonstrated increases in water surface elevations in the lower and middle project reaches (Reaches 2, 3, 4, 5, and 6) associated with the establishment of cottonwood/willow and wetland vegetation in the main channel. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-3.

Mitigation Measure HWR-3: Identify Changes in 100-year Floodplain

Same as described above.

Impact: Beneficial Changes in Flooding Frequency and Severity

Hydraulic modeling conducted by the Corps for Alternative N demonstrated decreases in water surface elevations in the middle reach of the project area (upper segment of Reach 5) associated with projected future gravel mining activities. These activities have the potential to change 100-year water surface elevations in the reach and reduce the potential for flooding in the project area. This is considered a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Changes in Groundwater Hydrology

Under Alternative N potential changes in groundwater hydrology associated with well construction and the pumping of groundwater for irrigation purposes would be similar to those described under Alternative F. Under Alternative N, groundwater will be pumped from a new well and diverted to planting areas through distribution channels or pipelines during periods when surface water sources are not available. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-4. This alternative is not anticipated to alter the groundwater hydrology and water delivery system above Granite Reef Dam.

Mitigation Measure HWR-4: Obtain Permits for Groundwater Withdrawal

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water

Under Alternative N, potential adverse effects on water quality associated with the use of stormwater discharge for irrigation would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

Same as described above.

5.2.2.4 Alternative O (Preferred Alternative)

Impact: Temporary Adverse Effects on Water Quality during Project Construction

Under Alternative O, potential adverse effects on water quality associated with construction and O&M activities (e.g., soil disturbance and temporary discharges of soil and sediment) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-1.

Mitigation Measure HWR-1: Implement Erosion Control Measures

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials during Project Construction

Under Alternative O, potential adverse effects on water quality associated with accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

Same as described above.

Impact: Beneficial Changes in Flooding Frequency and Severity

Hydraulic modeling conducted by the Corps for Alternative O demonstrated decreases in water surface elevations in the lower and middle reaches (Reach 3 and the lower segment of Reach 5) of the project area associated with the construction of a low-flow channel, and projected future gravel mining activities. These activities have the potential to change 100-year water surface elevations in the reach and reduce the potential for flooding in the project area. This is considered a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Changes in Groundwater Hydrology

Under Alternative O potential changes in groundwater hydrology associated with well construction and the pumping of groundwater for irrigation purposes would be similar to those described under Alternative F. Under Alternative N, groundwater will be pumped from a new well and diverted to planting areas through distribution channels or pipelines during periods when surface water sources are not available. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-4. This alternative is not anticipated to alter the groundwater hydrology and water delivery system above Granite Reef Dam.

Mitigation Measure HWR-4: Obtain Permits for Groundwater Withdrawal

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water

Under Alternative O, potential adverse effects on water quality associated with the use of stormwater discharge for irrigation would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

Same as described above.

5.2.2.5 Alternative E

Impact: Temporary Adverse Effects on Water Quality during Project Construction

Under Alternative E, potential adverse effects on water quality associated with construction and O&M activities (e.g., soil disturbance and temporary discharges of soil and sediment) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-1.

Mitigation Measure HWR-1: Implement Erosion Control Measures

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials during Project Construction

Under Alternative E, potential adverse effects on water quality associated with accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

Same as described above.

Impact: Changes in 100-year Water Surface Elevations

Channel reshaping and vegetation planting activities proposed under Alternative E have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. Hydraulic modeling conducted by the Corps for Alternative E demonstrated increases in water surface elevations in the lower and upper project reaches (Reaches 2 and 7) associated with the establishment of Upper Sonoran Desert vegetation in the main channel. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-3.

Mitigation Measure HWR-3: Identify Changes in 100-year Floodplain

Same as described above.

Impact: Beneficial Changes in Flooding Frequency and Severity

Hydraulic modeling conducted by the Corps for Alternative E demonstrated decreases in water surface elevations in the middle reach of the project area (Reach 5) associated with projected future gravel mining activities. These activities have the potential to change 100-year water surface elevations in the reach and reduce the potential for flooding in the project area. This is considered a beneficial impact.

Mitigation Measure: No mitigation is required.

Impact: Changes in Groundwater Hydrology

Under Alternative E potential changes in groundwater hydrology associated with well construction and the pumping of groundwater for irrigation purposes would be similar to those described under Alternative F. Under Alternative E, groundwater will be pumped from a new well and diverted to planting areas through distribution channels or pipelines when surface water sources are not available. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-4. This alternative is not anticipated to alter the groundwater hydrology and water delivery system above Granite Reef Dam.

Mitigation Measure HWR-4: Obtain Permits for Groundwater Withdrawal

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water

Under Alternative E, potential adverse effects on water quality associated with the use of stormwater discharge for irrigation would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

Same as described above.

5.2.2.6 Alternative A

Impact: Temporary Adverse Effects on Water Quality during Project Construction

Under Alternative A, potential adverse effects on water quality associated with construction and O&M activities (e.g., soil disturbance and temporary discharges of soil and sediment) would be

slightly less than those described under Alternative F because of the smaller construction area. . This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-1.

Mitigation Measure HWR-1: Implement Erosion Control Measures

Same as described above.

Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials during Project Construction

Under Alternative A potential adverse effects on water quality associated with accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents) would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

Same as described above.

Impact: Changes in 100-year Water Surface Elevations

Channel reshaping and vegetation planting activities proposed under Alternative A have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. Hydraulic modeling conducted by the Corps for Alternative A demonstrated no increases in water surface elevations in the project area. No impact was identified.

Mitigation Measure: No mitigation required.

Impact: Changes in Groundwater Hydrology

The construction of new groundwater wells and the pumping of groundwater for irrigation purposes is not proposed under Alternative A. No impact was identified.

Impact: Potential Adverse Effects on Water Quality Associated with Irrigation Water

Under Alternative A, potential adverse effects on water quality associated with the use of stormwater discharge for irrigation would be similar to those described under Alternative F. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

Same as described above.

5.3 BIOLOGICAL RESOURCES

This section analyzes the impact of each alternative on the biological resources of the project study area. The analysis is centered on the short- to intermediate-term impacts associated with disruption of habitat during restoration and construction activities. The long-term biological impacts are expected to be beneficial because the major focus of the alternatives is to increase wildlife habitat in the project study area.

5.3.1 APPROACH AND METHODOLOGY

Biological baseline studies were used as the basis to evaluate project impacts for each alternative. Plans for each alternative were reviewed and the potential changes in habitat communities were determined. Short-term impacts were determined through the analysis of existing habitats in the area and the projected areas of disturbance that would occur during construction and restoration activities. Impacts related to wetlands were primarily based on the increase in vegetative coverage in acres as well as the increase in habitat value as indicated by the changes in AAFCUs anticipated in the modified HGM modeling process.

Tables 5.3-1, 5.3-2, 5.3-3, 5.3-4 and 5.3-5 provide an analysis of the increase in habitat acreage for each of the project alternatives. Figure 5.3-1 provides a comparison of the increases in AAFCUs over time for each of the project alternatives. These tables appear on the pages that follow.

The following criteria were considered in determining impacts on biological resources:

- federal legal protection (e.g., Endangered Species Act of 1973),
- federal agency regulations and policies,
- documented resource scarcity and sensitivity (e.g., species tracked in the AGFD Heritage Data Management System),
- adverse effects on special aquatic habitats (e.g., wetlands),
- reduction in native vegetation communities over at least a 20-year period,
- disruption or loss of high-quality wildlife habitat, and
- take or harassment of any listed threatened or endangered species.

Impacts on substantial portions of local populations of federal candidate species were also considered in assessing impacts on biological resources.

Figure 5.3-1. Trend in Average Annual Functional Capacity Units (AAFCUs) for the Va Shly'ay Akimel Alternatives

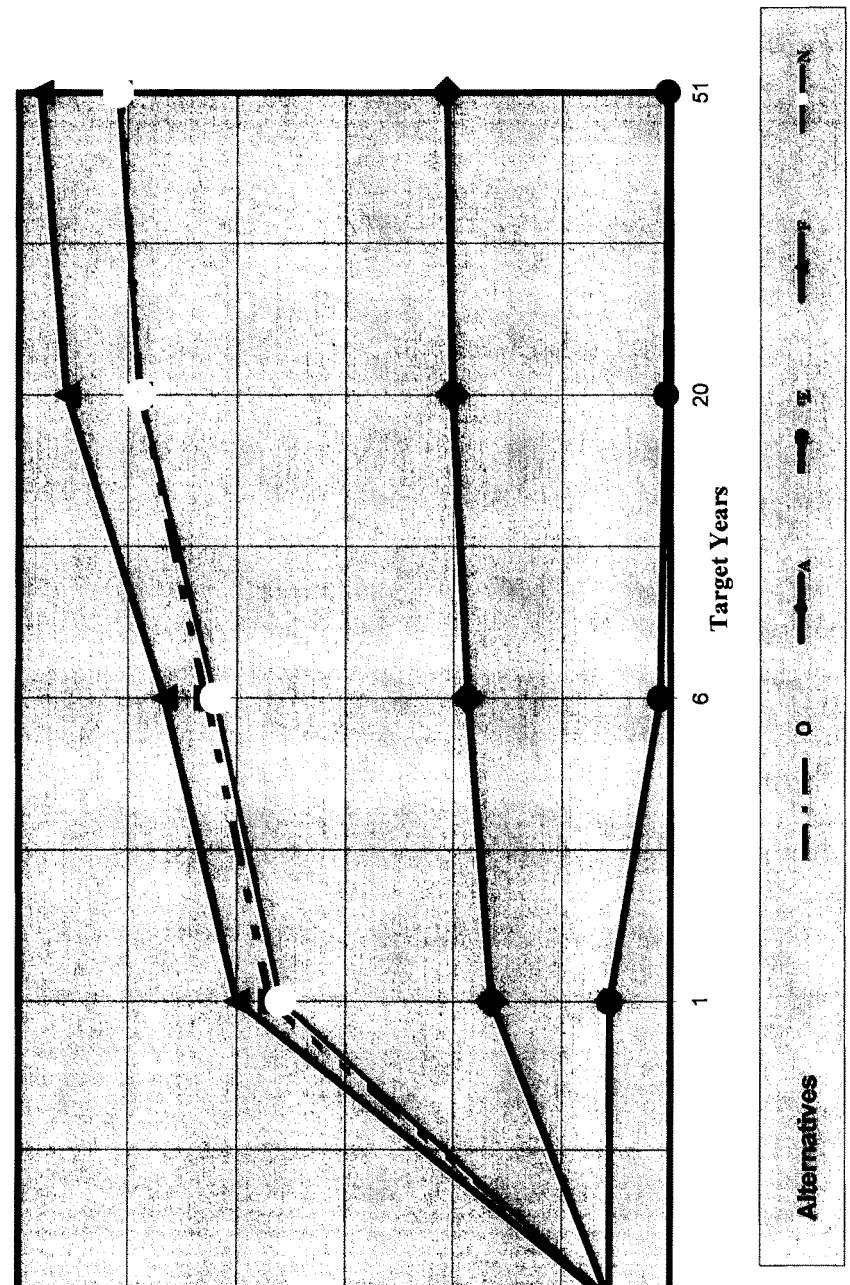


Table 5.3-1. Comparison of Habitat Types (Acres): No-Action Alternative and Alternative F

Code	Description	Target Year - No Action Alternative					Target Year - Alternative F				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70	249.70	247.40	247.40	247.40	249.70	210.90	210.90	210.90	210.90
BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50	69.50	30.60	30.60	0.00	69.50	67.90	67.90	67.90	67.90
DESERT	Desert Areas - Bare Earth, Cacti, Rabbitbush, Acacia	961.90	961.90	931.90	931.90	931.90	961.90	457.00	457.00	457.00	457.00
DITCHES	Ditches	56.50	56.50	47.20	47.20	47.20	56.50	44.30	44.30	44.30	44.30
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10

Code	Description	Target Year - No Action Alternative					Target Year - Alternative F				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
NEWBUFFER	Newly Developed Upland Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	701.10	701.10	701.10	701.10
NEWMESQUIT	Newly Developed Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	558.00	558.00	558.00	558.00
NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	30.60	0.00	602.90	602.90	602.90	602.90
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	266.40	266.40	266.40	266.40

1544

Code	Description	Target Year - No Action Alternative					Target Year - Alternative F				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50	100.50	79.90	79.90	79.90	100.50	100.30	100.30	100.30	100.30
PARKS	Parks and Recreation Areas	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60	334.60	216.30	216.30	216.30	334.60	271.40	271.40	271.40	271.40
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60	1651.60	1621.60	1621.60	1621.60	1651.60	1099.20	1099.20	1099.20	1099.20
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.10	2057.10	2035.90	2035.90	2035.90	2057.10	1041.30	1041.30	1041.30	1041.30
SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90	33.90	16.30	16.30	16.30	33.90	33.90	33.90	33.90	33.90

1545

Code	Description	Target Year - No Action Alternative					Target Year - Alternative F				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
URBAN	Existing Residential, Industrial and Transportation Avenues	341.60	341.60	629.80	629.80	629.80	341.60	341.00	341.00	341.00	341.00
	TOTALS:	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60

1546

Table 5.3-2. Comparison of Habitat Types (Acres): No-Action Alternative and Alternative N

Code	Description	Target Year - No Action Alternative					Target Year - Alternative N				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70	249.70	247.40	247.40	247.40	249.00	235.90	235.90	235.90	235.90
BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50	69.50	30.60	30.60	0.00	69.50	67.20	67.20	67.20	67.20
DESERT	Desert Areas - Bare Earth, Cacti, Rabbit brush, Triangle bursage, Acacia	961.90	961.90	931.90	931.90	931.90	961.90	393.40	393.40	393.40	393.40
DITCHES	Ditches	56.50	56.50	47.20	47.20	47.20	56.50	54.50	54.50	54.50	54.50
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10

1547

Code	Description	Target Year - No Action Alternative					Target Year - Alternative N				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
NEWBUFFER	Newly Developed Upland Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	853.10	853.10	853.10	853.10
NEWMESQUIT	Newly Developed Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	379.70	379.70	379.70	379.70
NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	30.60	0.00	331.80	331.80	331.80	331.80
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	23.60	23.60	23.60	23.60

1548

Code	Description	Target Year - No Action Alternative					Target Year - Alternative N				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50	100.50	79.90	79.90	79.90	100.50	85.00	85.00	85.00	85.00
PARKS	Parks and Recreation Areas	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60	334.60	216.30	216.30	216.30	334.60	274.40	274.40	274.40	274.40
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60	1651.60	1621.60	1621.60	1621.60	1651.60	1252.60	1252.60	1252.60	1252.60
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Triangle Bursage, Quailbush, Ironwood, and Saltbush	2057.10	2057.10	2035.90	2035.90	2035.90	2057.10	1545.90	1545.90	1545.90	1545.90
SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90	33.90	16.30	16.30	16.30	33.90	33.10	33.10	33.10	33.10

1549

Code	Description	Target Year - No Action Alternative					Target Year - Alternative N				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
URBAN	Existing Residential, Industrial and Transportation Avenues	341.60	341.60	629.80	629.80	629.80	341.60	326.70	326.70	326.70	326.70
	Totals:	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60

1550

Table 5.3-3. Comparison of Habitat Types (Acres): No-Action Alternative and Alternative O

Code	Description	Target Year - No Action Alternative					Target Year - Alternative O				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.7	249.7	247.4	247.4	247.4	249.7	235.9	235.9	235.9	235.9
BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0	0	0	0	0	0	0	0	0	0
CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.5	69.5	30.6	30.6	0	69.5	67.2	67.2	67.2	67.2
DESERT	Desert Areas - Bare Earth, Cacti, Rabbitbush, Acacia	961.9	961.9	931.9	931.9	931.9	961.9	393.4	393.4	393.4	393.4
DITCHES	Ditches	56.5	56.5	47.2	47.2	47.2	56.5	54.5	54.5	54.5	54.5
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
NEWBUFFER	Newly Developed Upland Buffer Zones - Mesquite, Ironwood, Rabbitbush, Quailbush, Cat-claw Acacia, Palo Verde, and Creosote	0	0	0	0	0	0	0	0	0	0
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests in the Active Channel	0	0	0	0	0	0	883.4	883.4	883.4	883.4

1551

Code	Description	Target Year - No Action Alternative					Target Year - Alternative O				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
NEWMESQUIT	Newly Developed Mesquite Woodlands - on the Terraces and in the Active Channel	0	0	0	0	0	0	379.7	379.7	379.7	379.7
NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0	0	0	0	0	0	0	0	0	0
NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0	0	0	0	30.6	0	425.1	425.1	425.1	425.1
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	0	0	0	0	0	0	23.6	23.6	23.6	23.6
OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.5	100.5	79.9	79.9	79.9	100.5	85	85	85	85
PARKS	Parks and Recreation Areas	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.6	334.6	216.3	216.3	216.3	334.6	254.5	254.5	254.5	254.5
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.6	1651.6	1621.6	1621.6	1621.6	1651.6	1201	1201	1201	1201

Code	Description	Target Year - No Action Alternative					Target Year - Alternative O				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.1	2057.1	2035.9	2035.9	2035.9	2057.1	1496.7	1496.7	1496.7	1496.7
SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.9	33.9	16.3	16.3	16.3	33.9	32	32	32	32
URBAN	Existing Residential, Industrial and Transportation Avenues	341.6	341.6	629.8	629.8	629.8	341.6	324.9	324.9	324.9	324.9
	TOTALS:	5870.6	5870.6	5870.6	5870.6	5870.6	5870.6	5870.6	5870.6	5870.6	5870.6

1553

Table 5.3-4. Comparison of Habitat Types (Acres): No-Action Alternative and Alternative E

Code	Description	Target Year - No Action Alternative					Target Year - Alternative E				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
GCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70	249.70	247.40	247.40	247.40	249.70	238.20	238.20	238.20	238.20
BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50	69.50	30.60	30.60	0.00	69.50	69.30	69.30	69.30	69.30
DESERT	Desert Areas - Bare Earth, Cacti, Triangle Bursage, Acacia	961.90	961.90	931.90	931.90	931.90	961.90	359.20	359.20	359.20	359.20
DITCHES	Ditches	56.50	56.50	47.20	47.20	47.20	56.50	53.80	53.80	53.80	53.80
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
NEWBUFFER	Newly Developed Upland Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1554

Code	Description	Target Year - No Action Alternative					Target Year - Alternative E				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	286.40	286.40	286.40	286.40
NEWMESQUIT	Newly Developed Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	296.00	296.00	296.00	296.00
NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	30.60	0.00	340.80	340.80	340.80	340.80
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	808.00	808.00	808.00	808.00
OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50	100.50	79.90	79.90	79.90	100.50	84.90	84.90	84.90	84.90
PARKS	Parks and Recreation Areas	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60	334.60	216.30	216.30	216.30	334.60	326.10	326.10	326.10	326.10

1555

Code	Description	Target Year - No Action Alternative					Target Year - Alternative E				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60	1651.60	1621.60	1621.60	1621.60	1651.60	857.30	857.30	857.30	857.30
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.10	2057.10	2035.90	2035.90	2035.90	2057.10	1698.50	1698.50	1698.50	1698.50
SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90	33.90	16.30	16.30	16.30	33.90	33.90	33.90	33.90	33.90
URBAN	Existing Residential, Industrial and Transportation Avenues	341.60	341.60	629.80	629.80	629.80	341.60	313.70	313.70	313.70	313.70
	TOTALS:	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60

Table 5.3-5. Comparison of Habitat Types (Acres): No-Action Alternative and Alternative A

Code	Description	Target Year - No Action Alternative					Target Year - Alternative A				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa	249.70	249.70	247.40	247.40	247.40	249.70	243.80	243.80	243.80	243.80
BUFFER	Existing Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTWWFOR	Existing Cottonwood-Willow Forests in the Active Channel	69.50	69.50	30.60	30.60	0.00	69.50	69.30	69.30	69.30	69.30
DESERT	Desert Areas - Bare Earth, Cacti, Triangle Bursage, Acacia	961.90	961.90	931.90	931.90	931.90	961.90	613.10	613.10	613.10	613.10
DITCHES	Ditches	56.50	56.50	47.20	47.20	47.20	56.50	53.80	53.80	53.80	53.80
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
NEWBUFFER	Newly Developed Upland Buffer Zones - Mesquite, Ironwood, Triangle Bursage, Quailbush, Cat-claw Acacia, Paloverde, and Creosote	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWCWWFOR	Newly Developed Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWMESQUIT	Newly Developed Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1557

Code	Description	Target Year - No Action Alternative					Target Year - Alternative A				
		2002	2008	2013	2033	2058	2002	2008	2013	2033	2058
		0	1	6	26	51	0	1	6	26	51
NEWRVRBOTM	Newly Developed River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	0.00	0.00	0.00	0.00	30.60	0.00	152.30	152.30	152.30	152.30
NEWSCRUB	Newly Developed Scrub-Shrublands in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	495.80	495.80	495.80	495.80
OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations	100.50	100.50	79.90	79.90	79.90	100.50	100.50	100.50	100.50	100.50
PARKS	Parks and Recreation Areas	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
RIVERBOTTM	Existing River Bottom Areas in the Active Channel - Largely Unvegetated (Includes Emergents)	334.60	334.60	216.30	216.30	216.30	334.60	332.10	332.10	332.10	332.10
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	1651.60	1651.60	1621.60	1621.60	1621.60	1651.60	1352.10	1352.10	1352.10	1352.10
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	2057.10	2057.10	2035.90	2035.90	2035.90	2057.10	2057.10	2057.10	2057.10	2057.10
SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	33.90	33.90	16.30	16.30	16.30	33.90	33.90	33.90	33.90	33.90
URBAN	Existing Residential, Industrial and Transportation Avenues	341.60	341.60	629.80	629.80	629.80	341.60	353.10	353.10	353.10	353.10
	TOTALS:	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60	5870.60

5.3.2 ENVIRONMENTAL IMPACTS

5.3.2.1 No Action

Under the No-Action Alternative, riparian and wetland habitats would not be restored and immediate conditions would not change from those documented in baseline studies. Alternative O would result in no change, or possibly a decrease, in the AAFCUs available.

Impact: Long-Term Increase in Saltcedar and Decrease in Cottonwood/Willow Vegetation

The No-Action Alternative would result in a long-term increase in saltcedar. Cottonwood/willow habitat would be expected to decline. Though undesirable, this would still be considered a less-than-significant impact to biological resources in the project area.

Mitigation Measure: No mitigation required.

Impact: Long-Term Decrease in Wildlife Habitat

Implementation of the No-Action Alternative would result in long-term habitat degradation. The increase in saltcedar and decrease in cottonwood/willow habitat would diminish habitat values of vegetation available to riparian-obligate wildlife. The decline of cottonwood/willow habitat value would result in the eventual decrease of optimal habitat available to the southwestern willow flycatcher. However, saltcedar is utilized by southwestern willow flycatchers and its spread would constitute a less-than-significant impact.

Mitigation Measure: No mitigation required.

5.3.2.2 Alternative F

Alternative F would result in a substantial increase in the cottonwood/willow, new river bottom (including freshwater marsh), and open water communities compared to future conditions without the project (Figure 3-6). Alternative F would result in an expected increase of nearly 1,035 AAFCUs.

This alternative would substantially increase the habitat values of the area, including preventing the anticipated decrease in cottonwood/willow habitat and corresponding increase in saltcedar. This alternative would also result in the physical removal of non-native saltcedar habitat in areas where the new habitat cells would be created. On a long-term basis, a substantial improvement in vegetation communities in the area would result.

Impact: Substantial Short-Term Impacts on Vegetation

Implementation of Alternative F would also result in substantial short-term impacts on vegetation. The major disruption would be to saltcedar habitat, which would be removed in some areas. There is also the potential for other communities to be indirectly disturbed during grading and restoration. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure BR-1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

During the final design of the project, disturbances to areas of existing vegetation that are not within the project footprint can be minimized through careful phasing of the project construction. Areas of desirable vegetation can be delineated on construction plans as areas that are not to be disturbed. Additionally, vegetation removal would occur outside of the spring breeding season (usually late January to early April) to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Impact: Substantial Increase in Wildlife Habitat

On a long-term basis, habitat value in the region would increase substantially. The primary benefit would be to riparian-obligate bird species due to increases in cottonwood/willow and mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. In addition, it is anticipated that amphibian species would benefit from implementation of Alternative F, and that this alternative would increase foraging habitat for raptors and mammalian carnivores. This is a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Common Wildlife Species

Construction and restoration activities may have a potentially significant short-term impact on common wildlife. Of particular concern is the disruption of nesting and nesting habitat for riparian-obligate species. Even saltcedar, an exotic weed species proposed for removal, provides some nesting habitat for these species.

Noise and other construction activities may also tend to cause wildlife to avoid the area. Although the short-term effects may be considerable, with the exception of listed wildlife species, the species that would be affected are locally abundant and would only be displaced on a temporary basis. In addition, mitigation described below for listed wildlife species would also have benefits for common wildlife in the project study area. Therefore, this is not considered a significant impact.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

During the final design of the project, disturbances to areas of existing vegetation that are not within the project footprint can be minimized through careful phasing of the project construction. Areas of desirable vegetation can be delineated on construction plans as areas that are not to be disturbed. Additionally, vegetation removal would occur outside of the spring breeding season (usually late January to early April) to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Impact: Short-Term Impact on Habitat for Listed Species

Suitable habitat for the Yuma clapper rail is present adjacent to the SR 101/202 interchange. Surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Bald eagles are not known to nest in the project area; however, bald eagles foraging within the project area could experience short-term impacts due to the removal of vegetation used as cover and foraging habitat by bald eagle prey. This impact can be mitigated through the implementation of Mitigation Measure BR-1, which will be timed to occur during the bald eagle nesting season and when the likelihood of bald eagles foraging within the project area is decreased.

Tamarisk vegetation provides habitat for breeding populations of southwestern willow flycatchers and western yellow-billed cuckoos. While isolated patches of this type of vegetation are present within the project area, there are no known occurrences of breeding flycatchers or cuckoos within the project area (Corman pers. comm.). Removal of exotic tamarisk would not impact either of these two species.

Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support threatened and endangered species. If suitable habitat has developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of of surveys.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

During the final design of the project, disturbances to areas of existing vegetation that are not within the project footprint can be minimized through careful phasing of the project construction. Areas of desirable vegetation can be delineated on construction plans as areas that are not to be disturbed. Additionally, vegetation removal would occur outside of the spring breeding season (usually late January to early April) to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Impact: Long-Term Increase in Habitat for Listed Wildlife Species

On a long-term basis, a substantial increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail is anticipated. Implementation of Alternative F is also expected to increase potential habitat for the cactus

ferruginous pygmy-owl and increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle. A substantial beneficial impact on the sensitive species occurring or potentially occurring in the study area is expected in the long term.

Mitigation Measure: No mitigation required.

Impact: Potential Impact on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities

As described in Section 3.2.1.5, long-term maintenance activities would be needed to maintain flood protection capacity and retain the habitat values of the restored vegetation. The implementation of this alternative would result in increased habitat values and would create high-quality habitat for the southwestern willow flycatcher and the Yuma clapper rail. The O&M activities have the potential to affect the restored habitat and sensitive species. Channel and drainage maintenance, vector control, sediment removal from restoration features, and removal of saltcedar regrowth can produce potentially significant short-term impacts.

The greatest potentially significant impact would be the necessary removal of sediment from the open water and marsh habitat. Although this activity is necessary to maintain the habitat, there would be short-term loss of marsh vegetation and potential loss of Yuma clapper rail habitat. This activity may also disturb nesting southwestern willow flycatchers in cottonwood/willow habitat by creating substantial noise. Other activities may also create short-term disturbances to this habitat. Implementation of Mitigation Measure BR-2 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

Sediment removal activities and other activities would only be conducted during non-nesting periods of the southwestern willow flycatcher, the yellow-billed cuckoo, and the Yuma clapper rail. In the case of sediment removal, these activities would be conducted on a rotating basis so that no more that 25% of the marsh area would be affected in any one year.

Impact: Short-Term Impacts on Waters of the United States

Alternative F would result in disturbance of waters of the United States during the construction phase as habitat areas located between the riverbanks. However, these areas would only be disturbed during the construction phase. Once constructed, these areas would gradually provide high-quality habitat to replace the existing degraded areas. No permanent loss of jurisdictional waters would occur; thus, this is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impacts on Waters of the United States during O&M Activities

O&M activities required to maintain the habitat cells and supporting features have the potential to affect jurisdictional waters within the project footprint. However, these effects would be short-term in duration and are required to ensure that the new habitat areas remain viable. Implementation of Mitigation Measure BR-3 would reduce this impact to a less-than-significant level.

Mitigation Measure BR-3: Minimize Disturbance to Waters of the United States

During O&M activities, care would be taken to minimize any necessary disturbance to waters of the United States and to ensure that such activities comply with the provisions of Section 404 of the Clean Water Act and its associated regulations.

5.3.2.3 Alternative N

As with Alternative F, Alternative N would result in a substantial increase in the cottonwood/willow, new river bottom (including freshwater marsh), and open water communities compared to future conditions without the project (Figure 3-6). This alternative would substantially increase the habitat values of the area, including preventing the anticipated decrease in cottonwood/willow habitat and the subsequent increase in saltcedar. This alternative would also result in the physical removal of non-native saltcedar habitat in areas where the new habitat cells would be created. As a result, an increase of nearly 913 AAFCUs is expected with the implementation of Alternative N. On a long-term basis, a substantial improvement in vegetation communities in the area would result.

Impact: Substantial Short-Term Impacts on Vegetation

As with Alternative F, implementation of Alternative N would also result in substantial short-term impacts on vegetation. The major disruption would be to saltcedar habitat, which would be removed in some areas. There is also the potential for other communities to be indirectly disturbed during grading and restoration. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure BR-1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Substantial Increase in Wildlife Habitat

As with Alternative F, on a long-term basis, habitat value in the region would increase substantially. The primary benefit would be to riparian-obligate bird species due to increases in cottonwood/willow and mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. It is also

anticipated that amphibian species would benefit from implementation of Alternative N, and that this alternative would increase foraging habitat for raptors and mammalian carnivores. This is a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Common Wildlife Species

As with Alternative F, construction and restoration activities may have a potentially significant short-term impact on common wildlife. Of particular concern is the disruption of nesting and nesting habitat for riparian-obligate species. Even saltcedar, an exotic weed species proposed for removal, provides some nesting habitat for these species.

Noise and other construction activities may also tend to cause wildlife to avoid the area. Although the short-term effects would be considerable, with the exception of listed wildlife species, the species that would be affected are locally abundant and would only be displaced on a temporary basis. In addition, mitigation described below for listed wildlife species would also have benefits for common wildlife in the project study area. Therefore, this is not considered a significant impact.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impact on Habitat for Listed Species

Suitable habitat for the Yuma clapper rail is present adjacent to the SR 101/202 interchange. Surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Bald eagles are not known to nest in the project area; however, as with Alternative F, bald eagles foraging within the project area could experience short-term impacts due to the removal of vegetation used as cover and foraging habitat by bald eagle prey. This impact can be mitigated through the implementation of Mitigation Measure BR-1, which will be timed to occur during the bald eagle nesting season and when the likelihood of bald eagles foraging within the project area is decreased.

Tamarisk vegetation provides habitat for breeding populations of southwestern willow flycatchers and western yellow-billed cuckoos. While isolated patches of this type of vegetation are present within the project area, there are no known occurrences of breeding flycatchers or cuckoos within the project area (Corman pers. comm.). Removal of exotic tamarisk would not impact either of these two species.

Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support threatened and endangered species. If suitable habitat has

developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of of surveys.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Long-Term Increase in Habitat for Listed Wildlife Species

As with Alternative F, on a long-term basis, a substantial increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail is anticipated. Implementation of Alternative N is also expected to increase potential habitat for the cactus ferruginous pygmy-owl and increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle. A substantial beneficial impact on the sensitive species occurring or potentially occurring in the study area is expected in the long term.

Mitigation Measure: No mitigation required.

Impact: Potential Impact on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities

As described in Section 3.2.1.5, long-term maintenance activities would be needed to maintain flood protection capacity and retain the habitat values of the restored vegetation. The implementation of this alternative would result in increased habitat values and would create high-quality habitat for the southwestern willow flycatcher and the Yuma clapper rail. The O&M activities have the potential to affect the restored habitat and sensitive species. Channel and drainage maintenance, vector control, sediment removal from restoration features, and removal of saltcedar regrowth can produce potential short-term impacts.

The greatest potential impact would be the necessary removal of sediment from the open water and marsh habitat. Although this activity is necessary to maintain the habitat, there would be short-term loss of marsh vegetation and potential loss of Yuma clapper rail habitat. This activity may also disturb nesting southwestern willow flycatchers in cottonwood/willow habitat by creating substantial noise. Other activities may also create short-term disturbances to this habitat. However, implementation of Mitigation Measure BR-2 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impacts on Waters of the United States

As with Alternative F, Alternative N would result in disturbance of waters of the United States during the construction phase as habitat areas located between the riverbanks. However, these areas would only be disturbed during the construction phase. Once constructed, these areas would gradually provide high-quality habitat to replace the existing degraded areas. No permanent loss of jurisdictional waters would occur; thus, this is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impacts on Waters of the United States during O&M Activities

As with Alternative F, O&M activities required to maintain the habitat cells and supporting features have the potential to affect jurisdictional waters within the project footprint. However, these effects would be short-term in duration and are required to ensure that the new habitat areas remain viable. Implementation of Mitigation Measure BR-3 would reduce this impact to a less-than-significant level.

Mitigation Measure: BR-3: Minimize Disturbance to Waters of the United States

See Alternative F for a description of this mitigation measure.

5.3.2.4 Alternative O (Preferred Alternative)

As with Alternative F, Alternative O would result in a substantial increase in the cottonwood/willow, new river bottom (including freshwater marsh), and open water communities compared to future conditions without the project. This alternative would substantially increase the habitat values of the area, including preventing the anticipated decrease in cottonwood/willow habitat and the subsequent increase in saltcedar. This alternative would also result in the physical removal of non-native saltcedar habitat in areas where the new habitat cells would be created. As a result, an increase of nearly 963 AAFCUs is expected with the implementation of Alternative O. On a long-term basis, a substantial improvement in vegetation communities in the area would result.

Impact: Substantial Short-Term Impacts on Vegetation

As with Alternative F, implementation of Alternative O would also result in substantial short-term impacts on vegetation. The major disruption would be to saltcedar habitat, which would be removed in some areas. There is also the potential for other communities to be indirectly disturbed during grading and restoration. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure BR-1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Substantial Increase in Wildlife Habitat

As with Alternative F, on a long-term basis, habitat value in the region would increase substantially. The primary benefit would be to riparian-obligate bird species due to increases in cottonwood/willow and mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. It is also anticipated that amphibian species would benefit from implementation of Alternative O, and that this alternative would increase foraging habitat for raptors and mammalian carnivores. This is a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Common Wildlife Species

As with Alternative F, construction and restoration activities may have a potentially significant short-term impact on common wildlife. Of particular concern is the disruption of nesting and nesting habitat for riparian-obligate species. Even saltcedar, an exotic weed species proposed for removal, provides some nesting habitat for these species.

Noise and other construction activities may also tend to cause wildlife to avoid the area. Although the short-term effects would be considerable, with the exception of listed wildlife species, the species that would be affected are locally abundant and would only be displaced on a temporary basis. In addition, mitigation described below for listed wildlife species would also have benefits for common wildlife in the project study area. Therefore, this is not considered a significant impact.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impact on Habitat for Listed Species

Suitable habitat for the Yuma clapper rail is present adjacent to the SR 101/202 interchange. Surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Bald eagles are not known to nest in the project area; however, as with Alternative N, bald eagles foraging within the project area could experience short-term impacts due to the removal of vegetation used as cover and foraging habitat by bald eagle prey. This impact can be mitigated through the implementation of Mitigation Measure BR-1, which will be timed to occur during the bald eagle nesting season and when the likelihood of bald eagles foraging within the project area is decreased.

Tamarisk vegetation provides habitat for breeding populations of southwestern willow flycatchers and western yellow-billed cuckoos. While isolated patches of this type of vegetation are present within the project area, there are no known occurrences of breeding flycatchers or cuckoos within the project area (Corman pers. comm.). Removal of exotic tamarisk would not impact either of these two species.

Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support threatened and endangered species. If suitable habitat has developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of of surveys.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Long-Term Increase in Habitat for Listed Wildlife Species

As with Alternative F, on a long-term basis, a substantial increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail is anticipated. Implementation of Alternative F is also expected to increase potential habitat for the cactus ferruginous pygmy-owl and increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle. A substantial beneficial impact on the sensitive species occurring or potentially occurring in the study area is expected in the long term.

Mitigation Measure: No mitigation required.

Impact: Potential Impact on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities

As described in Section 3.2.1.5, long-term maintenance activities would be needed to maintain flood protection capacity and retain the habitat values of the restored vegetation. The implementation of this alternative would result in increased habitat values and would create high-quality habitat for the southwestern willow flycatcher and the Yuma clapper rail. The O&M activities have the potential to affect the restored habitat and sensitive species. Channel and drainage maintenance, vector control, sediment removal from restoration features, and removal of saltcedar regrowth can produce potential short-term impacts.

The greatest potential impact would be the necessary removal of sediment from the open water and marsh habitat. Although this activity is necessary to maintain the habitat, there would be short-term loss of marsh vegetation and potential loss of Yuma clapper rail habitat. This activity may also disturb nesting southwestern willow flycatchers in cottonwood/willow habitat by creating substantial noise. Other activities may also create short-term disturbances to this habitat. However, implementation of Mitigation Measure BR-2 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impacts on Waters of the United States

As with Alternative F, Alternative O would result in disturbance of waters of the United States during the construction phase as habitat areas located between the riverbanks. However, these areas would only be disturbed during the construction phase. Once constructed, these areas would gradually provide high-quality habitat to replace the existing degraded areas. No permanent loss of jurisdictional waters would occur; thus, this is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impacts on Waters of the United States during O&M Activities

As with Alternative F, O&M activities required to maintain the habitat cells and supporting features have the potential to affect jurisdictional waters within the project footprint. However, these effects would be short-term in duration and are required to ensure that the new habitat areas remain viable. Implementation of Mitigation Measure BR-3 would reduce this impact to a less-than-significant level.

Mitigation Measure: BR-3: Minimize Disturbance to Waters of the United States

See Alternative F for a description of this mitigation measure.

5.3.2.5 Alternative E

Alternative E would result in impacts similar to Alternative F. A substantial increase in cottonwood/willow, new river bottom (including freshwater marsh), and open water communities is expected (Figure 3-7). The alternative would substantially increase habitat values of the area and limit the spread of saltcedar. An increase of nearly 926 AAFCUs would be expected with the implementation of Alternative E.

Impact: Substantial Short-Term Impacts on Vegetation

As with Alternative F, implementation of Alternative E would result in substantial short-term impacts on vegetation, including removal of saltcedar in some areas. Indirect disturbance of other communities during grading and restoration may be potentially significant but can be mitigated through Mitigation Measure BR-1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Substantial Increase in Wildlife Habitat

As with Alternative F, habitat value in the region would increase substantially over the long term. The primary benefit would be to riparian-obligate bird species dues to increases in cottonwood/willow and mesquite communities. There will also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. It is also anticipated that amphibians will benefit from implementation of this alternative. This alternative is also expected to increase foraging habitat for raptors and mammalian carnivores. This is a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Common Wildlife Species

Construction and restoration activities may have a substantial short-term impact on common wildlife resources as described for Alternative F. Of particular concern is the short-term disruption of nesting and nesting habitat for riparian-obligate species. Even saltcedar, an exotic species proposed for removal, provides nesting habitat for these species. Noise and other construction activities may cause wildlife to avoid the area. With the exception of listed wildlife species, the species that would be affected are locally abundant and would only be displaced on a temporary basis; therefore, this is not considered a significant impact. Mitigation described below for listed wildlife species would also have benefits for common wildlife in the project study area.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impact on Habitat for Listed Wildlife Species

Suitable habitat for the Yuma clapper rail is present adjacent to the SR 101/202 interchange. Surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Bald eagles are not known to nest in the project area; however, as with Alternative O, bald eagles foraging within the project area could experience short-term impacts due to the removal of vegetation used as cover and foraging habitat by bald eagle prey. This impact can be mitigated through the implementation of Mitigation Measure BR-1, which will be timed to occur during the bald eagle nesting season when the likelihood of bald eagles foraging within the project area is decreased.

Tamarisk vegetation provides habitat for breeding populations of southwestern willow flycatchers and western yellow-billed cuckoos. While isolated patches of this type of vegetation are present within the project area, there are no known occurrences of breeding flycatchers or cuckoos within the project area (Corman pers. comm.). Removal of exotic tamarisk would not impact either of these two species.

Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support threatened and endangered species. If suitable habitat has developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of of surveys.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation During Construction

See Alternative F for a description of this mitigation measure.

Impact: Long-Term Increase in Habitat for Listed Wildlife Species

On a long-term basis, a substantial increase in habitat is anticipated for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail. Implementation of Alternative E would also increase potential habitat for the cactus ferruginous pygmy-owl and increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle. A substantial beneficial impact on the sensitive species occurring or potentially occurring in the study area is expected in the long term.

Mitigation Measure: No mitigation required.

Impact: Potential Impact on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities

O&M activities have the potential to affect restored habitat and sensitive species as discussed for Alternative F. Removal of sediment from open water and marsh habitat would result in potential loss of Yuma clapper rail habitat and noise disturbance of nesting southwestern willow flycatchers. However, implementation of Mitigation Measure BR-2 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only during Non-Nesting Periods

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impacts on Waters of the United States

As with Alternative F, Alternative E would result in disturbance of waters of the United States during the construction phase as habitat areas located between the riverbanks are constructed. However, these areas would only be disturbed during the construction phase. Once constructed, these areas would gradually provide high-quality habitat to replace the existing degraded areas. No permanent loss of jurisdictional waters would occur; therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impacts on Waters of the United States during O&M Activities

As with Alternative F, O&M activities required to maintain the habitat cells and supporting features have the potential to affect jurisdictional waters within the project footprint. However, these effects would be short-term in duration and are required to ensure that the new habitat areas remain viable. This would not constitute a significant impact.

Mitigation Measure BR-3: Minimize Disturbance to Waters of the United States

See Alternative F for a description of this mitigation measure.

5.3.2.6 Alternative A

Implementation of Alternative A would result in a long-term increase in the cottonwood/willow, because of the removal of saltcedar (Figure 3-8). As with Alternative F, this alternative would increase the habitat values of the area, though not to the magnitude of the other alternatives. This alternative would, in affect, prevent an increase in saltcedar. An increase of nearly 373 AAFCUs is predicted with the implementation of Alternative A.

Impact: Substantial Short-Term Impacts on Vegetation

Potentially significant short-term impacts on vegetation would result under this alternative, as under Alternative F. Saltcedar habitat would be removed in some areas, and grading could indirectly disturb other communities. This impact can be mitigated through Mitigation Measure BR-1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation During Construction

See Alternative F for a description of this mitigation measure.

Impact: Increase in Wildlife Habitat

An increase in habitat value in the region is expected with Alternative A, as for the other action alternatives. Riparian-obligate bird species would benefit from the removal of saltcedar to allow for cottonwood/willow growth. This is a beneficial impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Common Wildlife Species

Construction and restoration would have a less-than-significant impact on common wildlife resources. The species that would be affected are locally abundant and would only be displaced on a temporary basis.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impact on Habitat for Listed Species

Suitable habitat for the Yuma clapper rail is present adjacent to the SR 101/ 202 interchange. Surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Bald eagles are not known to nest in the project area; however, as with Alternative E, bald eagles foraging within the project area could experience short-term impacts due to the removal of vegetation used as cover and foraging habitat by bald eagle prey. This impact can be mitigated through the implementation of Mitigation Measure BR-1, which will be timed to occur during the bald eagle nesting season when the likelihood of bald eagles foraging within the project area is decreased.

Tamarisk vegetation provides habitat for breeding populations of southwestern willow flycatchers and western yellow-billed cuckoos. While isolated patches of this type of vegetation are present within the project area, there are no known occurrences of breeding flycatchers or cuckoos within the project area (Corman pers. comm.). Removal of exotic tamarisk would not impact either of these two species.

Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support threatened and endangered species. If suitable habitat has developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of of surveys.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation During Construction

See Alternative F for a description of this mitigation measure.

Impact: Long-Term Increase in Habitat for Listed Wildlife Species

Habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail would increase over the long term, as with Alternative F. Implementation of Alternative A is also expected to increase potential habitat for the cactus ferruginous pygmy-owl and increase foraging habitat for sensitive raptors such as the peregrine falcon and bald eagle. Sensitive species occurring or potentially occurring in the study area would benefit over the long term.

Mitigation Measure: No mitigation required.

Impact: Potential Impact on Vegetation, Wildlife, and Sensitive Species during Long-Term O&M Activities

Maintenance activities to retain flood protection capacity and habitat values of the restored wetlands have the potential to affect restored habitat and sensitive species. Channel and drainage maintenance, vector control, sediment removal from restoration features, and removal of saltcedar regrowth can produce potential short-term impacts as described for Alternatives F, N, and E. Removal of sediment from open water and marsh habitat may result in loss of Yuma clapper rail habitat and disturbance of nesting southwestern willow flycatchers. However, implementation of Mitigation Measure BR-2 would reduce this impact to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only during Non-Nesting Periods.

See Alternative F for a description of this mitigation measure.

Impact: Short-Term Impacts on Waters of the United States

As with Alternative F, Alternative A would result in disturbance of waters of the United States during the construction phase as habitat areas located between the riverbanks are constructed. However, these areas would only be disturbed during the construction phase. Once constructed, these areas would gradually provide high-quality habitat to replace the existing degraded areas. No permanent loss of jurisdictional waters would occur; therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Short-Term Impacts on Waters of the United States during O&M Activities

As with Alternative F, O&M activities required to maintain the habitat cells and supporting features have the potential to affect jurisdictional waters within the project footprint. However, these effects would be short-term in duration and are required to ensure that the new habitat areas

remain viable. Implementation of Mitigation Measure BR-3 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-3: Minimize Disturbance to Waters of the United States

See Alternative F for a description of this mitigation measure.

5.4 CULTURAL RESOURCES

5.4.1 APPROACH AND METHODOLOGY

5.4.1.1 Significance Criteria

Adverse effects to sites and properties listed on, or eligible for inclusion in the National Register of Historic Places (NRHP) are evaluated based on the *Criteria of Adverse Effect* as outlined in 36 Code of Federal Regulations (CFR) 800.5 of the regulations implementing Section 106 of the National Historic Preservation Act (NHPA). These regulations were recently amended and became final in 2000. The *Criteria of Adverse Effect* are described as follows:

> An adverse effect is found when an undertaking may alter, directly or indirectly, the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative. Adverse effects on historic properties include, but are not limited to:
>
> (I) Physical destruction of or damage to all or part of the property; (ii) Alteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation and provision of handicapped access, that is not consistent with the Secretary's Standards for the Treatment of Historic Properties (36 CFR part 68) and applicable guidelines; (iii) Removal of the property from its historic location; (iv) Change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance; (v) Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features; (vi) Neglect of a property which causes its deterioration, except where such neglect and deterioration are recognized qualities of a property of religious and cultural significance to an Indian tribe or Native Hawaiian organization; and (vii) Transfer, lease, or sale of property out of Federal ownership or control without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance.

5.4.1.2 Coordination and Preliminary Archaeological Surveys

To meet the requirements of Section 106 of the NHPA, as implemented by 36 CFR 800, the Corps has conducted a records and literature search and field survey of the areas of potential effect for each of the project alternatives. NRHP evaluations have been made for some of the prehistoric and historic sites that have been identified. If any resources are determined to be NRHP eligible, and avoidance is not feasible, mitigation measures would be detailed in a Memorandum of Agreement (MOA) between the Corps, the SRPMIC, the City of Mesa, and the Arizona State Historic Preservation Officer (SHPO). Initial informal consultations with the SHPO have been initiated towards compliance with the NHPA.

Results of the archival studies and archeological surveys, along with the Corps' determinations of NRHP eligibility, will be sent to the Arizona SHPO for review and comment. If it is determined that the project will have an adverse effect on NRHP-listed or eligible properties, the Advisory Council on Historic Preservation will be afforded the opportunity to comment on the project in accordance with Section 106 of the NHPA.

All archival and archeological studies will be provided to the Salt River Pima-Maricopa Indian Community.

5.4.2 ENVIRONMENTAL IMPACTS

5.4.2.1 No Action

Implementation of the No-Action Alternative will not result in any direct impacts on cultural resources. It is probable, however, that sites may be disturbed or lost both by other human actions that are not project related and through natural processes such as erosion.

5.4.2.2 Alternative F

Activities involved in constructing features to accomplish ecosystem restoration under this alternative would involve ground disturbance to varying degrees, depending on specific location within the project area. Defined activities necessary for ecosystem restoration under this alternative include reshaping and grading for irrigation, planting of vegetation, river channelization, construction of grade control structures, and bank stabilization. All of these activities would have an adverse effect on NRHP sites.

Impact: Potential Disturbance or Loss of Properties Listed or Eligible for Listing on the National Register

The restoration activities described above would move artifacts, ecofactual materials, and features from their original provenance. This displacement would either destroy or significantly diminish the scientific value of any information potential, and hence adversely affect NRHP eligibility. Additionally, the newly planted vegetation would create adverse affects as the plants grow and develop root systems. Roots are a common form of archeological site disturbance (bioturbation). Increasing the levels of water in the soil would change the soil chemistry, and possibly increase the degradation of important perishable ecofactual remains.

Under Alternative F, several known cultural sites have the potential to be adversely affected. This represents a significant and unavoidable impact. The exact number is being updated based on recent survey and subsurface testing. This represents a significant and unavoidable impact if any of them are determined to be eligible for the NRHP. The list of NRHP sites to be affected may be reduced or eliminated as the design of the project is refined. There may be opportunities to incorporate site preservation into project plans that would result in beneficial effects to cultural sites. This might be accomplished by providing for avoidance and/or isolation from future human impacts.

Mitigation Measure CR-1: Ensure Compliance with Section 106 of National Historic Preservation Act

Compliance with Section 106 of the NHPA as implemented by 36 CFR 800 will potentially require additional field surveys, subsurface test excavations, and other studies. The results of all studies will be coordinated with the SHPO.

Mitigation Measure CR-2: Conclude Memorandum of Agreement to Complete Field Surveys and Conduct Testing and Data Recovery Activities as Appropriate

In the event that NRHP-eligible cultural resources cannot be avoided, an MOA shall be executed between the Corps, the SHPO, SRPMIC, and the City of Mesa. The MOA will detail the mitigation measures that will be implemented prior to construction.

Mitigation Measure CR-3: Monitor Construction Activities for Potential Impact on Cultural Resources

A qualified archeologist meeting the Secretary of the Interior's standards will monitor construction activities. In the event that previously unknown cultural resources are found, the Corps will comply with the procedures contained in 36 CFR 800.13(d).

5.4.2.3 Alternative N

Since Alternative N does not include channelization or bank stabilization, the area of potential effect for Alternative N is slightly smaller than the area of potential effect for Alternative F. Under this alternative, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. Impacts and mitigation measures that are discussed above under Alternative F would be applicable to this alternative. Implementation of Alternative N would still represent a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.

5.4.2.4 Alternative O (Preferred Alternative)

Under Alternative O, potential effects are similar to Alternative N because the alternative does not include channelization or bank stabilization. Similar to Alternatives F and N, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. Impacts and mitigation measures that are discussed above under Alternative F would be applicable to this alternative. Implementation of Alternative O would still represent a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.

5.4.2.5 Alternative E

The potential impacts of Alternative E to cultural resources are similar to, but slightly smaller than, the impacts of Alternatives F and N, since, due to a more limited work area, the area of potential effect is smaller. Under this alternative, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. This would still constitute a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.

Impacts and mitigation measures that are discussed above under Alternative F would be applicable to this alternative.

5.4.2.6 Alternative A

Restoration activities under Alternative A are more limited in scope than under Alternatives F, N, and E, and would thus have the potential to affect fewer known cultural resources. Under this alternative, several cultural sites have the potential to be adversely affected. The exact number is being updated based on recent surface and subsurface testing. This would represent a significant and unavoidable impact to cultural resources in the project area, in the event that any of these sites are determined to be NRHP eligible.

Impacts and mitigation measures that are discussed above under Alternative F would also be applicable to this alternative.

5.4.3 COMMITMENTS

An archeological survey (surface and subsurface) of the entire project's area of potential effect has been conducted. If additional areas are needed at a later date, additional surveys would be required. If sites cannot be avoided by the project, evaluation studies regarding NRHP eligibility are required. Mitigation measures for any cultural resource listed or eligible for listing in the NRHP that will be affected by the proposed action will be negotiated with the Corps, the SRPMIC, the City of Mesa, and the SHPO, resulting in a Memorandum of Agreement. Mitigation measures will be implemented prior to construction.

All construction activities will be monitored by qualified archaeologists. If cultural resources are discovered during construction and cannot be avoided, work will be suspended in that area until the properties are evaluated for eligibility for listing in the NRHP in consultation with the Arizona SHPO. If the properties are determined to be eligible for the NRHP, the effects of the proposed construction will be taken into consideration in consultation with the SRPMIC, the City of Mesa, and the SHPO, and the SHPO will be provided the opportunity to comment in accordance with 36 CFR 800.13.

5.5 AESTHETIC RESOURCES

5.5.1 APPROACH AND METHODOLOGY

Impacts to aesthetic resources are evaluated based on the potential for permanent degradation to the scenic beauty of the project area. Long-term degradation, either as direct or indirect impact of the proposed project, would be considered a significant impact. Each action alternative includes features that would restore and enhance the river corridor. Incidental to the objectives of the project are the aesthetic improvements associated with restoration. Potential impacts were identified by qualitatively evaluating the project components for each of the alternatives against the existing aesthetic conditions within the project area.

5.5.2 ENVIRONMENTAL IMPACTS

5.5.2.1 No Action

Under the No-Action Alternative, the existing aesthetic environment would remain relatively unaffected, with the exception of natural changes occurring from flood events over time. With the No-Action Alternative, there would be no short-term impacts on aesthetic resources that are associated with construction activities. However, long-term aesthetic improvements would not be realized with this alternative.

5.5.2.2 Alternative F

Impact: Potential Short-Term Adverse Aesthetic Effects

This alternative involves excavation and grading in the river corridor; construction of diversion and grade control structures; installation of constructed wetlands; and development of cottonwood/willow, mesquite, and Sonoran Desert habitat. These temporary activities could result in impacts on the aesthetic quality of the area. Passersby on adjacent streets and the Red Mountain Freeway may experience temporary views of construction activities and construction equipment in the river corridor and nearby areas. However, there are relatively limited viewing/access points from adjacent roadways and construction activities would not appear to be much different to the casual observer than the current sand and gravel mining activities. The potential impacts from these construction-related activities would be less than significant. In addition, the long-term environmental and aesthetic benefits of the project would outweigh temporary adverse construction-related effects.

Mitigation Measure: No mitigation required.

Impact: Potential Long-Term Adverse Aesthetic Effects

This alternative includes diversion structures in several locations. The structures will require riprap or soil cement on the river side to provide necessary stability to the channel during flood events. These structures are generally located away from the edges of the project area, and the soil cement or riprap would be placed on the bank below the adjacent ground surface elevation. The diversion structures should not be highly visible from nearby areas and the view of the structures will be reduced as vegetation matures in the adjacent habitats. Thus, the installation of diversion structures is not considered a significant impact.

Mitigation Measure: No mitigation required.

Impact: Long-Term Aesthetic Benefits

The proposed action includes the restoration and enhancement of environmental resources in the Salt River. The project would include provision of open water and marsh habitat, cottonwood/willow riparian corridors, and constructed wetland areas. Additionally, removal of saltcedar, an invasive vegetation species, would improve habitat values and increase biodiversity in the project study area. Structural features associated with the proposed action would be visually softened with vegetation where possible.

Although the study area currently exists as passive open space, the proposed action would further improve the aesthetic quality. Additional riparian vegetation corridors, wetland and upland habitats, and increased wildlife would contribute to the aesthetic quality of the area. Long-term aesthetic improvements would result from restoration and enhancement efforts. This is considered a beneficial effect.

Mitigation Measure: No mitigation required.

5.5.2.3 Alternative N

The aesthetic impacts of Alternative N are similar to those described for Alternative F. The lack of bank stabilization elements would diminish potential short-term impacts from construction because of the reduced amount of grading. While there would be slightly less mesquite and cottonwood/willow habitat, the visual mosaic of habitats would be similar to Alternative F and ultimately be a long-term beneficial impact.

5.5.2.4 Alternative O (Preferred Alternative)

The aesthetic impacts of Alternative O are similar to those described for Alternative F. The lack of bank stabilization elements would diminish potential short-term impacts from construction because of the reduced amount of grading. While there would be slightly less mesquite and slightly more cottonwood/willow habitat, the visual mosaic of habitats would be similar to Alternative F. The additional cottonwood/willow habitat is primarily located in Reaches 1 and 2 at the west end of the project and would enhance the visual character on the vicinity of the

SR 101/202 interchange. As with Alternative F, the habitat restoration would ultimately be a long-term beneficial impact to the visual character of the area.

5.5.2.5 Alternative E

This alternative is similar to Alternative F with respect to aesthetics. Potential short-term impacts from construction would be diminished because of the reduced amount of grading and excavation. This alternative relies more heavily on the Sonoran Desert vegetation habitat, with a corresponding reduced emphasis on cottonwood/willow and wetland habitats. Long-term aesthetic quality will be enhanced by these restoration efforts.

5.5.2.6 Alternative A

Under Alternative A, aesthetic impacts would be limited to the central and eastern portions of the project area. There would be minimal short-term impacts from construction; however, the lack of diverse habitats such as cottonwood/willow and wetlands would somewhat diminish long-term aesthetic improvements. The existing aesthetic environment in the western portion of the project would remain relatively unaffected, with the exception of natural changes occurring from flood events over time. Although limited, restoration activities under this alternative are considered beneficial with regard to aesthetic values.

5.6 AIR QUALITY

5.6.1 APPROACH AND METHODOLOGY

Implementation of any of the proposed alternatives would generate construction-related emissions composed of fugitive dust from exposed disturbed soil, exhaust emissions produced by the use of heavy construction equipment, and exhaust emissions from construction worker commute trips. Operation and maintenance (O&M) of any alternative other than the No-Action Alternative would also generate exhaust and dust emissions from vehicles driven by workers and recreational visitors.

As discussed in Section 4.6, "Air Quality," federal projects must be evaluated to determine whether they conform to applicable state implementation plans (SIPs). Total project emissions of ozone precursors, carbon monoxide (CO), oxides of nitrogen (NOx), and fugitive dust (PM10) associated with each alternative are thus compared to *de minimis* thresholds. Air quality impacts would be considered significant if the proposed action results in exceeding any of these emission thresholds.

Detailed information on the methods and assumptions used to estimate air pollutant emissions is provided in Appendix H. To calculate construction and O&M emissions, emission factors developed by EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, have been used to calculate exhaust and fugitive dust emissions. Calculations are also based on construction information provided in the feasibility study. The following types of air pollutant emission sources were included in the calculations:

- Fugitive dust emissions from haul trucks and passenger cars on unpaved roads were estimated based on the assumed number of vehicle trips and travel distance, using AP-42 emission factors applicable for the western United States. For the construction phases, it was assumed unpaved haul roads would be aggressively watered to reduce dust emissions. During restoration (revegetation) activities and normal maintenance subsequent to project completion, it was assumed the unpaved haul roads would not be watered.
- Fugitive dust emissions from excavating, loading, dumping, and spreading of bulk soil during channel excavation and bank stabilization were estimated based on the assumed earthwork volumes, using AP-42 emission factors for surface mining operations.
- Emissions from construction equipment tailpipes were estimated based on the type and number of equipment, using recent emission factors for off-road equipment.

5.6.2 ENVIRONMENTAL IMPACTS

5.6.2.1 No Action

Under the No-Action Alternative, no project-related construction activities would take place and no new construction-related commute trips would occur. Thus, no construction-related emissions would be generated. Recreational use of the site would likely remain about the same, with no increases in criteria emissions resulting from new recreational use of the Va Shly'ay Akimel site.

5.6.2.2 Alternative F

Impact: Generation of Construction-Related and Operational Tailpipe Emissions (ROG, NO_x and CO Emissions)

Construction and O&M activities would generate emissions of ozone precursors and CO in the form of tailpipe emissions. Construction emissions would originate from a combination of construction equipment activities, vegetation burning, material screening, and construction worker commute trips. O&M activities would generate emissions from recreational vehicle trips, employee trips, and a variety of maintenance activities.

Table 5.6-1 summarizes the estimated emissions associated with implementation of Alternative F. Annual emissions of reactive organic gases (ROG), NOx, and CO would be below federal conformity *de minimis* levels during each year of project construction and operation; thus, this impact is considered less than significant.

The construction contractor would be required to obtain appropriate air pollution permits for stationary processing equipment used for the project, as required under local air quality regulations.

Mitigation Measure: No mitigation is required.

Impact: Generation of Construction-Related and Operational Fugitive Dust (PM10) Emissions

Channel excavation and bank stabilization would generate PM10 as a component of tailpipe emissions from construction equipment and construction worker commute vehicles, as well as fugitive dust generated by activities at the construction site. O&M activities would also generate PM10 emissions.

Table 5.6-1 summarizes the estimated emissions that are associated with implementation of Alternative F. Annual PM10 emissions during the maximum construction year would be less than federal *de minimis* thresholds for General Conformity. As described by the detailed emission calculations provided in Appendix H, most of the PM10 emissions would be caused by

fugitive dust generated by excavation of and spreading of riverbed material, and from haul trucks on unpaved roads.

The construction contractor would be required to obtain appropriate air pollution permits for stationary processing equipment (e.g., rock crushers and screens) as required under local air quality regulations. The contractors would also be required to implement stringent fugitive dust controls in accordance with Maricopa County Air Quality Rule 310.

As listed in Table 5.6-1, the estimated annual PM10 emissions during the restoration activities and long-term recreational usage would be less than the federal *de minimus* thresholds for General Conformity.

Implementation of Mitigation Measure AQ-1 would reduce these emissions and potential nuisance effects from dust to a less-than-significant level.

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

All construction activities would be required to include fugitive dust control measures in accordance with Maricopa County Air Quality Rule 310. The Corps would implement an appropriate combination of the following PM10-reducing construction practices throughout the construction period and during O&M activities:

- Apply water to unpaved haul roads at a frequency adequate to maintain visible surface moisture. Alternatively, apply nontoxic binders (e.g., latex acrylic copolymer) to supplement road watering.
- Minimize vehicle speed on unpaved roads.
- Water active storage piles at least twice daily.
- Cover inactive storage piles.
- Cover haul trucks securely or maintain at least 2 feet of freeboard on all haul trucks when transporting materials.
- Water all active construction sites at least twice daily. Frequency should be increased if wind speeds exceed 15 mph.
- Prohibit all grading activities during periods of high wind (i.e., winds greater than 30 mph).
- Apply nontoxic chemical soil stabilizers to inactive construction areas (i.e., disturbed lands within construction areas that are unused for at least 4 consecutive days), or water at least twice daily.
- Apply nontoxic binders (e.g., latex acrylic copolymer) to exposed areas after cut-and-fill operations and hydroseed the areas if appropriate for the project location.
- Install wheel washers for all exiting trucks.

- Sweep public streets serving the construction sites if visible soil material is carried onto adjacent public roads.

These practices would be made a condition of the construction contract and would be enforced through weekly inspection by the Corps.

5.6.2.3 Alternative N

Air quality impact mechanisms associated with construction of Alternative N would be similar to those occurring under Alternative F. However, the total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be lower under Alternative N than they would be under Alternative F.

Impact: Generation of Construction-Related and Operational Tailpipe Emissions (ROG, NO_x and CO Emissions)

ROG, NOx, and CO emissions would be below federal conformity *de minimis* levels during each year of project construction and operation for Alternative N (Table 5.6-1). Therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation is required.

Impact: Generation of Construction-Related and Operational Fugitive Dust (PM10) Emissions

Annual PM10 emissions during the maximum construction year would be less than *de minimus* thresholds for General Conformity (Table 5.6-1). Implementation of Mitigation Measure AQ-1 would reduce these emissions and limit potential nuisance effects from dust to a less-than-significant level.

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

See Alternative F for a description of this mitigation measure.

5.6.2.4 Alternative O (Preferred Alternative)

Air quality impact mechanisms associated with construction of Alternative N would be similar to those occurring under Alternative F. However, the total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be less under Alternative O than they would be under Alternative F because Alternative O entails lower volumes of earthwork, haul truck usage, and commute travel.

Impact: Generation of Construction-Related and Operational Tailpipe Emissions (ROG, NO_x and CO Emissions)

ROG, NOx, and CO emissions would be below federal conformity *de minimis* levels during each year of project construction and operation for Alternative O (Table 5.6-1). Therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation is required.

Impact: Generation of Construction-Related and Operational Fugitive Dust (PM10) Emissions

Annual PM10 emissions during the maximum construction year would be less than *de minimus* thresholds for General Conformity (Table 5.6-1). Implementation of Mitigation Measure AQ-1 would reduce these emissions and limit potential nuisance effects from dust to a less-than-significant level.

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

See Alternative F for a description of this mitigation measure.

5.6.2.5 Alternative E

Air quality impact mechanisms associated with construction of Alternative E would be similar to those occurring under Alternative F. However, the total quantities of emissions from channel excavation, bank stabilization, and riverbank restoration would be lower under Alternative E than they would be under Alternative F.

Impact: Generation of Construction-Related and Operational Tailpipe Emissions (ROG, NO_x and CO Emissions)

ROG, NOx, and CO emissions would be below federal conformity *de minimis* levels during each year of project construction and operation for Alternative E (Table 5.6-1). Therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation is required.

Impact: Generation of Construction-Related and Operational Fugitive Dust (PM10) Emissions

Annual PM10 emissions during the maximum construction year would exceed *de minimus* thresholds for Alternative E (Table 5.6-1). Mitigation Measure AQ-1 would reduce these emissions and limit potential nuisance effects from dust to a less-than-significant level.

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

See Alternative F for a description of this mitigation measure.

5.6.2.6 Alternative A

Air quality impact mechanisms associated with construction of Alternative A would be similar to those under Alternative F. However, the total quantities of emissions from construction activities would differ (Table 5.6-1). Post-construction mobile source emissions would be the same as described for Alternative F.

Impact: Generation of Construction-Related and Operational Tailpipe Emissions (ROG, NO_x and CO Emissions)

ROG, NOx, and CO emissions would be below federal conformity *de minimis* levels during each year of project construction and operation for Alternative A. Therefore, this is not considered a significant impact.

Mitigation Measure: No mitigation is required.

Impact: Generation of Construction-Related and Operational Fugitive Dust (PM10) Emissions

Although PM10 emissions would be well below conformity thresholds under Alternative A (Table 5.6-1 on the following page), Mitigation Measure AQ-1 would further reduce these emissions and limit potential nuisance effects from dust to a less-than-significant level.

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

See Alternative F for a description of this mitigation measure.

Table 5.6-1. Estimated Annual Air Pollutant Emissions (tpy) Associated with Alternatives F, N, O, E, A

Pollutants of Concern	Max. Construction Year Channel Excavation, Bank Stabilization, and Wetlands Construction	Restoration and Maintenance	Long-Term Recreational Use	*De Minimus* Thresholds for General Conformity
Alternative F				
ROG	6	1	1	50
NOx	46	4	3	50
CO	41	6	32	100
PM10	40	8	48	70
Alternative N				
ROG	5	1	1	50
NOx	39	4	3	50
CO	44	5	32	100
PM10	24	5	48	70
Alternative O				
ROG	5	1	1	50
NOx	39	4	3	50
CO	44	5	32	100
PM10	23	5	48	70
Alternative E				
ROG	5	1	1	50
NOx	38	4	3	50
CO	40	5	32	100
PM10	26	5	48	70
Alternative A				
ROG	5	1	1	50
NOx	36	4	3	50
CO	36	5	32	100
PM10	10	3	48	70

Note: Assumptions used to estimate emissions are provided in Appendix H

5.7 NOISE

5.7.1 APPROACH AND METHODOLOGY

The evaluation of noise impacts is highly subjective. Therefore, determining the level of significance for noise impacts is highly dependent on the particular scope and location of the project. For the project area, noise impacts were considered significant if the ambient noise level was permanently raised to a detectable level as a result of the proposed project.

Noise impacts were analyzed using standard noise modeling methods. First, potential sources of noise were identified. Then, noise levels for each source were identified from standard references or monitoring data for similar sources. The distance from sources to noise-sensitive receptors was determined, and the projected sound level of sources at the receptor was calculated, taking into account attenuation factors such as distance and atmospheric effects. Resulting sound levels at receptors were compared to relevant sound level criteria to determine the relative magnitude of a noise effect.

For each of the project alternatives below, except for Alternative O (the Preferred Alternative), noise effects would occur during the construction phase of the selected alternative, during post-construction use of the site by recreationists in the form of increased traffic noise in the project study area, and during periodic O&M activities.

5.7.2 ENVIRONMENTAL IMPACTS

5.7.2.1 No Action

Under the No-Action Alternative, no changes to ambient noise conditions in the project study area would occur. No construction-related noise would be generated, no new project-related traffic would use area roadways, and there would be no follow-on maintenance. For these reasons, there would be no adverse noise impacts associated with this alternative.

5.7.2.2 Alternative F

Activities under this alternative include the creation of irrigation and drainage ditches, spillways, bank armors, constructed wetlands, a low-flow channel, a grade control structure west of Gilbert Road at the center point of the old Gilbert Quarry, and a water distribution channel. Many of the procedures would involve excavation, grading, and other heavy construction activities at multiple sites throughout the project area.

Impact: Exposure of Sensitive Land Uses to Construction Noise

Residential uses adjacent to or near the areas that would be subject to construction would be exposed to noise from construction activities. Typical equipment used during construction would include graders, loaders, rollers, bulldozers, trucks, scrapers, pumps, and generators.

Specific information on when and how long equipment would be used has not yet been determined. Table 5.7-1 on the following page summarizes typical noise emissions levels for construction equipment. A reasonable worst-case assumption is that the three loudest pieces of equipment would operate simultaneously and continuously over a 1-hour period. The combined sound level of three of the loudest pieces of equipment listed in Table 5.7-1 is 92 dBA L_{eq} measured at 50 feet. Table 5.7-2, which follows Table 5.7-1, assumes this combined source level, summarizes predicted noise levels at various distances from an active construction site. These estimations take into account distance attenuation, attenuation from molecular absorption, and anomalous excess attenuation.

The study area has moderate activity levels and several sources of adverse noise. The principle sources of noise in the study area are sand and gravel mining operations. This is the largest contributor to ambient noise in the area.

Table 5.7-1. Noise Emission Levels Typical for Construction Equipment

Equipment	Typical Noise Level (dBA) 50 feet from Source
Grader	85
Loader	85
Roller	75
Bulldozer	85
Truck	88
Scraper	89

dBA = A-weighted decibel scale.
Source: Federal Transit Administration 1995.

Automobiles traversing SR 202 and SR 101 are another contributor of ambient noise in the area. Traffic noise in the area may be characterized as moderately loud. Aircraft departing from and entering Phoenix Sky Harbor Airport contribute to the ambient noise in the study area. The airport is not within the immediate vicinity of the study area, though the study area runs generally parallel to the airport's takeoff and approach zone. However, because aircraft produce intense noise and pass over the area at relatively low altitudes, these aircraft are considered to be moderate noise sources. As indicated in Table 5.7-2, noise conditions at sensitive receptors would be increased in comparison to the 45 to 55 dBA L_{eq} ambient noise levels typical for this area.

Sensitive receptors for noise in the study area consist of residential uses located to the south of the river channel and a few scattered houses on the north side of the river channel. Some sensitive residential receptors are located within 1,000 feet of construction activities and would be exposed to noise levels over 64 dB. Most of these exposed sensitive sensors are also located within 1,000 feet of either the SR 202 corridor or existing sand and gravel operations, meaning

that construction activities would not substantially increase detectable noise levels. The exception is that Reaches 4 and 5 are farther away from the SR 202 corridor (which is generally about 1 mile to the south) and are not near sand and gravel operations. In Reaches 4 and 5, noise levels of over 64 dB would likely be noticeable by nearby sensitive receptors.

Table 5.7-2. Estimated Construction Noise in the Vicinity of Active Construction Sites

Distance to Receptor (feet)	Sound Level at Receptor (dBA)
50	92
100	86
200	80
500	71
600	69
800	67
1,000	64
1,500	60
2,000	57
2,500	54
3,000	51
4,000	47
5,280	43
7,500	36

The following assumptions were used:

Basic sound level drop-off rate:	6.0 dB per doubling of distance
Molecular absorption coefficient:	0.7 dB per 1,000 feet
Anomalous excess attenuation:	1.0 dB per 1,000 feet
Reference sound level:	92 dBA
Distance for reference sound level:	50 feet

Note: This calculation does not include the effects, if any, of local shielding, which may reduce sound levels further.

Implementation of the following mitigation measure will reduce this impact to a less-than-significant level.

Mitigation Measure N-1: Employ Noise-Reducing Construction Measures

The Corps and their contractors shall incorporate the following measures into construction contract specifications:

- Construction within 1,000 feet of residences or other noise-sensitive uses shall be restricted to daytime hours. No construction shall be performed within 1,000 feet of an occupied dwelling on Sundays, on legal holidays, or between the hours of 7 p.m. and 7 a.m. on other days.
- All construction equipment shall have sound-control devices that are at least as effective as those devices provided on the original equipment. No equipment shall have an unmuffled exhaust.
- As directed by the Corps, the contractor shall implement appropriate additional noise mitigation, including, but not limited to, changing the location of stationary construction equipment, shutting off idling equipment, notifying adjacent residents in advance of construction work, and installing acoustic barriers around stationary construction noise sources.

Impact: Increased Traffic Noise in the Project Vicinity from Recreational Users

As described in Section 4.9, "Transportation," new vehicle trips in the project study area would be generated by recreational users traveling to visit the newly constructed site. The additional traffic would contribute to traffic noise conditions on roadways in the project study area. However, these trips would be distributed throughout a typical day and would not be concentrated during peak hours. Since expected recreation-related traffic represents a very small fraction of total traffic volume in the area, the contribution of project traffic to local noise conditions would not be considered significant.

Mitigation Measure: No mitigation is required.

Impact: Increased Noise from O&M Activities

Noise levels associated with O&M activities would be smaller in magnitude compared to noise described for initial construction activities. This noise would occur over a much shorter period of time and on an infrequent basis compared to initial construction. O&M noise would still have the potential to adversely affect sensitive receptors, but implementation of Mitigation Measure N-1 should reduce these impacts to a less-than-significant level.

Mitigation Measure N-1: Employ Noise-Reducing Construction Measures

Same as above.

5.7.2.3 Alterative N

Under Alternative N, construction-related noise associated with new construction would be similar to those described under Alternative F, since construction work would occur in nearly the same areas as in Alternative F. However, since bank stabilization and the associated heavy-construction activities are not present in Alternative N, the noise impacts would be less than for Alternative F. Post-construction noise effects from new traffic and O&M activities would likely be identical to the effects described for Alternative F. Implementation of the same mitigations as described for Alternative F would reduce these impacts to a less-than-significant level.

5.7.2.4 Alternative O (Preferred Alternative)

The construction-related noise associated with new construction under Alternative O would be similar to those described under Alternative F, since construction work would occur in nearly the same areas as in Alternative F. Post-construction noise effects from new traffic and O&M activities would likely be identical to the effects described for Alternative F. Implementation of the same mitigations as described for Alternative F would reduce these impacts to a less-than-significant level.

5.7.2.5 Alternative E

Under Alternative E, the noise impacts would be approximately the same as described under Alternative F since construction work would occur in nearly the same areas as in Alternative F. Post construction noise effects from new traffic and O&M activities would be identical to the effects described for Alternative F. Implementation of the same mitigations as described for Alternative F would reduce these impacts to a less-than-significant level.

5.7.2.6 Alternative A

Under Alternative A, construction-related noise associated with new construction would be similar to those described under Alternative F, since construction activities would occur within proximity of the same receptors and would involve the same type and quantity of construction equipment as in Alternative F. However, because the proposed construction footprint for Alternative A (approximately 650 acres) is less than a third the size of the proposed construction footprint for Alternative F (approximately 2,200 acres), the duration of construction activities and noise impacts would be less than that described for Alternative F. Post-construction noise effects from new traffic and O&M activities would be identical to the effects described for Alternative F. Implementation of the same mitigations as described for Alternative F would reduce these impacts to a less-than-significant level.

5.8 SOCIAL AND ECONOMIC RESOURCES

5.8.1 APPROACH AND METHODOLOGY

Impacts to social and economic resources are considered significant if implementation of the proposed action results in substantial changes to socioeconomic conditions, either directly or indirectly. Substantial changes are detectable increases (or decreases) to population, housing, employment or income. Potential impacts were determined by qualitatively evaluating the project components for each of the alternatives against the existing social and economic conditions within the project area. Also included in this section is a discussion on environmental justice, identifying the possible social equity concerns relating to potential impacts from the project.

5.8.2 ENVIRONMENTAL IMPACTS

5.8.2.1 No Action

Under the Alternative O, the existing social and economic resources would remain relatively unaffected, with the exception of natural changes occurring from flood events over time. With Alternative O, there would be no short-term impacts on social and economic resources that are associated with the restoration and enhancement of the river corridor. Long-term social and economic improvements would not be realized with this alternative.

5.8.2.2 Alternative F

Alternative F would not result in any significant direct or indirect impacts on social or economic resources such as population, housing, employment, or income in the area. The proposed project would not directly increase population or housing as there will be no construction of such features. No effects on employment would result from the project, as there would not be employment opportunities associated with construction of the project and it does not have the capacity to affect local or regional income levels. No impacts are anticipated.

5.8.2.3 Alternative N

Alternative N, like Alternative F, would not result in any significant direct potential effects on social or economic resources such as population, housing, employment, or income in the area. No impacts are anticipated.

5.8.2.4 Alternative O (Preferred Alternative)

Alternative O, like Alternative F, would not result in any significant direct potential effects on social or economic resources such as population, housing, employment, or income in the area. No impacts are anticipated.

5.8.2.5 Alternative E

Alternative E is similar to Alternative F with respect to social and economic resources. No impacts are anticipated.

5.8.2.6 Alternative A

Potential social and economic resource effects associated with Alternative A would be the same as described for Alternative F. No impacts are anticipated.

5.8.3 ENVIRONMENTAL JUSTICE

Project impacts were reviewed to determine whether low-income or minority neighborhoods would be disproportionately affected by the proposed action. The proposed action would not generate environmental justice impacts. Although low-income or minority neighborhoods are located in proximity to the project area, impacts would not be inequitably distributed to affect these neighborhoods to a greater degree than other neighborhoods. No impacts associated with social equity or environmental justice are anticipated.

5.9 TRANSPORTATION

5.9.1 APPROACH AND METHODOLOGY

Impacts to transportation were assessed based on how project-related construction and post-construction traffic would benefit or adversely affect existing traffic and roadway infrastructure. Impacts that increased or reduced transportation to a level where the safety or movement of people, goods, or services was impacted would be considered significant. For this analysis, it was assumed that there would be no permanent or temporary road closures associated with any of the alternatives, with the exception of occasional closures of unbridged crossings related to high flows in the main channel.

To determine impacts to transportation, traffic and circulation effects were evaluated and analyzed. The number of vehicle trips associated with construction workers commuting to the project site were based on estimates of labor hours. Furthermore, estimates of daily vehicle trips were developed using the following assumptions:

- Ten labor hours generate 1 person-round-trip.
- Each employee will commute 40 miles round trip per day.
- Vehicle occupancy rates are 1.1 people per vehicle.
- Construction activities occur year-round on approximately 200 days per year.
- An adequate supply of construction workers resides within a reasonable distance of the proposed project sites.

Because Sky Harbor Airport would not be affected by this project, no detailed analysis was performed related to this facility. Haul routes for construction equipment and materials were assumed to be either within the river channel or via local arterial streets to the freeways.

The vehicle trips per day, by alternative, are reflected in Table 5.9-1 below.

Table 5.9-1. Estimated Traffic Associated with Deliveries to the Project Area and with Commuting

Alternative	Commute Trips per Day	Haul Truck Trips per Day
F	25	144
N	15	86
O	15	86
E	15	46
A	10	16

5.9.2 ENVIRONMENTAL IMPACTS

5.9.2.1 No Action

Under the No-Action Alternative, traffic would continue to increase as the surrounding areas become more developed. The areas that will continue to grow are the SRPMIC to the north and residential and commercial infill in Mesa to the south. In addition, to accommodate the increase in traffic volumes, the roadways would continue to be widened, typically up to six lanes with a median and, at intersections, dual left-turn lanes and a right-turn lane.

There would be no short-term increases in traffic from construction, no accelerated damage to roadways from heavy vehicles, and no disruption of traffic from construction activities. No impacts on transportation would result under this alternative.

5.9.2.2 Alternative F

Activities under this alternative include the creation of irrigation and drainage ditches, spillways, bank armors, constructed wetlands, a low-flow channel, a grade control structure west of Gilbert Road, and a water distribution channel. While implementation of this alternative will not substantially contribute to area traffic, either in the construction phase or during periodic O&M activities, the potential for damage to roadways during both phases does exist.

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction

Under this alternative, 144 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 25 daily round trips dispersed on local arterial streets over a period of 5 years. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic; thus, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

Impact: Potential Damage to Roadway Surfaces during Project Construction

Increased truck traffic associated with construction activities could result in damage to the roadway surface on roadways used as haul routes. This is a potentially significant impact but avoidable with Mitigation Measure T-1 below.

Mitigation Measure T-1: Repair Damaged Roadways

The Corps or its contractors shall repair any damage to existing roadways caused as a result of construction activities for this project. Repair work shall be coordinated with the agencies having jurisdiction of each roadway, and with the intent to return the roadways to the conditions existing immediately prior to the commencement of the project.

Impact: Generation of Additional Vehicle Trips by Recreationists

The Va Shly'ay Akimel project area will become, upon completion of construction, a destination point for recreationists seeking various recreation opportunities. Expected vehicle trips were calculated based on the revised study prepared by the Va Shly'ay Akimel recreation technical committee (Table 5.9-2 below). It is assumed that 2.75 visitors arrive in each vehicle. Prime recreation time is defined as weekends and holidays, while nonprime time is weekdays. The greater number of recreationist trips, therefore, would occur during off-peak hours—outside the weekday commute times. No impacts are anticipated on traffic and circulation.

Mitigation Measure: No mitigation required.

Table 5.9-2. Estimated Traffic Associated with Recreational Use

Period	Daily Recreationist Trips (round trips)
Summer	
Prime	273
Non-prime	69
Winter	
Prime	409
Non-prime	137

Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities

Major construction will be followed by restoration-related activities such as clearing and grubbing, excavation, and preparation for planting. After vegetation establishment, periodic maintenance and monitoring of project features will continue to generate minor levels of traffic. Under Alternative F, approximately 500 annual haul truck trips directly associated with restoration/ revegetation would occur on unpaved roads (and 25 daily employee trips) during the first year. Installation of the irrigation network and revegetation may require the use of heavy equipment, but these activities would occur infrequently and over a brief period of time. In addition, many of the trips would occur within the channel rather than on public streets. Given the few trips on public streets, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

5.9.2.3 Alternative N

Activities under this alternative would be similar to those described under Alternative F, but the lesser amount of construction activity associated with Alternative N would make for less potential damage to roadways.

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction

Under this alternative, 86 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 15 daily round trips on local arterial streets over a period of 5 years. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic; thus, only minor changes in traffic conditions are expected under this alternative. This would not constitute a significant impact.

Mitigation Measure: No mitigation required.

Impact: Potential Damage to Roadway Surfaces during Project Construction

Increased truck traffic associated with construction activities could result in damage to the roadway surface on roadways used as haul routes. This is a potentially significant impact but avoidable with implementation of Mitigation Measure T-1.

Mitigation Measure T-1: Repair Damaged Roadways

See Alternative F for a description of this mitigation measure.

Impact: Generation of Additional Vehicle Trips by Recreationists

Recreational trips were assumed not to vary by alternative, so the effects of Alternative N would be the same as the effects of Alternative F.

Mitigation Measure: No mitigation required.

Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities

Major construction will be followed by restoration-related activities such as clearing and grubbing, excavation, and preparation for planting. After vegetation establishment, periodic maintenance and monitoring of project features will continue to generate minor levels of traffic. Under Alternative N, approximately 300 annual haul truck trips on unpaved roads (and 15 daily employee trips) would occur during the first year. Installation of the irrigation network and revegetation may require the use of heavy equipment, but these activities would occur infrequently and over a brief period of time. In addition, many of the trips would occur within the channel rather than on public streets. Given the few trips on public streets, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

5.9.2.4 Alternative O (Preferred Alternative)

Activities under this alternative would be similar to those described under Alternative F, but the lesser amount of construction activity associated with Alternative O would make for less potential damage to roadways.

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction

Under this alternative, 86 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 15 daily round trips on local arterial streets over a period of 5 years. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic; thus, only minor changes in traffic conditions are expected under this alternative. This would not constitute a significant impact.

Mitigation Measure: No mitigation required.

Impact: Potential Damage to Roadway Surfaces during Project Construction

Increased truck traffic associated with construction activities could result in damage to the roadway surface on roadways used as haul routes. This is a potentially significant impact but avoidable with implementation of Mitigation Measure T-1.

Mitigation Measure T-1: Repair Damaged Roadways

See Alternative F for a description of this mitigation measure.

Impact: Generation of Additional Vehicle Trips by Recreationists

Recreational trips were assumed not to vary by alternative, so the effects of Alternative O would be the same as the effects of Alternative F.

Mitigation Measure: No mitigation required.

Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities

Major construction will be followed by restoration-related activities such as clearing and grubbing, excavation, and preparation for planting. After vegetation establishment, periodic maintenance and monitoring of project features will continue to generate minor levels of traffic. Under Alternative O, approximately 300 annual haul truck trips on unpaved roads (and 15 daily employee trips) would occur during the first year. Installation of the irrigation network and revegetation may require the use of heavy equipment, but these activities would occur infrequently and over a brief period of time. In addition, many of the trips would occur within the channel rather than on public streets. Given the few trips on public streets, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

5.9.2.5 Alternative E

Activities and, therefore, the traffic impacts of the activities would be similar to those occurring under Alternatives F, N, and O. The numbers of haul truck trips are approximately 46% lower than the numbers of haul truck trips for Alternative N, since the project characteristics for this alternative would not require that as many materials be brought in from off-site. The numbers of trips anticipated are the same for commute trips as in Alternatives N and O. The impacts are most similar to those for Alternative N.

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction

Under this alternative, 46 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 15 daily round trips on local arterial streets over a period of 5 years. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic; thus, only minor changes in traffic conditions are expected under this alternative. This would not constitute a significant impact.

Mitigation Measure: No mitigation required.

Impact: Potential Damage to Roadway Surfaces during Project Construction

Increased truck traffic associated with construction activities could result in damage to the roadway surface on roadways used as haul routes. This is a potentially significant impact but avoidable with implementation of Mitigation Measure T-1.

Mitigation Measure T-1: Repair Damaged Roadways

See Alternative F for a description of this mitigation measure.

Impact: Generation of Additional Vehicle Trips by Recreationists

Recreational trips were assumed not to vary by alternative, so the effects of Alternative E would be the same as the effects of Alternative F.

Mitigation Measure: No mitigation required.

Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities

Major construction will be followed by restoration-related activities such as clearing and grubbing, excavation, and preparation for planting. After vegetation establishment, periodic maintenance and monitoring of project features will continue to generate minor levels of traffic. Under Alternative E, approximately 300 annual haul truck trips on unpaved roads (and 15 daily employee trips) would occur during the first year. Installation of the irrigation network and revegetation may require the use of heavy equipment, but these activities would occur infrequently and over a brief period of time. In addition, many of the trips would occur within the channel rather than on public streets. Given the few trips on public streets, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

5.9.2.6 Alternative A

While the activities and, therefore, the traffic impacts of the activities would be similar to those occurring under Alternatives F, N, and E, the proposed construction footprint for Alternative A is less than a third the size of the footprint for Alternative F. The anticipated numbers of both construction worker commute trips and haul truck trips are less than under Alternatives F, N, and E.

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction

Under this alternative, 16 haul trips would occur per day to deliver materials from off-site to the project sites. Construction workers commuting to the project site would generate an additional 10 daily round trips on local arterial streets over a period of 1year. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic; thus, only minor changes in traffic conditions are expected under this alternative. This would not constitute a significant impact.

Mitigation Measure: No mitigation required.

Impact: Potential Damage to Roadway Surfaces during Project Construction

Increased truck traffic associated with construction activities could result in damage to the roadway surface on roadways used as haul routes. This is a potentially significant impact but avoidable with implementation of Mitigation Measure T-1.

Mitigation Measure T-1: Repair Damaged Roadways

See Alternative F for a description of this mitigation measure.

Impact: Generation of Additional Vehicle Trips by Recreationists

Recreational trips were assumed not to vary by alternative, so the effects of Alternative A would be the same as the effects of Alternative F.

Mitigation Measure: No mitigation required.

Impact: Minor Temporary Traffic Effects Associated with Restoration and Maintenance Activities

Major construction will be followed by restoration-related activities such as clearing and grubbing, excavation, and preparation for planting. After vegetation establishment, periodic maintenance and monitoring of project features will continue to generate minor levels of traffic. Under Alternative A, approximately 200 annual dump truck trips on unpaved roads (and 10 daily

employee trips) would occur during the first year. Installation of the irrigation network and revegetation may require the use of heavy equipment, but these activities would occur infrequently and over a brief period of time. In addition, many of the trips would occur within the channel rather than on public streets. Given the few trips on public streets, this impact is considered less than significant.

Mitigation Measure: No mitigation required.

5.10 LAND USE

5.10.1 APPROACH AND METHODOLOGY

Each of the alternatives includes a range of approaches to provide ecological restoration within the project study area. Potential impacts were identified by evaluating each of the alternatives against the existing land use patterns within the project study area. The alternatives were also analyzed regarding their compatibility with existing plans and policies that are relevant to the project area. Impacts that would result in inconsistencies with existing land use patterns or result in land being degraded so that it cannot be used for current or planned use were considered significant.

On the south side of the Salt River it is assumed that the possibility of direct effects upon land use should be considered for the lands where an alternative proposes any new construction. It is assumed that there is a possibility of indirect effects on the lands between the edge of new construction and SR 202. Because land uses south of SR 202 are set apart from those to the north due to the boundary effect of the highway, it is assumed that the project will have neither direct nor indirect land use effects south of SR 202.

On the north side of the Salt River it is assumed that the possibility of direct effects upon land use should be considered for the lands where an alternative proposes any new construction. It is assumed that there is a possibility of indirect effects on the lands between the edge of new construction and the outer boundary of the project area, 1 mile north of the river's thalweg. There is no boundary effect north of the Salt River comparable to that of SR 202 to the south.

5.10.2 ENVIRONMENTAL IMPACTS

5.10.2.1 No Action

Under the No-Action Alternative, land use conditions would stay substantially the same. There would be no short-term impacts from construction to affect adjacent land. Land use and planning policies to enhance and restore biological habitat and riparian areas and provide flood control and recreation opportunities in open space areas would not be fully realized.

5.10.2.2 Alternative F

To accomplish the construction required for the restoration of river-related habitat, activities under this alternative include the creation of irrigation and drainage ditches, spillways, bank armors, constructed wetlands, a low-flow channel, and a grade control structure west of Gilbert Road, and a water distribution channel. Nearby low-density development would experience temporary nuisance effects associated with noise, dust, aesthetics, and traffic, both during initial construction and occasional continued maintenance.

Impact: Temporary Adverse Effects on Land Use during Project Construction

The primary purpose of Alternative F is the restoration of river-related habitat to enhance environmental resources in the study area. The environmental restoration is expected to be beneficial and not have any substantial adverse effects; however, the nearby land uses in the study area could experience temporary adverse effects associated with construction activities. There is very limited development in the study area. Still, initial construction and occasional continued maintenance could disturb that development in the form of temporary nuisance effects of less than significant impact associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be of less than significant impact because the activities would take place during brief periods and would affect only limited areas.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Impact on Land Use Experience

While there is little existing development in the areas for which indirect effects on land use are being assessed, development will occur over the next several years both north and south of the Salt River. Considerable commercial development is expected at the SRPMIC, while some business park and general industrial development will take place in Mesa. The activities in the Salt River corridor, such as passive recreation, are beneficial and are cited in appropriate sections of this document. The absence of intensive land uses along the Salt River corridor is equally beneficial to the long-term prosperity of the area. The open space corridor will not contribute traffic, noise, limited vistas, or other effects of development, so it will make it easier for the area to absorb adjacent development.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

As discussed in Section 4.10, "Land Use," in addition to the Corps having jurisdiction over the project, the project area falls within the boundaries of several local government jurisdictions, including Maricopa County, the City of Mesa, and the SRPMIC. The county and city plans governing land use and development within the respective jurisdictions incorporate relevant policies related to the following:

- a balance between conservation and development,
- protection and preservation of sensitive plant and wildlife habitat and riparian areas,
- establishment of sufficient trails, wildlife corridors, and other linear linkages between large open space areas,

- provision for adequate flood control under FEMA regulations,
- an interconnected open space system, and
- encouraging open space designs that promote integration with surrounding demographics and land uses, provide pedestrian connections to adjacent neighborhoods, and contribute to the neighborhood's character and identity.

Alternative F would have a beneficial impact due to its consistency with the goals and policies of the Maricopa County Comprehensive Plan and the City of Mesa General Plan. Specifically, Mesa's Parks and Recreation element in the General Plan contains a policy to encourage the preservation of significant natural areas such as the Salt River corridor to enhance their recreational and aesthetic value. This alternative would also have a beneficial impact due to its consistency with the SRPMIC plans for a cultural center on the north side of the river. The City of Mesa has an objective to coordinate open space plans, related improvements and implementation strategies with neighboring jurisdictions, stakeholders and user groups, and SRPMIC has similar objectives.

Mitigation Measure: No mitigation required.

5.10.2.3 Alternative N

Less overall construction activity is anticipated under Alternative N than Alternative F. While the effects would be of the same character as for Alternative F, they would be lesser in degree. Initial construction and occasional continued maintenance could disturb development in the form of temporary nuisance effects associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be of less than significant impact because the activities would take place during brief periods and would affect only limited areas.

Impact: Temporary Adverse Effects on Land Use during Project Construction

Under Alternative N, temporary, less-than-significant impacts from construction activities will be substantially similar to those of Alternative F. There will be less river channelization than in Alternative F. More irrigation diversion structures will be constructed than for Alternative F. However, such activities will have minor effects upon surrounding land use.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Land Use Experience

The long-term beneficial effect on land use will be similar to the effect of Alternative F. The slight differences in the vegetative mix between Alternatives F and N will have almost no effect

and are unlikely to be apparent to most persons who frequent those portions of the project area beyond the immediate vicinity of new construction.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

The compatibility with land use and planning policies will be similar to the effect of Alternative F. The many land use goals, objectives, and policies furthered by the proposed Va Shly'ay Akimel project will be advanced to the same degree despite subtle differences between Alternatives F and N.

Mitigation Measure: No mitigation required.

5.10.2.4 Alternative O (Preferred Alternative)

Less overall construction activity is anticipated under Alternative O than Alternative F. While the effects would be of the same character as for Alternative F, they would be lesser in degree. Initial construction and occasional continued maintenance could disturb development in the form of temporary nuisance effects associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be of less than significant impact because the activities would take place during brief periods and would affect only limited areas.

Impact: Temporary Adverse Effects on Land Use during Project Construction

Under Alternative O, temporary, less-than-significant impacts from construction activities will be substantially similar to those of Alternative F. There will be less river channelization than in Alternative F. More irrigation diversion structures will be constructed than for Alternative F. However, such activities will have minor effects upon surrounding land use.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Land Use Experience

The long-term beneficial effect on land use will be similar to the effect of Alternative F. The slight differences in the vegetative mix between Alternatives F and O will have almost no effect and are unlikely to be apparent to most persons who frequent those portions of the project area beyond the immediate vicinity of new construction.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

The compatibility with land use and planning policies will be similar to the effect of Alternative F. The many land use goals, objectives, and policies furthered by the proposed Va Shly'ay Akimel project will be advanced to the same degree despite subtle differences between Alternatives F and O. The establishment of wetlands and cottonwood/willow on the north side of the channel at the far west of the project area can be an enhancement to the commercial development of the area by the Indian Community, with appropriate site design.

Mitigation Measure: No mitigation required.

5.10.2.5 Alternative E

Less overall construction activity is anticipated under Alternative E than Alternative F. The impacts are most similar to those for Alternative N. While the effects would be of the same character as for Alternative F, they would be lesser in degree. Initial construction and occasional continued maintenance could disturb development in the form of temporary nuisance effects associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be of less than significant impact because the activities would take place during brief periods and would affect only limited areas.

Impact: Temporary Adverse Effects on Land Use during Project Construction

Under Alternative E, temporary, less-than-significant impacts from construction activities will be substantially similar to those of Alternative F. River channelization and WWTP diversion structures will be engineered for this alternative, in contrast to Alternative F. More irrigation diversion structures will be constructed than for Alternative F. However, such activities will have minor effects upon surrounding land use.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Land Use Experience

The long-term beneficial effect on land use will be similar to the effect of Alternative F. The slight differences in the vegetative mix between Alternatives F and E will have almost no effect and are unlikely to be apparent to most persons who frequent those portions of the project area beyond the immediate vicinity of new construction.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

The compatibility with land use and planning policies will be similar to the effect of Alternative F. The many land use goals, objectives, and policies furthered by the proposed Va Shly'ay Akimel project will be advanced to the same degree despite subtle differences between Alternatives F and E.

Mitigation Measure: No mitigation required.

5.10.2.6 Alternative A

While the activities and, therefore, the traffic impacts of the activities would be similar to those occurring under Alternatives F, N, and E, the proposed construction footprint for Alternative A is less than a third the size of the footprint for Alternative F. While the effects would be of the same character as for the other three alternatives, they would be lesser in degree than for any of the others. Initial construction and occasional continued maintenance could disturb development in the form of temporary nuisance effects associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be of less than significant impact because the activities would take place during brief periods and would affect only limited areas.

Impact: Temporary Adverse Effects on Land Use during Project Construction

The temporary, less-than-significant impacts from construction activities will be somewhat less than those in Alternative F. While Alternative F comprises construction in Reaches 2 through 9, Alternative A calls for no activity in Reaches 2 through 4.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Land Use Experience

Given that the western portion of the project area will have no activity, the surrounding land uses will not accrue any environmental, aesthetic, or recreational benefit from the project. The central portion of the project area will produce roughly the same land use benefit to surrounding areas as would Alternative F.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

The compatibility with land use and planning policies will be similar to the effect of Alternative F, but the lack of restorative activities in the western portion of the area will advance the many land use goals, objectives, and policies furthered by the proposed Va Shly'ay Akimel project somewhat less, with subtle differences between Alternatives F and A.

Mitigation Measure: No mitigation required.

5.11 RECREATION

5.11.1 APPROACH AND METHODOLOGY

Potential impacts, both direct and indirect, to recreation resources were identified by evaluating each of the alternatives against existing recreational features within the project area. The alternatives were also analyzed regarding their compatibility with existing recreation plans and policies that are relevant to the project area. Impacts to recreation resources would be considered significant if the proposed project permanently alters recreational features in the project area, or if the proposed project anticipated outcome is found to be inconsistent with current recreation plans and/or policies.

5.11.2 ENVIRONMENTAL IMPACTS

5.11.2.1 No Action

Under the No-Action Alternative, recreational opportunities within the project area would remain substantially unchanged. There would be no short-term impacts from construction that would affect adjacent recreational activities. However, recreational experiences would also not be enhanced. Additionally, land use and planning policies to enhance and restore biological habitat and riparian areas and provide flood control and recreational opportunities in open space areas would not be realized.

5.11.2.2 Alternative F

Impact: Temporary Adverse Effects on Recreation during Project Construction

The primary purpose of Alternative F is the restoration of river-related habitat to enhance environmental resources in the project area. The environmental restoration is expected to be beneficial and not have any substantial adverse effects; however, the nearby recreation uses in the study area could experience temporary adverse effects associated with construction of restoration features and recreation facilties. Though there are very limited recreation uses in the study area, initial construction and occasional continued maintenance could preclude an ideal recreational experience by adversely affecting the character of the area. Disturbances could take the form of temporary nuisance effects associated with noise, dust, aesthetics, and traffic. O&M activities would also create potential nuisance effects, but they are expected to be minor because the activities would take place during brief periods and would affect only limited areas. Thus, impacts on recreation would be less than significant. These temporary adverse conditions are necessary to realize the long-term benefits of the project. These potential impacts are discussed in further detail in Sections 5.5, "Aesthetic Resources"; 5.6, "Air Quality"; 5.7, "Noise"; and 5.9, "Transportation."

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Recreational Experience

Incidental to the proposed restoration efforts of this alternative is the creation of valuable passive recreational opportunities. Although under the existing conditions there is very little recreation use in the area, the habitat restoration would create attractive open space that is conducive to the development of new recreational opportunities. The City of Mesa has identified a multi-use trail corridor along the Southern Canal in its Parks and Recreation Master Plan. The trail would be located toward the eastern end of the project site and could increase the potential for access and visitation to the Salt River by recreationists. The increase in passive open space through the implementation of Alternative F would enhance the overall experience of recreationists and O&M activities would maintain this benefit. This would be considered a long-term beneficial effect.

The proposed recreation options would enhance the long-term beneficial effects of the project through the development of multi-use trails and the Salt River Pima Maricopa Cultural Center. The cultural center would enhance the interpretive and education opportunities associated with the restoration of river habitat and SRPMIC culture. Each option would add multi-use trails in the western end of the project near the City of Mesa's recharge ponds that would connect to the City trail system under the Red Mountain Freeway. Recreation Option A would add a total of approximately 7.8 miles of multi-use trails and would also provide a connection to the City of Mesa trail along the Southern Canal n Reach 6. The effects of Option B would be somewhat reduced from Option A with a total of approximately 5.1 miles of multi-use trails. The trail on the south side of the river that would connect to the City trail along the Southern Canal would not be constructed and opportunities for connecting to the river area from the City's trail system would be reduced. Option C would significantly increase recreation opportunities with the development of approximately 13.6 miles of trails that would connect to the City trail on along the Southern Canal n Reach 6, and would also connect the cultural Center to the recharge ponds in the western end of the project with a trail along the southern side of the river.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

As discussed in Section 4.11, "Recreation," in addition to the Corps having jurisdiction over the project, the project area falls within the boundaries of several local government jurisdictions, including Maricopa County, the City of Mesa, and the Salt River Pima-Maricopa Indian Community (SRPMIC). The Maricopa County and City of Mesa plans governing land use and development within the respective jurisdictions incorporate relevant policies related to the following:

- open space and natural resource conservation,
- biological habitat preservation and restoration,

- protection and enhancement of riparian areas,
- provision for adequate flood control,
- protection of water and groundwater resources, and
- provision for recreational use.

Alternative F would be consistent with the goals and policies of the Maricopa County Comprehensive Plan and the City of Mesa General Plan. Specifically, the conservation element of Mesa's general plan defines goals to preserve and enhance environmental resources and to accommodate recreational opportunities in the vicinity of the Salt River. This alternative, in conjunction with any of the proposed recreation options, would also be consistent with the SRPMIC plans for a cultural center on the north side of the river. Collaboration between the SRPMIC and the City of Mesa will help assure coordination of their recreation plans. Thus, this alternative would constitute a beneficial effect.

Mitigation Measure: No mitigation required.

5.11.2.3 Alternative N

Impact: Temporary Adverse Effects on Recreation during Project Construction

Temporary impacts from construction of restoration features and recreation facilties associated with Alternative N will be similar to those under Alternative F. Construction impacts would be somewhat reduced because of the lack of bank stabilization elements in this alternative. An old recharge site on the south side of the river in close proximity to River View Park and River View Golf Course will be converted to cottonwood/willow habitat. This site, located in Reach 1, north of SR 202, should require minimal disturbance activities. Construction activities for this area should not cause impacts above and beyond those associated with the rest of the project construction. The impacts on recreation under this alternative would be less than significant.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Recreational Experience

Long-term beneficial effects of Alternative N, in conjunction with any of the proposed recreation options, will be substantially similar to those of Alternative F. Additional recreational benefits could be realized with the development of the cottonwood/ willow habitat in the old recharge site on the south side of the river in Reach 1. The beneficial effects are especially increased if recreation option C is selected, that would connect the recharge pond habitat to the cultural center. Alternative N includes higher amounts of Sonoran Desert vegetation and less cottonwood/willow than Alternative F, and could result in less wildlife diversity for recreation viewing.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

Alternative N is compatible with the land use goals and policies of local government jurisdictions. The inclusion of cottonwood/willow habitat in the southern area of Reach 1 enhances recreation opportunities in the City of Mesa-owned parcel at the western end of the project area.

Mitigation Measure: No mitigation required.

5.11.2.4 Alternative O (Preferred Alternative)

Impact: Temporary Adverse Effects on Recreation during Project Construction

Temporary impacts from construction of restoration features and recreation facilties associated with Alternative O will be similar to those under Alternative F. Construction impacts would be somewhat reduced because of the lack of bank stabilization elements in this alternative. An old recharge site on the south side of the river in close proximity to River View Park and River View Golf Course will be converted to cottonwood/willow habitat. This site, located in Reach 1, north of SR 202, should require minimal disturbance activities. Construction activities for this area should not cause impacts above and beyond those associated with the rest of the project construction. The impacts on recreation under this alternative would be less than significant.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Recreational Experience

Long-term beneficial effects of Alternative O, along with any of the recreation options would be substantially similar to Alternative F. Recreational and interpretive benefits would be realized with the development of the trail in association with the addition of cottonwood/ willow habitat in the old recharge site on the south side of the river in Reach 1. The multi-use trail in Reach 6, included in recreation options A and C, would allow trail users in other parts of the City of Mesa to access the restored habitat in the central portion of the project area.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

Alternative O is compatible with the land use goals and policies of local government jurisdictions. The inclusion of cottonwood/willow habitat in the southern area of Reach 1 enhances recreation opportunities in the City of Mesa-owned parcel at the western end of the project area.

Mitigation Measure: No mitigation required.

5.11.2.5 Alternative E

Impact: Temporary Adverse Effects on Recreation during Project Construction

Under Alternative E, temporary impacts from construction of restoration features and recreation facilties will be substantially similar to those in Alternative F. The old recharge site identified in Alternative N will be converted to cottonwood/willow habitat in this alternative as well, but should require minimal disturbance activities. Impacts on recreation from this alternative not be above and beyond those associated with the rest of the project construction and would be less than significant.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Recreational Experience

Long-term beneficial effects of Alternative E, with any of the recreation options, will be substantially similar to those of Alternative F. Additional recreation benefits could be realized with the development of the cottonwood/ willow habitat in the old recharge site on the south side of the river in Reach 1, especially when connected to the SRPMIC cultural center as in recreation option C. Alternative E includes higher amounts of Sonoran Desert vegetation and less cottonwood/willow than Alternative F, and could result in less wildlife diversity for recreation viewing.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

Alternative E is compatible with the land use goals and policies of local government jurisdictions. The inclusion of cottonwood/willow habitat in the southern area of Reach 1 enhances recreation opportunities in the City of Mesa-owned parcel at the western end of the project area especially if recreation Option C is selected and the habitat is connected to the SRPMIC cultural center.

Mitigation Measure: No mitigation required.

5.11.2.6 Alternative A

Impact: Temporary Adverse Effects on Recreation during Project Construction

Temporary adverse impacts from construction of restoration features and recreation facilties would be reduced in Alternative A. There is no construction activity planned in the western area of the project area where two existing recreation facilities are located. Thus, there should be no impacts to recreation from this alternative.

Mitigation Measure: No mitigation required.

Impact: Long-Term Beneficial Effect on Recreational Experience

Long-term recreation benefits associated with Alternative A would be reduced in comparison to those of Alternative F. New habitat development is limited to Sonoran Desert vegetation types, which could lead to lower wildlife diversity and may attract fewer recreationists who would use the trail system in any of the recreation options.

Mitigation Measure: No mitigation required.

Impact: Compatibility with Land Use and Planning Policies of Local and Tribal Government Jurisdictions

While not in direct conflict with local land use plans and policies, the recreation aspects of Alternative A will not advance the recreation goals of the local government jurisdictions. With any of the recreation options, recreation development opportunities will be more limited because of the lack of restored river habitat to attract a wide variety of recreationists. The Cultural Center would be the primary recreation feature and with limited opportunities there could be less collaboration between local jurisdictions to coordinate recreation along the Salt River. Though Alternative A will not serve to promote compatibility in land use plans, this is not considered a significant adverse impact.

Mitigation Measure: No mitigation required.

5.12 PUBLIC HEALTH AND SAFETY

5.12.1 APPROACH AND METHODOLOGY

Public health and safety issues were identified by estimating the potential effects of each alternative against existing environmental conditions. Potential public health and safety issues in the project study area were also identified. For this analysis, impacts were considered significant if the public's health or safety would be adversely affected as a result of the proposed project. The Phase I Environmental Site Assessment, which is found in Appendix I, provides a detailed analysis of the proposed project area.

5.12.2 ENVIRONMENTAL IMPACTS

5.12.2.1 No Action

Under the No-Action Alternative, the potential health and safety benefits associated with the other alternatives would not be realized. Safety threats associated with flood hazards would continue to exist for properties within the floodplain. Benefits to soil and water quality would not occur. Mosquitoes are currently a potential problem in the area. Implementation of the No-Action Alternative would not provide vector control beyond existing levels and, thus, existing vector problems would persist.

5.12.2.2 Alternative F

Alternative F involves excavation and grading in the river corridor, construction of wetlands, development of cottonwood/willow, mesquite, and Sonoran desert habitat, and installation of various irrigation systems to support the new vegetation.

Impact: Potential for Breach and/or Damage to Landfill Closure Caps

The *Final Closure Report and Postclosure Maintenance Plan for the Tri-Cites Landfill and North Center Street Landfill* (CH2M HILL 1994) states that additional cover fill materials may be placed over the Tri-City Landfill and North Center Street Landfill caps to accommodate post-closure uses, but that the 18-inch barrier layer underlying the existing 12-inch vegetative soil layer must not be disturbed. Additionally, if fill materials are added it should be assumed that the extra weight of imported soil will hasten settlement of the waste buried beneath, which may necessitate more frequent maintenance to regrade the cover to prevent ponding of water on the surface and consequent infiltration. Under Alternative F, mesquite and xeric Sonoran Desert species would be planted on the terrace formed by the Tri-City Landfill. This vegetation would be irrigated using surface and storm water routed via the constructed Surface Braided Irrigation Network (SBIN). CH2M HILL's *Final Closure Report and Postclosure Maintenance Plan* states that trees or shrubs may be incorporated into future uses of the land, but that soil mounds

and barrier layers should be created to prevent root systems from penetrating the closure cap barrier layer and releasing methane trapped within. Methane released by penetration of the barrier layer will kill the overlying vegetation. Finally, CH2M HILL specifies that any irrigation of new vegetation must be carefully regulated so as not to promote deep percolation and subsequent generation of leachate migrating to groundwater. Under Alternative F, none of the three remaining closed landfill sites are expected to receive or be impacted by newly planted vegetation. Implementation of the following mitigation measure would reduce the potential for breach or damage to the landfill closure caps to a less-than-significant level.

Mitigation Measure PHS-1: Redesign Vegetation Pallet for Landfill Closure Caps

The Corps should redesign the vegetation pallet for landfill cover to be limited to annual native grasses and herbaceous plants with shallow root systems. This plan should not include any species of trees or shrubs or columnar cactus, but may include cactus with shallow root systems. These plants should be hydroseeded and rely on minimal overhead irrigation for establishment. Implementation of this mitigation measure would obviate the potential for penetration of the landfill closure caps.

Impact: Addition of Cover Material on Tri-City Landfill May Cause Exceedance of Minimum Ground Clearance for Overhead Power Transmission Lines

Three sets of electrical transmission towers belonging to APS and SRP run generally northeast-southwest through the northern portion of the Tri-City Landfill. These towers must have a minimum ground clearance of 25 feet for the SRP lines and 23 feet for the APS lines. No overhead utility lines are present on the Cypress or North Center Street Landfills. Implementation of mitigation measure PHS-2 should eliminate any adverse effects to the power transmission towers, thus reducing this impact to a less-than-significant level.

Mitigation Measure PHS-2: Raise Power Transmission Poles to Maintain Minimum Ground Clearance

If additional cover materials to support new vegetation are placed around the APS or SRP power transmission poles that cross the Tri-City Landfill, the concrete encasements at the bases of the towers or poles would need to be raised to maintain the required minimum ground clearance.

Impact: Temporary Construction-Related Water Quality Impacts

Project-related construction activities in the river channel could cause temporary water quality impacts because disturbed and eroded soil, petroleum products, and miscellaneous construction wastes or unearthed waste debris may be discharged to receiving surface waters and groundwater. Soil and associated contaminants that enter stream channels can increase turbidity, stimulate the growth of algae, increase sedimentation of aquatic habitat, and introduce compounds that are toxic to aquatic organisms. Construction materials such as fuels, oils, paints, and concrete are potentially harmful to fish and other aquatic life if released into the

environment. The extent of potential environmental effects depends on the erodibility of soil types encountered, the type of construction practice, the extent of the disturbed area and the duration of the disturbance, the timing of precipitation, and the proximity to drainage channels. Implementation of the following mitigation would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-3: Implement Construction Site Management Practices

To minimize exposure of disturbed construction sites to rainfall and stormwater runoff, construction activities should be conducted in the dry weather season to the extent possible. The general contractor for the project will prepare and implement standard grading and erosion control measures (e.g., management, structural, and vegetative controls) to minimize exposure of soil that may contribute to contaminated runoff. Additionally, the contractor will complete the necessary paperwork to obtain an NPDES permit for construction-related projects. Best management practices (BMPs) must be implemented before predicted rain events. In addition, the construction contractor will implement standard hazardous materials management practices to reduce the possibility of chemical spills or releases of contaminants in runoff.

Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities

If areas are not maintained and properly monitored, standing water may be present for a short time following heavy rainfall or irrigation in various portions of the project area. Such standing water may have the potential to cause temporary increases in mosquito breeding in the project area, although any potential increase is expected to be offset by the comprehensive removal throughout the project area of discarded tires and other waste that holds standing water and allows mosquitoes to breed. Implementation of the following mitigation measure would ensure this impact remains less than significant.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

The project design will consider mosquito control to the extent feasible to limit issues associated with mosquitoes. In concept, the new habitat and channels constructed as principal elements of this restoration project will cycle water through the habitat areas, rather than allow water to pool. Thus, the proposed project is likely to help inhibit mosquito breeding. The Corps will work with the SRPMIC and other local government jurisdictions and agencies to coordinate vector control measures for this project. Potential control measures may include adjusting water levels, biological controls, spraying, or other measures. These measures are proposed as part of post-construction O&M activities.

Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

Currently, a number of illegal or unauthorized activities occur in the project study area, primarily dumping of refuse, unauthorized firearm discharges, and short-term habitation of certain portions of the project study area by transient persons. After this project is completed, increased use of the area by recreationists and maintenance staff would tend to decrease illegal activities in the area because of increased patrolling of the area by the city and use by the public. Project lands will be acquired by local and tribal jurisdictions, who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measure: No mitigation required.

5.12.2.3 Alternative N

Under Alternative N, the terrace formed by the Tri-City Landfill (in Reach 4) would not be revegetated, although a narrow strip of cottonwood/willow would be established along the north bank of the Salt River channel near this landfill. The ground clearance of existing APS and SRP power transmission lines would be unaffected. Further downstream, in Reach 2, it is proposed that cottonwood/willow and mesquite be established along the north bank of river channel southwest of the Cypress Golf Course. This newly planted vegetation would be maintained over time by water via an SBIN, with additional water possibly (if it is determined to be of sufficient quality) being supplied by the golf course.

Impact: Temporary Construction-Related Water Quality Impacts

Project-related construction activities in the river channel could cause temporary water quality impacts because disturbed and eroded soil, petroleum products, and miscellaneous construction wastes or unearthed waste debris may be discharged to receiving surface waters and groundwater. Soil and associated contaminants that enter stream channels can increase turbidity, stimulate the growth of algae, increase sedimentation of aquatic habitat, and introduce compounds that are toxic to aquatic organisms. Construction materials such as fuels, oils, paints, and concrete are potentially harmful to fish and other aquatic life if released into the environment. The extent of potential environmental effects depends on the erodibility of soil types encountered, the type of construction practice, the extent of the disturbed area and the duration of the disturbance, the timing of precipitation, and the proximity to drainage channels. Implementation of the following mitigation would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-3: Implement Construction Site Management Practices

See Alternative F for a description of this mitigation measure.

Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities

If areas are not maintained and properly monitored, standing water may be present for a short time following heavy rainfall or irrigation in various portions of the project area. Such standing water may have the potential to cause temporary increases in mosquito breeding in the project area, although any potential increase is expected to be offset by the comprehensive removal throughout the project area of discarded tires and other waste that holds standing water and allows mosquitoes to breed. Implementation of the following mitigation measure would ensure this impact remains less than significant.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

See Alternative F for a description of this mitigation measure.

Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

Currently, a number of illegal or unauthorized activities occur in the project study area, primarily dumping of refuse, unauthorized firearm discharges, and short-term habitation of certain portions of the project study area by transient persons. After this project is completed, increased use of the area by recreationists and maintenance staff would tend to decrease illegal activities in the area because of increased patrolling of the area by the city and use by the public. Project lands will be acquired by local and tribal jurisdictions, who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measure: No mitigation required.

5.12.2.4 Alternative O (Preferred Alternative)

Under Alternative O, the terrace formed by the Tri-City Landfill (in Reach 4) would not be revegetated, although a narrow strip of cottonwood/willow would be established along the north bank, at the edge of the main channel. The ground clearance of existing APS and SRP power transmission lines would be unaffected. Further downstream, in Reach 2, it is proposed that cottonwood/willow be established along the north bank of river channel southwest of the Cypress Golf Course. This newly planted vegetation would be maintained over time by water via an SBIN, with additional water possibly (if it is determined to be of sufficient quality) being supplied by the golf course.

Impact: Temporary Construction-Related Water Quality Impacts

Project-related construction activities in the river channel could cause temporary water quality impacts because disturbed and eroded soil, petroleum products, and miscellaneous construction

wastes or unearthed waste debris may be discharged to receiving surface waters and groundwater. Soil and associated contaminants that enter stream channels can increase turbidity, stimulate the growth of algae, increase sedimentation of aquatic habitat, and introduce compounds that are toxic to aquatic organisms. Construction materials such as fuels, oils, paints, and concrete are potentially harmful to fish and other aquatic life if released into the environment. The extent of potential environmental effects depends on the erodibility of soil types encountered, the type of construction practice, the extent of the disturbed area and the duration of the disturbance, the timing of precipitation, and the proximity to drainage channels. Implementation of the following mitigation would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-3: Implement Construction Site Management Practices

See Alternative F for a description of this mitigation measure.

Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities

If areas are not maintained and properly monitored, standing water may be present for a short time following heavy rainfall or irrigation in various portions of the project area. Such standing water may have the potential to cause temporary increases in mosquito breeding in the project area, although any potential increase is expected to be offset by the comprehensive removal throughout the project area of discarded tires and other waste that holds standing water and allows mosquitoes to breed. Implementation of the following mitigation measure would ensure this impact remains less than significant.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

See Alternative F for a description of this mitigation measure.

Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

Currently, a number of illegal or unauthorized activities occur in the project study area, primarily dumping of refuse, unauthorized firearm discharges, and short-term habitation of certain portions of the project study area by transient persons. After this project is completed, increased use of the area by recreationists and maintenance staff would tend to decrease illegal activities in the area because of increased patrolling of the area by the city and use by the public. Project lands will be acquired by local and tribal jurisdictions, who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measure: No mitigation required.

5.12.2.5 Alternative E

Under Alternative E, mesquite would be established in Reach 4 on the terrace formed by the closed Tri-City Landfill, which would be irrigated using surface water or stormwater redirected from the Evergreen Drain via an SBIN. In other respects, Alternative E is substantially similar to Alternatives F, N, and O in terms of public health and safety.

Impact: Potential for Breach and/or Damage to Landfill Closure Caps

The existing 12-inch vegetative soil layer on the Tri-City Landfill is insufficient to sustain mesquite; planting of mesquite at this location would quickly lead to penetration of the landfill closure cap. In addition, the saturated soil conditions 1–3 feet below the surface that mesquite require could not be provided, even with the addition of soil, without increasing the potential for irrigation water percolating down through the buried waste and possibly contaminating groundwater. Implementation of mitigation measure PHS-1 would obviate the potential for penetration of the landfill closure caps, thus reducing this impact to a less-than-significant level.

Mitigation Measure PHS-1: Redesign Vegetation Pallet for Landfill Closure Caps

See Alternative F for a description of this mitigation measure.

Impact: Addition of Cover Material on Tri-City Landfill May Cause Exceedance of Minimum Ground Clearance for Overhead Power Transmission Lines

Three sets of electrical transmission towers belonging to APS and SRP run generally northeast-southwest through the northern portion of the Tri-City Landfill. These towers must have a minimum ground clearance of 25 feet for the SRP lines and 23 feet for the APS lines. No overhead utility lines are present on the Cypress or North Center Street Landfills. Implementation of mitigation measure PHS-2 should eliminate any adverse effects to the power transmission towers, thus reducing this impact to a less-than-significant level.

Mitigation Measure PHS-2: Raise Power Transmission Poles to Maintain Minimum Ground Clearance

See Alternative F for a description of this mitigation measure.

Impact: Temporary Construction-Related Water Quality Impacts

Project-related construction activities in the river channel could cause temporary water quality impacts because disturbed and eroded soil, petroleum products, and miscellaneous construction wastes or unearthed waste debris may be discharged to receiving surface waters and groundwater. Soil and associated contaminants that enter stream channels can increase turbidity, stimulate the growth of algae, increase sedimentation of aquatic habitat, and introduce compounds that are toxic to aquatic organisms. Construction materials such as fuels, oils, paints,

and concrete are potentially harmful to fish and other aquatic life if released into the environment. The extent of potential environmental effects depends on the erodibility of soil types encountered, the type of construction practice, the extent of the disturbed area and the duration of the disturbance, the timing of precipitation, and the proximity to drainage channels. Implementation of the following mitigation would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-3: Implement Construction Site Management Practices

See Alternative F for a description of this mitigation measure.

Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities

If areas are not maintained and properly monitored, standing water may be present for a short time following heavy rainfall or irrigation in various portions of the project area. Such standing water may have the potential to cause temporary increases in mosquito breeding in the project area, although any potential increase is expected to be offset by the comprehensive removal throughout the project area of discarded tires and other waste that holds standing water and allows mosquitoes to breed. Implementation of the following mitigation measure would ensure this impact remains less than significant.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

See Alternative F for a description of this mitigation measure.

Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

Currently, a number of illegal or unauthorized activities occur in the project study area, primarily dumping of refuse, unauthorized firearm discharges, and short-term habitation of certain portions of the project study area by transient persons. After this project is completed, increased use of the area by recreationists and maintenance staff would tend to decrease illegal activities in the area because of increased patrolling of the area by the city and use by the public. Project lands will be acquired by local and tribal jurisdictions, who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measure: No mitigation required.

5.12.2.6 Alternative A

Under this alternative, no new vegetation would be planted at the locations of known landfills. Thus, no threat would be posed to public health and safety by the potential for breach of the

closure caps. The ground clearance of existing APS and SRP power transmission lines would be unaffected. In all other respects, such as vector control and potential for short-term water quality impacts, the impacts and mitigation measures for Alternative A are identical to those described above for Alternatives F, N, O, and E. No residual adverse impacts are anticipated.

Impact: Temporary Construction-Related Water Quality Impacts

Project-related construction activities in the river channel could cause temporary water quality impacts because disturbed and eroded soil, petroleum products, and miscellaneous construction wastes or unearthed waste debris may be discharged to receiving surface waters and groundwater. Soil and associated contaminants that enter stream channels can increase turbidity, stimulate the growth of algae, increase sedimentation of aquatic habitat, and introduce compounds that are toxic to aquatic organisms. Construction materials such as fuels, oils, paints, and concrete are potentially harmful to fish and other aquatic life if released into the environment. The extent of potential environmental effects depends on the erodibility of soil types encountered, the type of construction practice, the extent of the disturbed area and the duration of the disturbance, the timing of precipitation, and the proximity to drainage channels. Implementation of the following mitigation would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-3: Implement Construction Site Management Practices

See Alternative F for a description of this mitigation measure.

Impact: Potential for Temporary Increases in Mosquito Breeding following Irrigation Activities

If areas are not maintained and properly monitored, standing water may be present for a short time following heavy rainfall or irrigation in various portions of the project area. Such standing water may have the potential to cause temporary increases in mosquito breeding in the project area, although any potential increase is expected to be offset by the comprehensive removal throughout the project area of discarded tires and other waste that holds standing water and allows mosquitoes to breed. Implementation of the following mitigation measure would ensure this impact remains less than significant.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

See Alternative F for a description of this mitigation measure.

Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

Currently, a number of illegal or unauthorized activities occur in the project study area, primarily dumping of refuse, unauthorized firearm discharges, and short-term habitation of certain portions of the project study area by transient persons. After this project is completed, increased use of the area by recreationists and maintenance staff would tend to decrease illegal activities in the area because of increased patrolling of the area by the city and use by the public. Project lands will be acquired by local and tribal jurisdictions, who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measure: No mitigation required.

CHAPTER 6. UNAVOIDABLE SIGNIFICANT IMPACTS

Unavoidable significant impacts are impacts that remain following the implementation of mitigation measures, or impacts for which there are no mitigation measures. The following section details significant impacts that could occur as a result of implementing any of the analyzed construction alternatives [F, N, O (Preferred Alternative), E, and A]. The analysis is based on the evaluation of impacts attributable to Alternative F, which would require the greatest amount of vegetative and structural work. The remaining construction alternatives, including Alternative O (Preferred Alternative), would have an equal or smaller impact as described below.

Cultural Resources

Each of the construction alternatives could adversely affect a number of known cultural sites. The maximum number of prehistoric and historic cultural resources that may be affected is 40, which could occur under Alternatives F, N, and O. Alternative E could affect 38 known sites and Alternative A could affect 20 known sites. In addition to construction-related activities that could possibly affect NRHP sites, the root systems of newly planted vegetation, once developed, could disturb archaeological sites by increasing the moisture level in the soil. Such changes in the soil chemistry could increase the rate of degradation of important perishable ecofactual remains.

In accordance with the NHPA, further evaluations of cultural resources in the project area would need to be conducted. If resources were determined to be NRHP eligible and avoidance is not feasible, further mitigation measures would be detailed in a Memorandum of Agreement between the Corps, the SRPMIC, the City of Mesa, and the SHPO. These would include field surveys, testing, and data recovery. Mitigation measures would also contain provisions that if cultural or paleontological resources are encountered during construction or other activities, work in the area will stop until a qualified archaeologist can evaluate the finds and determine whether further investigation is necessary. The Corps, SRPMIC, City of Mesa, and the SHPO will be notified if buried cultural resources are encountered.

While data recovery actions may lessen the degree of impact, additional undiscovered sites, which are likely due to the significant number of known sites, may still be damaged during construction activities or as a result of planting vegetation in the project area.

CHAPTER 7. CUMULATIVE IMPACT ANALYSIS

Cumulative impacts are defined as negative or beneficial impacts on the environment that would result from incremental impacts of the project when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7). This cumulative impact analysis is an evaluation of impacts possible to Alternative F, which would require the greatest amount of vegetative and structural work. The remaining construction alternatives, including Alternative O (Preferred Alternative), would have similar cumulative impacts and are covered in the description below.

7.1 POTENTIAL CUMULATIVE IMPACT ZONE

For the purpose of this analysis, the Va Shly'ay Akimel project impact zone is identified as the Salt River corridor, stretching from the Granite Reef Dam to the confluence of the Agua Fria and Salt Rivers. This geographic boundary is set significantly larger than the project boundary to address cumulative impacts that may result from this project and additional projects and activities surrounding the project area. Currently, four ecosystem restoration projects (Tres Rios, Rio Salado Oeste, Rio Salado, and Va Shly'ay Akimel) have been proposed along the Salt River downstream from Granite Reef Dam. Although funding has not been secured for all of the projects, they are considered the past, present, and reasonably foreseeable projects that will be considered for this analysis. The analysis of cumulative impacts examined potential impacts from these surrounding projects over a period of approximately 10 years (1998–2008).

7.2 SUMMARY OF CUMULATIVE IMPACTS BY RESOURCE AREA

Thresholds and criteria used to determine the significance of effects vary depending on the type of resource being analyzed. For the project to contribute cumulatively to impacts of any particular resource, the project would first need to directly impact that resource in some way. An analysis of cumulative impacts to each of the resource areas is presented below.

Geology and Topography

Cumulative impacts to geology and topography would be beneficial in nature. The geomorphologic character of the existing landscape would be permanently altered due to reshaping procedures, however, these activities would help to enhance and restore the area. Bank stabilization would prevent further erosion and potential damage to roads and bridges in the vicinity.

Hydrology and Water Resources

Cumulative impacts to hydrology and water resources would be adverse only in the short term. Temporary soil disturbances during construction could discharge soil and sediment into the river channel. The discharge would be temporary and localized, as other projects within the project impact zone would not be simultaneously under construction. The project is designed to prevent long-term erosion, resulting in an overall long-term cumulatively beneficial impact. Furthermore, other existing and proposed ecosystem restoration projects along the Salt River within the project impact zone are not likely to cause cumulatively adverse impacts as a result of an accidental spill of fuels or other toxic materials due to the development and implementation of the Stormwater Pollution Prevention Plan (SWPPP), which will be required to obtain a construction permit.

Changes in the 100-year floodplain could cause a cumulative affect, however additional hydraulic analyses would continue and the proposed construction alternative would be redesigned if a cumulatively adverse impact was likely to occur. Additionally, cumulative impacts to groundwater hydrology could occur with the installation of a new well. The installation of new wells are permitted and implementation would require the development of institutional arrangements between the Corps and SRPMIC, City of Mesa or SRP, and ADWR, therefore reducing the likelihood for a cumulatively adverse impact to groundwater hydrology.

Effects on water quality associated with irrigation water would not cause a cumulatively adverse impact. If water sources are found to contain contaminants that could adversely effect water quality and aquatic organisms, the Corps would identify other irrigation sources or implement water quality improvement measures, therefore alleviating the adverse impact.

Despite minor short-term cumulatively adverse impacts, the proposed project in combination with other existing and proposed ecosystem restoration projects along the Salt River within the project impact zone are cumulatively beneficial in nature. The proposed construction activities would benefit hydrology and water resources by reducing the overall potential for flooding in the project area.

Biological Resources

Increasing and enhancing biological resources in the project study area is the major purpose of the project. Although short-term construction impacts may negatively impact some biological communities, long-term cumulative impacts to biological resources would be beneficial for all construction alternatives. Combined, the other existing and proposed ecosystem restoration projects along the Salt River within the project impact zone could greatly enhance native wildlife populations and habitat along several miles of the Salt River. Of all the proposed alternatives, cumulative adverse impacts would likely result only from the No-Action Alternative, which would result in further degradation of the Salt River corridor. While the amount of native wildlife and habitat would be expected to decrease under the no action alternative, populations of

invasive species such as saltcedar, would continue to increase, and could move back into restoration areas downstream from the project.

Cultural Resources

The implementation of any construction alternative (Alternatives F, N, O (Preferred Alternative), E, or A) may contribute to cumulative losses of cultural resources. However, while historic and/or prehistoric sites may be destroyed by construction activities, the informational value of those could be preserved through data collection and contribute to the understanding of past societies.

Aesthetic Resources

As a result of the existing and proposed project construction activities in the area, each of the construction alternatives could contribute to temporary adverse cumulative impacts on the aesthetic environment. However, the duration of these adverse impacts would be short since each construction alternative would implement measures intended to improve overall aesthetic conditions. Furthermore, the restoration projects along the Salt River will not be occurring within the same timeframe, therefore removing the likelihood for adverse cumulative impacts. The long-term cumulative effects of this project to the aesthetic resources would be beneficial since it would improve the aesthetic quality of the Salt River corridor.

Air Quality

Although construction activities would generate emissions of ozone precursors, carbon monoxide (CO), oxides of nitrogen (NOx), and fugitive dust (PM10), the annual emission levels would be below federal conformity *de minimus* levels during each year of project construction and operation. Furthermore, there is no indication that the other ecosystem restoration projects would be conducted simultaneous with the Va Shly'ay Akimel project. Therefore, it is unlikely the emissions from those projects would combine with the emissions from the Va Shly'ay Akimel project to cause the ambient concentrations to exceed the thresholds for General Conformity. The Va Shly'ay Akimel project would, therefore, not exacerbate the existing cumulative impact on air quality.

Noise

The project impact zone has relatively low levels of ambient noise compared to other, more urbanized areas in the region. Although the proposed action will generate both short-term construction noise and long-term traffic noise from visitors to the site, this increase in noise, in conjunction with the surrounding ecosystem restoration projects, would not substantially contribute to adverse cumulative noise conditions in the study area.

Social and Economic Resources

Cumulative impacts associated with social and economic resources are not likely to occur. As discussed previously, no proposed project features or activities would contribute to substantial changes in socioeconomic characteristics. The surrounding population will receive aesthetic and recreational benefits associated with restoration and enhancement of the river corridor/channel. Overall, growth in the area is not likely to be induced by the project. Therefore, there would be no cumulative effect on changes in social and economic resources in the area.

Transportation

The proposed project is not expected to contribute to adverse cumulative impacts on transportation. The project would generate short-term impacts associated with construction activities; however, most of these impacts are less than significant and others are potentially significant impact but avoidable with mitigation. Furthermore, the construction activities along the Salt River would not be occurring simultaneously, removing the possibility for adverse cumulative impacts caused by construction activities. Long-term cumulative impacts are expected to be beneficial because the area would be enhanced and restored. The project would be consistent with long-term planning policies and would not add to traffic congestion.

Land Use

The project area and surroundings fall within the boundaries of several local government jurisdictions, including Maricopa County, the City of Mesa, the City of Tempe, the City of Phoenix, the City of Avondale, the Gila River Indian Community, and the SRPMIC. The alternatives do not require the relocation of any businesses or residents, and therefore do not present potential for cumulative impacts to existing land use and/or ownership. However, projected growth and development surrounding the project area may occur at a faster rate with project implementation than without corridor improvements due to improvements of aesthetic quality. The enhanced and restored project area would not contribute to additional long-term traffic, noise, or limited vistas, allowing the planned development in the surrounding areas to proceed without conflict.

Recreation

Despite short-term impacts associated with construction activities, cumulative impacts to recreation should be beneficial due to an increased amount of attractive open space, enhancing the overall experience of recreational users. Combined, the existing and proposed habitat restoration projects in this area could increase recreational opportunities and value, therefore increasing the number of recreational users drawn to the area.

Public Health and Safety

Cumulative impacts associated with public health and safety would be beneficial. The project, in combination with the four previously mentioned ecosystem restoration projects, would improve the ecological health of the river and the human health associated with river resources. Flooding threats would be reduced, soil and water quality would be improved, and vector agents would be controlled. No adverse cumulative impacts are anticipated.

7.3 CONCLUSIONS REGARDING CUMULATIVE IMPACTS OF THE VA SHLY'AY AKIMEL PROJECT

In addition to the cumulative impacts discussed above, past, past, present, and future urban development surrounding the project area may also result in cumulative impacts. Increased urban development, whether residential or commercial, will lead to habitat degradation in a variety of ways. The most prominent degrading factors are: overall loss in habitat acreage, changes in the local hydrologic regime, and increases in human disturbance. Losses in habitat acreage would occur through development of land that might otherwise support various habitat types. Urbanization requires land surface, therefore any habitat that once occupied a site will be lost through land clearing, construction related activities, and replacement of the habitat by residences, commercial buildings, streets, and parking lots. What open space remaining is generally of highly degraded quality, diversity, and extent. Urbanization also creates an increase in impervious land surface (pavement, asphalt, and concrete replacing pervious open space), which in turn affects local hydrologic regimes. Increasing the amount of impervious surfaces prevents precipitation from penetrating into the ground, thereby increasing overland flow. Overland flow carries pollutants from road surfaces, roofs, and parking lots, into drainage ditches. The debris and sediment it carries as it moves over the land, eventually empties into existing or restored habitat areas or the river channel itself, where it can be carried downstream into other areas. These pollutants and sediments can contaminate existing vegetation directly, or alter conditions enough to prevent new vegetation from establishing. The loss of infiltration also prevents that water from being available on-site to support vegetation, eliminates shallow soil moisture recharge, and decreases the volume of deeper aquifer groundwater recharge. Trees and other vegetation that depends on these water sources are thereby eliminated. Finally, with an increase in development, one can assume an increase in human disturbance, whether through increased noise and activity on the channel banks or through more direct disturbance caused by individuals entering into the channel or riparian zone itself for recreational activities.

Negative cumulative effects of the Va Shly'ay Akimel project are generally temporary and associated only with project implementation. For many resource areas, implementation of any construction alternative would result in long-term beneficial effects. The anticipated negative effects of any construction alternative would be compensated by overall improvements in watershed condition, improved aesthetic quality of the area, improved public health and safety conditions, and an increase in the health and diversity of wildlife habitats and populations.

CHAPTER 8. MITIGATION MEASURES/ ENVIRONMENTAL COMMITMENTS

The following explanation details required mitigation measures for Alternative O, the preferred alternative. For a complete comparison of mitigation measures for each alternative, please refer to Table ES-1 "Environmental Impact Summary Matrix."

8.1 GEOLOGY AND TOPOGRAPHY

No mitigation required.

8.2 HYDROLOGY AND WATER RESOURCES

Mitigation Measure HWR-1: Implement Erosion Control Measures

The Corps and their contractors shall implement erosion control measures throughout the construction period and during implementation of O&M activities to minimize erosion and sediment input into the river. The Corps will oversee implementation of erosion control measures. The contractor selected for the project shall:

- conduct construction and O&M activities during the dry season;
- conduct all construction work in accordance with site-specific construction plans that minimize the potential for increased sediment inputs to the river;
- divert concentrated runoff away from channel banks;
- minimize vegetation removal;
- identify with construction fencing all areas that require clearing, grading, revegetation, or reshaping and minimize areas to be cleared, graded, reshaped or otherwise disturbed;
- grade and stabilize spoils and stockpile sites to minimize erosion and sediment input to the river;
- implement erosion control measures as appropriate to prevent sediment from entering the river channel or other watercourses to the extent feasible, including the use of silt fencing or fiber rolls to trap sediments and erosion control blankets to protect channel banks;
- mulch disturbed areas as appropriate and plant with appropriate species as soon as practicable after disturbance; and
- avoid operating equipment in flowing water by using temporary cofferdams or other suitable structures to divert flow around the channel and bank construction areas.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

The Corps and their contractors shall prepare a spill prevention and response plan that regulates the use of hazardous and toxic materials, such as petroleum-based fuels and lubricants for construction equipment. The Corps will oversee development and implementation of a stormwater pollution prevention plan. Elements of the plan will ensure that:

- workers are trained to avoid and manage spills;
- construction and maintenance materials are prevented from entering the river channel;
- all spills are cleaned up immediately and appropriate agencies are notified of any spills and of the cleanup procedures employed;
- staging and storage areas for equipment, materials, fuels, lubricants, solvents, and other possible contaminants are located at least 100 feet away from the river's normal high-water area;
- vehicles are removed from the river's normal high-water area before refueling or lubricating;
- vehicles are immediately removed from the work area if they are leaking; and
- equipment is not operated in flowing water (if necessary, suitable temporary structures can be installed to divert water around in-channel work areas).

Mitigation Measure HWR-4: Develop Institutional Agreements for Groundwater Use

The Corps will work with the appropriate agencies to develop the institutional agreements necessary to install/construct a new groundwater well and allow groundwater pumping for irrigation purposes.

Mitigation Measure HWR-5: Conduct Additional Stormwater Quality Sampling and Analysis

The Corps will develop a stormwater quality sampling plan and conduct sampling and analyses to identify potential contaminants and adverse effects on water quality associated with using stormwater as an irrigation source for restoration plantings. If the analyses show that constituents exceed applicable water quality standards, the Corps will identify other irrigation sources or implement water quality improvement measures (e.g., detention basins, treatment swales).

8.3 BIOLOGICAL RESOURCES

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

During the final design of the project, disturbances to areas of existing vegetation that are not within the project footprint can be minimized through careful phasing of the project construction. In addition, areas of desirable vegetation can be delineated on construction plans as areas that are not to be disturbed.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

Sediment removal activities and other activities would only be conducted during non-nesting periods of the southwestern willow flycatcher, the yellow-billed cuckoo, and the Yuma clapper rail. In the case of sediment removal, these activities would be conducted on a rotating basis so that no more that 25% of the marsh area would be affected in any one year.

Mitigation Measure BR-3: Minimize Disturbance to Waters of the United States

During O&M activities, care would be taken to minimize any necessary disturbance to waters of the United States and to ensure that such activities comply with the provisions of Section 404 of the Clean Water Act and its associated regulations.

8.4 CULTURAL RESOURCES

Mitigation Measure CR-1: Conclude Memorandum of Agreement to Complete Field Surveys and Conduct Testing and Data Recovery Activities as Appropriate

In accordance with the NHPA, additional evaluations need to be conducted to determine if any of the identified cultural sites not yet evaluated are eligible for the NRHP. If any resources are determined to be NRHP eligible, and avoidance is not feasible, mitigation measures would be detailed in a Memorandum of Agreement between the Corps, the Salt River Pima-Maricopa Indian Community, the City of Mesa, and the SHPO.

8.5 AESTHETIC RESOURCES

No mitigation required.

8.6 AIR QUALITY

Mitigation Measure AQ-1: Implement PM10-Reducing Measures During Channel Excavation and Bank Stabilization

The Corps would implement the following PM10-reducing construction practices throughout the construction period and during O&M activities:

- Apply water to unpaved haul roads at a frequency adequate to maintain visible surface moisture. Alternatively, apply nontoxic binders (e.g., latex acrylic copolymer) to supplement road watering.
- Water active storage piles at least twice daily.
- Cover inactive storage piles.
- Cover haul trucks securely or maintain at least 2 feet of freeboard on all haul trucks when transporting materials.
- Water all active construction sites at least twice daily. Frequency should be increased if wind speeds exceed 15 mph.
- Prohibit all grading activities during periods of high wind (i.e., winds greater than 30 mph).
- Apply nontoxic chemical soil stabilizers to inactive construction areas (i.e., disturbed lands within construction areas that are unused for at least 4 consecutive days), or water at least twice daily.
- Apply nontoxic binders (e.g., latex acrylic copolymer) to exposed areas after cut-and-fill operations and hydroseed the areas if appropriate for the project location.
- Install wheel washers for all exiting trucks.
- Sweep streets if visible soil material is carried onto adjacent public roads.

These practices would be made a condition of the construction contract and would be enforced through weekly inspection by the Corps.

8.7 NOISE

Mitigation Measure N-1: Employ Noise-Reducing Construction Measures

The Corps and their contractors shall incorporate the following measures into construction contract specifications:

- Construction within 1,000 feet of residences or other noise-sensitive uses shall be restricted to daytime hours. No construction shall be performed within 1,000 feet of an occupied dwelling on Sundays, on legal holidays, or between the hours of 7 p.m. and 7 a.m. on other days.
- All construction equipment shall have sound-control devices that are at least as effective as those devices provided on the original equipment. No equipment shall have an unmuffled exhaust.

As directed by the Corps, the contractor shall implement appropriate additional noise mitigation, including, but not limited to, changing the location of stationary construction equipment, shutting off idling equipment, notifying adjacent residents in advance of construction work, and installing acoustic barriers around stationary construction noise sources.

8.8 SOCIAL AND ECONOMIC RESOURCES

No mitigation required.

8.9 TRANSPORTATION

Mitigation Measure T-1: Repair Damaged Roadways

The Corps or its contractors shall repair any damage to existing roadways caused as a result of construction activities for this project. Repair work shall be coordinated with the agencies having jurisdiction of each roadway, and with the intent to return the roadways to the conditions existing immediately prior to the commencement of the project.

8.10 LAND USE

No mitigation required.

8.11 RECREATION

No mitigation required.

8.12 PUBLIC HEALTH AND SAFETY

Mitigation Measure PHS-3: Implement Construction Site Management Practices

To minimize exposure of disturbed construction sites to rainfall and stormwater runoff, construction activities should be conducted in the dry weather season to the extent possible. The general contractor for the project will prepare and implement standard grading and erosion control measures (e.g., management, structural, and vegetative controls) to minimize exposure of soil that may contribute to contaminated runoff. Additionally, the contractor will complete the necessary paperwork to obtain an NPDES permit for construction-related projects. Best management practices (BMPs) must be implemented before predicted rain events. In addition, the construction contractor will implement standard hazardous materials management practices to reduce the possibility of chemical spills or releases of contaminants in runoff.

Mitigation Measure PHS-4: Coordinate O&M Vector Control Measures with SRPMIC, Other Local Governments and Agencies

The project design will consider mosquito control to the extent feasible to limit issues associated with mosquitoes. In concept, the new habitat and channels constructed as principal elements of this restoration project will cycle water through the habitat areas, rather than allow water to pool. Thus, the proposed project is likely to help inhibit mosquito breeding. The Corps will work with the SRPMIC and other local government jurisdictions and agencies to coordinate vector control measures for this project. Potential control measures may include adjusting water levels, biological controls, spraying, or other measures. These measures are proposed as part of post-construction O&M activities.

CHAPTER 9. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Short-term impacts caused by the proposed project (including the preferred alternative) would be similar for any of the construction alternatives. These impacts would occur during and immediately after construction and would generally result in adverse effects. However, the long-term impacts that would occur over the life of the project would result in overall beneficial effects.

Short-term impacts during project implementation would result in construction effects on traffic, water resources, air quality, noise, public health and safety, recreation, and aesthetic and biological resources. However, these effects would be temporary, lasting only for the duration of the construction activities.

Generally over time, the implementation of any construction alternative would result in beneficial long-term impacts. The proposed action would restore and enhance environmental resources in the Salt River, thereby enhancing its long-term biological productivity. A substantial increase in suitable habitat for several common and sensitive species occurring or potentially occurring in the study area is expected. Species that could benefit from the habitat restoration include the southwestern willow flycatcher, yellow-billed cuckoo, and Yuma clapper rail. Additionally, foraging habitat for sensitive raptor species would increase. Habitat values would also substantially improve as a result of native vegetation restoration and invasive species (e.g., saltcedar) removal. Cottonwood-willow, new river bottom, and open water communities would all receive long-term benefits. Together, these improvements would enhance the natural environment and increase biodiversity throughout the project study area.

CHAPTER 10. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The preferred alternatives described in the feasibility report and evaluated in this EIS would involve the construction of several components that would use specific resources. The use of these resources is described below.

10.1 WATER RESOURCES

There are six water sources for the project:

21. Salt River Project water leaking from Granite Reef Dam
22. groundwater from existing and new wells
23. stormwater
24. City of Mesa Wastewater Treatment Facility water (used within existing recharge basins)
25. irrigation tailwater, and
26. surface water available for use by the SRPMIC via existing water source locations.

The construction of a well may require additional diversion structures. Although groundwater is an irretrievable resource, this project will rely primarily on excess surface water from the SRPMIC and effluent from the City of Mesa Wastewater Treatment Facility. Groundwater is considered a secondary source of water.

10.2 IRRIGATION TECHNIQUES

Irrigation techniques would require the construction of a network of lined irrigation channels and buried pipes. Materials used to build the channels include irrigation lining and concrete. Other required irrigation materials include the piping, water pumps, and wells. All of the above-mentioned materials are both readily available and easily generated.

10.3 VEGETATION

The water resources that will support the vegetation represent expenditure of a nonrenewable resource; however, the proposed vegetation would not have a significant impact on the groundwater table. The vegetation will be primarily dependent on surface water for irrigation, with groundwater considered a secondary source.

The wetland areas will be excavated and then lined by layering a silt/clay substrate overlain by a mixed gravel and a cobble layer. Furthermore, erosion control measures consisting of a series of

drainage ditches will be constructed. River bottom will require only surface reshaping, including partially filling large depressions and excavating large mounds.

All materials that will be used for vegetation, including plants and seeds, are readily available and easily generated. Additionally, materials being used during reshaping will be removed and reused elsewhere in the project area, meaning there will be no permanent commitment of resources beyond what is available and easily generated.

10.4 RESHAPING

Reshaping through channelization, as well as surface reshaping for vegetation installation and irrigation, would require moving materials during the construction process. Because materials that are being used during reshaping are being removed and reused elsewhere in the project area, there is no permanent commitment of resources beyond what is available and easily generated.

10.5 RIVER CHANNELIZATION

Channelization will require the river bottom to be excavated. The excavated materials can be used to created benches along the channel, to fill quarry pits, and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas. Because these materials are being removed and reused elsewhere in the project area, there is no permanent commitment of resources beyond what currently takes place in the natural system.

10.6 GRADE CONTROL STRUCTURE

A grade control structure would use a combination of construction materials and earth and rock materials to create the structure. All of the resources used for the grade control structure are considered to be readily available and plentiful and would not affect the availability of these materials for other uses.

10.7 BANK STABILIZATION

Methods used for bank stabilization could include berms, riprap, buried groins, or bendway weirs (wingdams, groins). The preferred material is soil cement, though reinforced concrete may also be required.

In addition to soil cement, quarry pits will be filled with materials from the reshaping and excavating, therefore utilizing materials being removed from elsewhere in the project area.

Structures being developed would use materials that are considered readily available and plentiful and would not affect the availability of these materials for other uses.

CHAPTER 11. PUBLIC INVOLVEMENT AND INTERAGENCY COORDINATION

11.1 SCOPING

The SRPMIC and the City of Mesa formally requested assistance from the Corps to explore possible remedies for several problems recognized along the Salt River. Many of these problems have long-standing and regionally widespread roots, but are evident in the immediate region of the study area. In brief, they can be attributed to land use changes in the past 150 years. The Salt River no longer runs as a perennial stream and the average depth to groundwater is far greater than was true in 1850. Without previously available groundwater, most of the native vegetation and wildlife cannot survive, and the Salt River is biologically quite impoverished.

The initiatives the sponsors wish to address through the study include:

- increasing native riparian quality for both plants and animals;
- attracting migratory birds into these better habitats;
- gradually creating a continuous biological corridor;
- fostering the reestablishment of species native to the riparian communities and augmenting overall species diversity;
- creating physical settings in the river bottom itself which promote reestablishment of cottonwood willow gallery forests and mesquite bosques;
- eliminating invasive and non-native plant species;
- restoring vegetative communities within the river corridor to a more natural state; and
- increasing acreage of functional seasonal wetland habitat.

The non-federal views and preferences regarding ecosystem restoration, with some recreation, were in general obtained through coordination with the study sponsors and with various local and regional agencies and organizations, neighborhood associations, and the general public. These coordination efforts consisted of a series of public meetings held during the reconnaissance and feasibility study phases, through the maintenance of a "point-of-contact" with whom any interested party could discuss matters, through various citizens groups, and through mailing lists by means of which invitations to public meetings were distributed.

Announcements for public meetings were made in local newspapers, including date, time, place, and subject matter.

Formal public scoping meetings were held with the sponsors (SRPMIC and the City of Mesa) between January 24, 2002 and April 1, 2003. The purpose of these meetings was to introduce the project to the public, give individuals and agencies an opportunity to identify issues for consideration in this EIS, and to solicit input on the project. The Corps received no written public comments during the scoping period.

The Corps, in conjunction with the local sponsors, held or made presentations at the following locations:

- Public meeting with the SRPMIC – January 24, 2002
- Public meeting with City of Mesa – March 20, 2002
- City of Mesa Council – October 31, 2002; March 20, 2003
- SRPMIC Tribal Council meeting – January 15, 2003
- SRPMIC public participation forum – February 13, 2003
- SRPMIC Tribal Council and City of Mesa Council meeting – April 1, 2003.

In addition, news articles relating to the project were published on the following dates:

- City of Mesa news release – July 18, 2002
- *East Valley Tribune* newspaper article – November 1, 2002
- *Arizona Republic* newspaper article – March 21, 2003

Public concerns expressed at the public meetings included the following (those items in bold were expressed repeatedly):

27. Where will the water come from and how will future droughts be addressed?

28. Who will maintain the aquifer in the future and what are the risks of aquifer contamination?

29. Concern was expressed about the City of Mesa's involvement.

30. Concern was expressed about future rights to the land surrounding the river and future possession by federal government.

31. Concern was expressed about future property loss of project site.

32. Where does project fit in with Sand and Gravel mining?

33. Concern was expressed about the protection of burial grounds.

34. Concern was expressed that preservation of this land would encourage the FAA to cement their flight plans over Community land due to lack of human establishment.

35. Concern was expressed about future restrictions of Community land use due to project.

11.2 HGM MODEL PREPARATION

The hydrogeomorphic modeling (HGM) approach to assessing wetland functions has been developed by scientists and the Engineering Research and Development Center (ERDC) Environmental Laboratory (EL) under its wetlands research program. Under this assessment procedure, the focus is narrowed to 1) the functions a particular type of wetland will perform and 2) the characteristics of the ecosystem and landscape controls of those functions. Wetlands are classified by their geomorphic setting, water source, and hydrodynamics.

From March 26–28, 2002, the Corps sponsored a workshop in Tucson, Arizona, to modify the HGM models that would be used for this project. In addition to the Corps and its consultants, participants included representatives of federal, state and local agencies; technical experts in hydrology, soils, wildlife, and riparian vegetation; and local sponsors. A subset of workshop participants gathered the base field data for the HGM model during the week of April 22, 2002. In June 2002 representatives of federal, state, and local agencies with an interest in the Va Shly'ay Akimel project met to discuss baseline project area conditions and without-project results. In August 2002 a similar group met to project future without-project conditions for the HGM models. This same team has continued to meet as alternatives were formulated and evaluated.

11.3 AGENCY COORDINATION

This EIS has been prepared in compliance with NEPA to meet the needs of federal, state, and local permitting agencies in considering the proposed restoration of this reach of the Salt River. The lead agency responsible for preparing this EIS for the proposed action is the U.S. Army Corps of Engineers, Los Angeles District. The SRPMIC and the City of Mesa are the non-federal sponsors for the project. The lead agency is responsible for ensuring that this EIS has been prepared in compliance with the provisions of NEPA. The Corps will determine the adequacy and completeness of the final EIS prior to rendering any decisions on the proposed action. The Corps will issue a decision for the proposed action in the form of a Record of Decision. The Corps will rely upon this EIS when considering whether to move forward with any of the restoration projects described in the proposed action. This EIS will also be utilized by other federal and state agencies to evaluate the project for permitting decisions.

The Corps has coordinated with the following agencies during the completion of this EIS:

U.S. Fish & Wildlife Service
Flood Control District of Maricopa County
Arizona Game and Fish
Arizona Department of Water Quality

11.4 DRAFT EIS REVIEW

This draft EIS has been provided to the following individuals, agencies, and organizations for review and comment:

ELECTED OFFICIALS

Honorable Janet Napolitano, Governor, State of Arizona
Honorable Jon Kyl, U.S. Senator
Honorable John McCain, Senator
Honorable J.D. Hayworth, U.S. Congressman
Honorable Toni Hellon, Arizona State Senator
Honorable Steve Huffman, Arizona State Representative
Honorable Pete Hershberger, Arizona State Representative
Honorable Fulton Brock, Supervisor, Maricopa County
Honorable Don Stapley, Supervisor, Maricopa County
Honorable Andrew Kunasek, Supervisor, Maricopa County
Honorable Max Wilson, Supervisor, Maricopa County
Honorable Mary Rose Wilcox, Supervisor, Maricopa County
Honorable Keno Hawker, Mayor, City of Mesa
President Joni Ramos, Salt River Pima Maricopa Indian Community

FEDERAL AGENCIES

Advisory Council on Historic Preservation
Animal and Plant Health Inspection Service, Wildlife Services
Bureau of Indian Affairs
Federal Aviation Administration
Federal Emergency Management Agency
Federal Highway Administration
National Resources Conservation Service
U.S. Army Corps of Engineers, Regulatory Branch
U.S. Bureau of Reclamation
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey

STATE AGENCIES

Arizona Department of Environmental Quality
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona Native Plant Society
Arizona State Parks

Arizona State Parks-Historic Preservation
State Historic Preservation Officer

REGIONAL AGENCIES

Flood Control District of Maricopa County
Regional Planning Manager, Planning and Project Management Division
Maricopa County Environmental Services
Maricopa County Historical Society
Maricopa County Parks and Recreation Department

SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

Bryan Myers, SRPMIC, Community Manager

CITY OF MESA

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Council Member Mike Whalen
Council Member Dennis Kavanaugh
Council Member Kyle Jones
Council Member Rex Griswold
Council Member Janie Thom
Mike Hutchinson, City Manager
Gordon Haws, Senior Engineer
Mesa Parks and Recreation
Water and Wastewater Department

LIBRARIES

Salt River Pima-Maricopa Indian Community, Community Library
Mesa Public Library
Burton Barr Central Library
Arizona State University Library

INTERESTED GROUPS

Gila River Indian Community, Department of Environmental Quality
Gila River Indian Community, Pima Maricopa Irrigation Project
Fort McDowell Yavapai Nation, President
Maricopa Audubon Society

Sierra Club, Southwest Field Office
Center for Biological Diversity
Dr. Douglas Green, Arizona State University
Dr. Roland Wass, WASS Gerke & Associates

INTERESTED PARTY LETTERS SENT TO:

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Lew and Cora Lenz, Citrus Groves Homeowner's Association
Robert Parker, Mesa Grand Homeowner's Association
Dave and Laura Richins, Mesa Grand Homeowner's Association
Kevin Rogers, Lehi Community Improvement Association
Cathy Shepherd, Mesa Grand Homeowner's Association
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The following individuals participated in the preparation of this EIS.

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12.3 CITY OF MESA

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Julianne Hamilton — Phase I Environmental Site Assessment

WEST CONSULTANTS, INC.

Dennis Richards — Hydraulic and Sedimentation Analysis for Without-Project Condition

CHAPTER 13. REFERENCES

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PERSONAL COMMUNICATIONS

Catchpole, Mark. Manager, Data Analysis Section, Arizona Department of Transportation, Transportation Planning Division. March 7, 2002 – telephone conversation regarding ADOT right-of-way volumes and levels of service.

Corman, Troy. Neo-Tropical Migratory Bird Coordinator, Arizona Game and Fish Department, Nongame Branch. March 19, 2003 – telephone conversation regarding recent southwestern willow flycatcher surveys.

Draper, Brian. Pretreatment Supervisor, Northwest Water Reclamation Plant, City of Mesa, AZ. March 6, 2002 – telephone conversation about wastewater quality reports and Mesa's treatment plant.

Fitzpatrick, Lesley. Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Arizona Ecological Services. March 19, 2003 – telephone conversation regarding Yuma clapper rail surveys.

Foy, Mitch. Transportation Engineer, City of Mesa, Transportation Division. March 6, 2002 – telephone conversation regarding transportation plans and street ADTs.

Janke, David. Recycling Research Analyst, Arizona Department of Environmental Quality. May 7, 2003 – telephone conversation regarding recycling facilities in project vicinity.

Jeffries, Dick. Manager, Planning and Permitting Unit, Solid Waste Section, Arizona Department of Environmental Quality. April 2, 2003 – telephone conversation regarding landfills in project area.

Mendelzon, Lee. Senior Environmental Engineer, Environmental Programs, City of Mesa. March 6, 2002 – telephone conversation regarding stormwater and stormwater sampling.

Mwale, Lisa. Waste Tire Coordinator, Maricopa County Solid Waste Department. May 9, 2003 – telephone conversation regarding Maricopa County waste transfer stations.

Ramirez, Dan. Maricopa County Vector Control Supervisor. March 7, 2002 – telephone conversation regarding mosquito monitoring.

Thompson, Rusty. Compliance Division Manager, Department of Engineering and Construction Services, Salt River Pima-Maricopa Indian Community. March 7, 2002 – telephone conversation regarding planning and noise issues in the Salt River Pima-Maricopa Indian Community.

Watkins, Randy. Compliance and Recycling Coordinator, Salt River Landfill. May 7, 2003 – telephone conversation regarding recyclable materials.

CHAPTER 14. GLOSSARY OF TERMS AND ACRONYMS

14.1 ACRONYMS AND ABBREVIATIONS

ac-ft	acre-foot
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
ADT	Average Daily Traffic
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
AMA	Active Management Area (Arizona Department of Water Resources designation for particular groundwater basins throughout the state)
BOD	biochemical oxygen demand
CAA	Clean Air Act
CAFO	Concentrated Animal-Feeding Operation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (commonly referred to as the "Superfund" Act)
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System (EPA database of current and potential Superfund sites)
cfs	cubic feet per second
CNEL	community noise equivalent level
CO	carbon monoxide
Corps	U.S. Army Corps of Engineers
dB	decibel
dBA	A-weighted decibel
DES	Arizona Department of Economic Security

EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCDMC	Flood Control District of Maricopa County
FCI	Functional Capacity Index
FCU	Functional Capacity Unit
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GRIC	Gila River Indian Community
HGM	Hydrogeomorphic modeling method
LAU	Lower Alluvial Unit
L_{dn}	day-night average sound level
L_{eq}	equivalent sound level
LOS	Level of Service (quantifies capability of a given roadway segment to handle traffic flow)
LUST	leaking underground storage tank
$\mu g/m^3$	micrograms per cubic meter
MAG	Maricopa Association of Governments
MAU	Middle Alluvial Unit
mg/l	milligrams per liter
MM	Modified Mercalli Intensity Scale (used in quantifying intensity of seismic events)
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NER Plan	National Ecosystem Restoration Plan
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NO_2	nitrogen dioxide
NOx	oxides of nitrogen

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List (EPA list of Superfund sites)
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O_3	ozone
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
PM10	particulate matter 10 microns or less in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act (federal law regulating the generation, transportation, treatment, storage, and disposal of hazardous wastes)
RID	Roosevelt Irrigation District
SARA	Superfund Amendment and Reauthorization Act
SIP	State Implementation Plan (EPA approved, state-level measures for meeting clean air standards)
SO_2	sulfur dioxide
SRP	Salt River Project
SRPMIC	Salt River Pima-Maricopa Indian Community
SWPPP	Stormwater Pollution Prevention Plan
TAC	toxic air contaminant
TDS	total dissolved solids
thalweg	centerline of drainage flow within a watercourse
TMDL	Total Maximum Daily Load
tpy	tons per year
TSD	RCRA-approved treatment, storage, and disposal facilities
UAU	Upper Alluvial Unit
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

USGS	U.S. Geological Survey
VOC	volatile organic compound
WQARF	Arizona Water Quality Assurance Revolving Fund
WWTP	wastewater treatment plant

14.2 GLOSSARY

100-year flood. A major destructive flood event that would occur on average once every 100 years.

A-weighting. Process in which noise measurements are weighted more heavily within those frequencies of maximum human sensitivity.

acre-foot. Volume of water that could cover 1 acre to a depth of 1 foot.

alluvium. Clay, silt, sand, gravel, or similar material deposited by running water.

National Ambient Air Quality Standards. The specified average concentration of an air pollutant in ambient air during a specified time period at or above which undesirable effects may be produced.

area of potential effects. Geographical area that may be affected by a project.

average daily traffic. Volume of traffic occurring on a roadway averaged over 1 day.

attenuation. To decrease in severity.

bedrock. Solid rock underlying unconsolidated surface soils.

biochemical oxygen demand. The oxygen used in meeting the metabolic needs of aerobic microorganisms in water rich in organic matter.

biological assessment. A document prepared under Section 7 process of the Endangered Species Act to determine whether a proposed action is likely to adversely affect listed species, proposed species, or designated critical habitat.

bosques. Groves or stands of vegetation.

braided channel. A stream with a complex tangle of converging and diverging channels separated by sand bars or islands.

census tract. A standard area in certain large American cities used by the U.S. Bureau of the Census for purposes of population enumeration.

Council on Environmental Quality. The agency responsible for the oversight and development of national environmental policy. Created by NEPA, CEQ shares this responsibility with the EPA.

criteria pollutants. Air pollutants for which the federal or state government have established ambient air quality standards, or criteria, for outdoor concentration in order to protect public health.

de minimis. Refers to a project with criteria air pollutant emissions that do not exceed federal conformity thresholds.

decibel. A unit for expressing the relative intensity of sounds.

diurnal variations. Daily changes.

ecorestoration. Renewal, revival, or reestablishment of an ecological community.

effluent. Waste material (such as wastewater) discharged into the environment.

endangered. The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

environmental impact statement. The detailed report required by NEPA that describes the environmental impacts of a major federal action that may significantly affect the quality of the environment.

ephemeral. Present only during certain seasons.

Federal Register. An index of all the public notices of all the departments in the federal government.

federal Endangered Species Act. Federal legislation intended to provide a means whereby the ecosystems on which endangered and threatened species depend may be conserved and programs provided for the conservation of those species, thus preventing extinction of native plants and animals.

fugitive dust. Dust particles that have become suspended in the air.

General Industrial Stormwater Permit. Permits for the discharge of stormwater runoff to waters of the United States from specified industrial activities.

General Construction Stormwater Permit. Permits for the discharge of stormwater runoff to waters of the United States from disturbances of more than 5 acres.

General Conformity Rule. Applies to all nontransportation federal projects to ensure that the project conforms to applicable SIPs so that the project does not interfere with strategies to attain NAAQS in nonattainment areas.

geomorphic. Relating to the form of the earth.

geomorphology. A science that deals with the land and submarine relief features of the earth's surface.

Hohokam. Of, belonging to, or characteristic of an American Indian culture of the central and southern deserts of Arizona, about A.D. 450–1450.

hydrogeology. The science dealing with the occurrence, distribution, and movement of water below the surface of the earth, with a greater emphasis on geology.

hydrologic. Dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

igneous rock. Rocks formed from solidification of magma.

Level of Service. Operating ratio (volume/capacity) of an intersection of roadway segment that is presented in terms of traffic conditions on a scale from A to F.

listed species. A species, subspecies, or distinct vertebrate population segment that has been added to the federal lists of endangered and threatened wildlife and plants as they appear in sections 17.11 and 17.12 of Title 50 of the Code of Federal Regulations (50 CFR 17.11 and 17.12).

National Register of Historic Places. A database containing a list of historic resources that meet specific eligibility requirements.

National Emission Standards for Hazardous Air Pollutants. Designated to control emissions of toxic air pollutants to prevent adverse health effects.

National Pollutant Discharge Elimination Systems. Provides regulations for discharging pollutants into surface water bodies, including providing mechanisms to eliminate nonstormwater discharge, pollution prevention plans, inspection, and monitoring.

National Environmental Policy Act. The federal law established in 1970 to protect the environment by ensuring that federal agency decision makers take environmental factors relating to federal actions into account.

New Source Review. Preconstruction review requirements for new and modified major and minor stationary sources.

nonattainment area. A regional area that exceeds air quality standards for certain pollutants as designated by the EPA.

ozone precursors. Chemicals, such as reactive organic compounds and nitrogen oxides, that occur either naturally or as a result of human activities and that contribute to the formation of ozone.

particulate matter (PM10 and PM 2.5). Criteria pollutant consisting of solid material that is small enough in size to be inhaled.

peak mean daily flow. Highest average flow of a river or watercourse that occurs over the course of a 1-day period.

perennial. Present at all seasons of the year.

phreatophyte. Deep rooted plant that obtains its waters from the water table or the layer of soil just above it.

prevention of significant deterioration. An air pollution permitting program for new or modified major stationary sources in attainment areas.

raptors. Birds of prey.

ruderal. Connotes weeds or other non-native vegetation growing where previous vegetation has been disturbed by human activity.

saltcedar. A non-native, invasive shrub or small tree with bluish foliage and white or pinkish flowers.

scour-and-fill. Generally a condition where flood events degrade a channel and deposit sediments.

Section 7. The section of the Endangered Species Act that requires all federal agencies, in consultation with USFWS, to ensure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat.

sedimentation. The action or process of forming or depositing sediment.

shorebirds. Any of a suborder of birds that frequent the seashore or other surface water bodies.

sinuosity. The degree to which a watercourse varies back and forth across its flow centerline.

State Implementation Plan. A state's plan to attain the federal air quality standards for all non-attainment areas with the state.

tailwater. Excess surface water draining from a field under cultivation.

thalweg. A figurative line connecting the lowest points along the main drainage of a waterway.

threatened. The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

total dissolved solids. The amount of material (inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of milligrams per liter.

toxic air contaminants. Air pollutants that are carcinogens or produce acute effects. Toxic air pollutant thresholds are based on quantitative risk assessment rather than ambient air standards as with criteria pollutants.

toxicological benchmark. Contaminant threshold level that results in a toxic effect on a given subject.

turbidity. Water that is not clear or transparent because of stirred-up sediment.

volatile organic compounds. Secondary petrochemicals, including light alcohols, acetone, trichloroethylene, percholoroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence, and widespread industrial use, they are commonly found in soil and groundwater.

water table. The upper surface of a zone of saturation by groundwater.

waterfowl. Swimming game birds as distinguished from upland game birds and shorebirds.

waters of the United States. Broadest category of regulated water bodies under the Clean Water Act. Includes wetlands along with nonwetland habitat, including streams, rivers, lakes, ponds, bays, and oceans.

INDEX

Acacia, 4-39
Adverse effects, xii, 2, 2-7, 4-80, 4-83, 4-94, 4-108, 5-7, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-18, 5-52, 5-53, 5-56, 5-66, 5-67, 5-84, 5-97, 5-102, 5-104, 7-2, 7-3, 7-4, 7-5, 8-3, 9-1, 14-7, 14-8
Aesthetic resources, 2-4, 4-68, 5-56, 7-3
African American, 4-87
Agua Fria River, 4-8, 4-13, 4-46, 4-49
Air quality, 2-4, 2-7, 4-74, 4-75, 4-78, 4-79, 4-80, 4-81, 4-109, 5-60, 5-61, 9-1, 14-6, 14-7, 14-8
Alaskan native, 4-87
Alma School Road, 3-16, 3-20, 3-23, 3-25, 3-29, 3-31, 3-32, 3-33, 3-34, 3-35, 3-36, 3-37, 3-38, 3-39, 4-78, 4-96, 4-97, 4-98, 4-100, 4-102, 4-125, 4-126, 4-127, 5-3
Alternative A, vi, viii, ix, 3, 6, 3-8, 3-26, 3-27, 5-4, 5-15, 5-16, 5-33, 5-48, 5-49, 5-50, 5-55, 5-58, 5-64, 5-65, 5-71, 5-73, 5-81, 5-88, 5-103, 5-104, 6-1
Alternative B, 3-28
Alternative C, 3-29
Alternative D, 3-30
Alternative E, vi, viii, ix, 3, 6, 3-13, 3-23, 3-26, 5-3, 5-4, 5-14, 5-15, 5-30, 5-46, 5-47, 5-48, 5-49, 5-55, 5-58, 5-63, 5-65, 5-71, 5-73, 5-79, 5-80, 5-87, 5-102, 6-1
Alternative F, vi, viii, ix, 3, 6, 3-8, 3-13, 3-14, 3-17, 3-18, 3-19, 5-2, 5-3, 5-6, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-19, 5-36, 5-37, 5-38, 5-39, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-47, 5-48, 5-49, 5-50, 5-51, 5-53, 5-54, 5-55, 5-56, 5-57, 5-58, 5-60, 5-62, 5-63, 5-64, 5-65, 5-66, 5-71, 5-72, 5-73, 5-75, 5-77, 5-78, 5-79, 5-80, 5-81, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 5-89, 5-96, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 6-1, 7-1
Alternative G, 3-31
Alternative H, 3-32
Alternative I, 3-34
Alternative J, 3-35
Alternative K, 3-36
Alternative L, 3-37
Alternative M, 3-38
Alternative N, vi, viii, ix, 3, 6, 3-18, 3-20, 5-3, 5-10, 5-11, 5-13, 5-23, 5-40, 5-41, 5-42, 5-44, 5-54, 5-57, 5-62, 5-65, 5-71, 5-72, 5-77, 5-78, 5-79, 5-85, 5-87, 5-99
Alternative O, vi, viii, ix, 1, 3, 6, 3-21, 3-23, 5-3, 5-12, 5-13, 5-27, 5-36, 5-43, 5-45, 5-47, 5-54, 5-57, 5-62, 5-63, 5-65, 5-66, 5-71, 5-72, 5-78, 5-79, 5-86, 5-100, 6-1, 7-1, 8-1
American coot, 4-35
American Indian, 2-5, 4-87, 14-7
American Indian Religious Freedom Act, 2-5
American kestrel, 4-32, 4-33, 4-40
Apache Lake, 4-8, 4-114
Archaic period, 4-54, 4-59
Arizona Aquiver Protection Permit Program, 4-23
Arizona Canal, x, 4-9, 4-35, 4-59, 4-63, 4-69
Arizona Department of Economic Security (ADES), 4-86, 4-89, 4-90, 13-1, 14-1
Arizona Department of Environmental Quality (ADEQ), 4-16, 4-26, 4-27, 4-75, 4-76, 4-77, 4-78, 4-79, 4-121, 13-1, 13-8, 13-9, 14-1
Arizona Department of Transportation (ADOT), 4-25, 4-95, 13-9, 14-1
Arizona Department of Water Resources (ADWR), 4-12, 4-120, 13-1, 14-1
Arizona Executive Order 91-6, 2-8
Arizona Game and Fish Department (AGFD), 2-5, 4-11, 4-43, 4-47, 4-48, 4-49, 4-50, 4-51, 13-1, 13-2, 13-9, 14-1
Arizona Pollutant Discharge Elimination System (AZPDES), 4-27
Arizona Water Quality Asurance Revolving Fund (WQARF), 4-121, 14-4
Arterial roadways, 4-97, 4-100
Ash-throated flycatcher, 4-34
Average annual functional capacity units (AAFCUS), x
Average temperature, 4-75
Avondale, 4-21, 4-114, 7-4
Bald and Golden Eagle Protection Act, 2-7
Banded gecko, 4-34
Banded sand snake, 4-34, 4-35
Barn owl, 4-32
Barrel cactus, 4-34
Bartlett Dam, 4-8, 4-9, 4-10
Bartlett Lake, 4-8, 4-114
Base and meridian, 4-114
Beeline Highway, x, 3-45, 3-46, 4-69, 4-95, 4-123, 4-128
Belted kingfisher, 4-35
Biochemical oxygen demand (BOD), 4-22, 14-1, 14-5

Biological resources, 2-3, 4-28, 4-51, 5-18, 5-36, 7-2, 9-1
Black Canyon Shooting Range, 4-114
Black phoebe, 4-34, 4-35
Black-bellied whistling duck, 4-36
Black-tailed jackrabbit, 4-35
Black-throated sparrow, 4-35
BLM lands, 4-114
Blue paloverde, 3-11, 3-12, 4-39, 4-68
Blue Point Terrace, 4-60, 4-61
Bobcat, 4-32, 4-34, 4-35
Buckhorn mesa project, 4-12, 13-3
Burro brush, 3-11, 3-13, 4-38, 4-40
Cactus ferruginous pygmy owl, 4-43, 4-48
Cactus mouse, 4-34, 4-35
California brown pelican, 4-52
Canyon Lake, 4-8, 4-114
Canyon towhee, 4-35
Carbon monoxide, 2-7, 4-75, 5-59, 7-3, 14-1
Cashion, 4-21, 4-114
Cattails, 3-12, 3-13, 4-35, 4-50
Channelization, 2, 3-13, 3-15, 3-18, 4-21, 5-2, 5-3, 5-53, 5-54, 5-85, 5-86, 5-87, 10-2
Cholla, 4-30, 4-34, 4-35
Cinnamon teal, 4-36, 4-37
City of Chandler, 4-17, 4-95, 4-112, 4-126
City of Glendale, 4-16, 4-21
City of Mesa, vii, x, xii, 1, 7, 1, 2-2, 3-7, 3-20, 3-25, 3-41, 3-42, 3-46, 4-1, 4-7, 4-12, 4-13, 4-14, 4-17, 4-21, 4-23, 4-25, 4-28, 4-30, 4-33, 4-35, 4-36, 4-52, 4-54, 4-58, 4-59, 4-60, 4-61, 4-68, 4-69, 4-70, 4-71, 4-72, 4-78, 4-85, 4-86, 4-88, 4-89, 4-93, 4-95, 4-97, 4-98, 4-99, 4-100, 4-101, 4-102, 4-103, 4-104, 4-106, 4-107, 4-109, 4-110, 4-111, 4-113, 4-115, 4-116, 4-117, 4-118, 4-119, 4-120, 4-122, 4-123, 4-124, 4-125, 4-126, 4-127, 4-128, 5-9, 5-52, 5-54, 5-55, 5-75, 5-84, 5-85, 6-1, 7-2, 7-4, 8-3, 10-1, 11-1, 11-2, 11-3, 13-3, 13-5, 13-6, 13-7, 13-9
  General Plan, 4-71, 4-105, 4-107, 4-109, 4-110, 4-117, 4-118, 5-85
City of Peoria, 4-17
Classic period, 4-57, 4-65, 13-2
Clean Air Act, 2-7, 4-79, 4-80, 14-1
Clean Water Act, 2-4, 2-6, 3-9, 4-23, 4-26, 4-27, 5-40, 8-3, 13-1, 14-9
  Section 303(d), 4-26, 13-1
  Section 402, 4-27
  Section 404(b), xi, 2-4, 2-6
  Section 404(r), 2-6
Colonial period, 4-56
Common kingsnake, 4-34, 4-35
Common merganser, 4-35
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 4-121, 14-1
Concentrated animal-feeding operations (CAFOS), 4-22
Coolidge Dam, 4-8
Cottonwood willow (CW), 11-1
Council on Environmental Quality, 2-5, 14-5
Country Club Road, 3-16, 3-25, 3-29, 3-32, 3-33, 3-34, 3-36, 3-38, 5-3
Country Club storm drain, 3-17, 3-19, 3-22, 3-25, 3-28, 3-29, 3-31, 3-33, 3-35, 3-37, 3-38, 3-39
Coyote, 4-32, 4-34, 4-35, 4-40
Creosote bush, 4-34, 4-38, 4-68, 4-70
Cultural Center, 3-40, 3-43, 3-44, 3-45, 3-46, 3-47
Cultural resources, 2-4, 4-53, 4-61, 4-107, 4-116, 5-53, 5-54, 5-55, 6-1, 13-8
Cumulative impacts
  Aesthetic resources, 7-3
  Air quality, 7-3
  Biological resources, 7-2
  Cultural resources, 7-3
  Geology and topography, 7-1
  Hydrology and water resources, 7-2
  Land use, 7-4
  Noise, 7-3
  Public health and safety, 7-5
  Recreation, 7-4
  Social and economic resources, 7-4
  Transportation, 7-4
Curve-billed thrasher, 4-35, 4-38
Cypress landfill, 4-123, 4-125
Deer mouse, 4-34
Deer Valley, 4-14
Desert blackheaded snake, 4-34
Desert broom, 2-1, 4-33
Desert cottontail, 4-35
Desert spiny lizard, 4-34, 4-35
Desert tortoise, 4-28, 4-43, 4-50
Desert willow, 4-33
Dissolved organic carbon (DOC), 4-23
Dock, 4-35
Dusky flycatcher, 4-34
Earless lizard, 4-34, 4-35

East Salt River Valley (ESRV), 4-12, 13-8
Elf owl, 4-35
Employment sectors, 4-90
Endangered Species Act (ESA), 2-5, 4-43, 4-47, 14-2, 14-5, 14-6, 14-8
Section 7, 2-5, 4-52, 14-5, 14-8
Environmental Impact Statement (EIS), xii, 1, 2, 1, 2-3, 2-4, 2-5, 2-6, 2-7, 4-51, 4-94, 5-23, 10-1, 11-2, 11-3, 11-4, 14-2
Environmental impact summary matrix, ES-3, 8-1
Environmental justice analysis, 4-94
Environmental monitoring, ES-2, 3-8
Ethnic makeup, 4-87
Evergreen drain, 3-15, 3-19, 3-22, 3-24, 3-25, 3-27, 3-36, 3-37, 3-39, 5-102
Executive Order 11988, 2-7
Executive Order 11990, 2-7
Executive Order 12898, 2-7, 4-94
Executive Order 13045, 2-8
Executive Order 13084, 2-6
Farmland Protection Policy Act, 2-8
Federal Emergency Management Agency (FEMA), 4-26, 14-2
Finches, 4-32
Fish and Wildlife Coordination Act (FWCA), xi, 2-5, 4-51
Flood Control Act of 1938
Section 6, ES-1
Flood Control District of Maricopa County (FCDMC), 4-11, 4-12, 4-25, 4-112, 11-3, 13-3, 14-2
Flood damage, xii, ES-1, 3-13, 4-10, 5-5, 5-6, 5-8, 8-2, 10-2
Flood Disaster Protection Act of 1973, 4-26
Floodflows, 4-10, 4-21
Fugitive dust, 4-81, 5-59, 5-60, 5-61, 7-3, 14-6
Functional capacity index (FCI), 4-42
Functional capacity units (FCUS), 4-41
General Conformity Rule, 4-80, 14-6
General plan development area, 4-107
Geology and topography, 2-3
Gila River, vi, ix, ES-1, 2-1, 2-2, 4-7, 4-8, 4-21, 4-24, 4-25, 4-26, 4-45, 4-46, 4-47, 4-49, 4-50, 4-55, 4-58, 4-59, 4-114, 7-4, 13-2, 14-2
Gila River Wildlife Area, 4-114
Gila woodpecker, 4-35
Gilbert Quarry, 3-15, 3-16, 3-19, 3-22, 3-24, 3-27, 3-28, 3-29, 3-30, 3-31, 3-32, 3-33, 3-34, 3-35, 3-39, 5-2, 5-4, 5-66
Gilbert Road Bridge, 3-14, 3-15, 3-19, 3-22, 3-38, 3-39, 4-5
Grade control structure, 2
Gradient, 4-5, 4-41, 4-120
Granite Reef Dam, x, xii, 1, 2-2, 2-3, 4-1, 4-3, 4-5, 4-10, 4-11, 4-12, 4-13, 4-14, 4-17, 4-28, 4-34, 4-35, 4-36, 4-60, 4-61, 4-68, 4-70, 4-95, 7-1, 10-1
Granite Reef Diversion Dam, 4-9, 4-59
Granite Reef Underground Storage Project (GRUSP), 3-8
Gray fox, 4-32, 4-35
Great blue heron, 4-33, 4-36
Great egret, 4-33
Great horned owl, 4-32, 4-33
Greater roadrunner, 4-32, 4-38
Ground squirrels, 4-36
Groundwater, 1, 4, 2-1, 6, 3-7, 3-11, 3-14, 3-15, 3-17, 3-18, 3-19, 3-20, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 4-4, 4-6, 4-9, 4-12, 4-13, 4-14, 4-15, 4-16, 4-18, 4-23, 4-26, 4-32, 4-33, 4-36, 4-41, 4-69, 4-104, 4-120, 4-121, 4-124, 4-125, 4-126, 5-5, 5-8, 5-9, 5-11, 5-13, 5-15, 5-16, 5-97, 5-99, 5-101, 5-102, 5-104, 7-2, 8-2, 10-1, 11-1, 13-1, 14-1, 14-9
Groundwater hydrology, 5-11, 5-13, 5-15, 7-2
HB 2601, 4-106
Headcutting, ES-2, 3-15, 3-24, 4-5, 5-2, 5-3
Hennessey drain, 3-14, 3-15, 3-18, 3-21, 3-24, 3-27, 3-28, 3-29, 3-30, 3-31, 3-32, 3-33, 3-34, 3-35, 3-36, 3-37, 3-39
Higley Quarry, 3-14, 3-18, 3-21, 3-24, 3-26
Hispanic, x, 4-58, 4-87, 4-94
Hispid cotton rat, 4-34
Historic period, 4-58
Hohokam culture, 4-54, 4-56, 4-57
Horse Mesa Dam, 4-8
Horseshoe Dam, 4-8, 4-59
Horseshoe Lake, 4-8
House finch, 4-35, 4-37
House Resolution 2425, ES-1
House wren, 4-34
Household income, 4-93
Housing units, 4-88
Hydrogeomorphic (HGM), 4-41, 14-2
Hydrology and water resources, 2-3, 7-2
Hyperthermic torrifluvents, 4-4
Impacts
Aesthetic resources, 5-56–5-58
Air quality, 5-59–5-65

Biological resources, 5-36–5-51
Cultural resources, 5-52–5-55
Land use, 5-83–5-89
Noise, 5-66–5-71
Public health and safety, 5-96–5-105
Social and economic resources, 5-72–5-73
Transportation, 5-74–5-82
Indian Bend Wash, 4-9, 4-12, 4-25
Ions, 4-14, 4-15, 4-16, 5-9
Irrigation, ES-1, 2, 6, 3-7, 3-8, 3-9, 3-11, 3-12, 3-13, 3-14, 3-15, 3-16, 3-17, 3-18, 3-19, 3-20, 3-21, 3-22, 3-23, 3-24, 3-25, 3-26, 3-27, 3-28, 3-29, 3-30, 3-31, 3-32, 3-33, 3-35, 3-36, 3-37, 3-38, 3-39, 4-8, 4-13, 4-14, 4-16, 4-22, 4-24, 4-32, 4-35, 4-55, 4-57, 4-58, 4-59, 4-65, 4-120, 5-2, 5-4, 5-9, 5-10, 5-11, 5-13, 5-15, 5-16, 5-53, 5-66, 5-75, 5-77, 5-78, 5-79, 5-80, 5-82, 5-83, 5-85, 5-86, 5-87, 5-96, 5-97, 5-98, 5-100, 5-101, 5-102, 5-103, 5-104, 7-2, 8-2, 8-3, 10-1, 10-2, 13-4, 13-6
Jeffries, Dick, 4-123
Jerome-Wasatch Structural zone, 4-5
Knotweeds, 4-35
Lake Pleasant, 4-8, 4-114
Land use, 2-4, 2-6, 4-17, 4-22, 4-25, 4-40, 4-60, 4-68, 4-84, 4-85, 4-104, 4-105, 4-106, 4-107, 4-108, 4-109, 4-110, 4-112, 4-119, 4-120, 5-9, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 5-89, 11-1, 11-3, 13-4
Land use pattern, 4-104, 4-105
Laveen, 4-21
Leaking underground storage tanks (LUSTS), 4-125
Lehi Cemetery, 3-25, 3-32, 3-33
Lehi School, 4-61
Lehi Terrace, 4-60, 4-61
Lesser long-nosed bat, 4-43, 4-48, 4-49
Loggerhead shrike, 4-38
Longmore Road, 3-25
Long-term impacts, 9-1
Loop 101 (Pima Freeway), 1, 3-46, 4-36, 4-95, 4-97, 4-102, 4-120, 5-38, 5-41, 5-44, 5-47, 5-49, 5-58, 5-67
Loop 202, 4-36, 4-95, 4-97, 5-67, 5-83
Lower alluvial unit (LAU), 4-12, 14-2
Lowland leopard frog, 4-44
Luke Air Force Base, 4-6, 4-14
Main street Fault, 4-5
Mallard, 4-35, 4-36
Maricopa Association of Governments (MAG), 4-79, 4-86, 4-88, 4-93, 13-5, 14-2
Maricopa County, vii, xii, 1, 2-2, 2-7, 4-1, 4-17, 4-21, 4-24, 4-25, 4-37, 4-40, 4-49, 4-65, 4-68, 4-70, 4-72, 4-74, 4-78, 4-79, 4-80, 4-81, 4-84, 4-86, 4-87, 4-88, 4-89, 4-90, 4-93, 4-94, 4-97, 4-103, 4-104, 4-106, 4-107, 4-108, 4-109, 4-112, 4-113, 4-114, 4-115, 4-116, 4-121, 4-127, 4-128, 5-61, 5-84, 5-85, 7-4, 13-1, 13-2, 13-5, 13-7, 13-8, 13-9
Maricopa County Comprehensive Plan, 4-84, 4-106, 4-107, 4-116, 5-85
Marsh fleabane, 4-33
Mcdowell Mountains, 4-69, 4-70
Memorandum of Understanding, 7, 5-52, 5-54
Mesa Falcon Field Municipal Airport, 4-102
Mesa Terrace, 4-60, 4-61
Mesquite (MS), 1, 2-2, 6, 3-10, 3-11, 3-12, 4-9, 4-39, 4-41, 4-48, 4-49, 5-37, 5-40, 5-43, 5-46, 5-56, 5-57, 5-96, 5-99, 5-102, 11-1
Metals, 4-14, 4-15, 4-16, 4-17, 4-22, 4-27, 4-45, 4-48, 4-120, 5-9
Mexican garter snake, 4-28, 4-43, 4-44, 4-50
Microorganisms, 4-14, 14-5
Middle alluvial unit (MAU), 4-12, 14-2
Migratory Bird Treaty Act, 2-7
Miocene period, 4-1
Mitigation measure, 2, 2-3, 4-81, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-47, 5-48, 5-49, 5-50, 5-51, 5-52, 5-54, 5-55, 5-62, 5-63, 5-64, 5-70, 5-77, 5-79, 5-80, 5-81, 5-97, 5-98, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 6-1, 8-1, 8-3
Mitigation measures
Air quality, 5-61, 5-62, 5-63, 5-64, 8-4
Biological resources, 5-37, 5-38, 5-39, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-47, 5-48, 5-49, 5-50, 5-51, 8-3
Cultural resources, 5-54, 8-3
Hydrology and water resources, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 8-1, 8-2, 8-3
Noise, 5-70, 8-5
Public health and safety, 5-97, 5-98, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 8-6
Transportation, 5-76, 5-77, 5-79, 5-80, 5-81, 8-5
Monitoring and adaptive management plan, xi, 3-9
Mormon Flat Dam, 4-8

Mosquitoes, 4-121, 5-96
Breeding, 3-9, 4-121, 5-98, 5-100, 5-101, 5-103, 5-104, 8-6, 13-9
Mourning dove, 4-32, 4-35, 4-40
Muskrats, 4-36
National Ambient Air Quality Standards (NAAQS), 4-75, 14-2, 14-5
National Emission Standards for Hazardous Air Pollutants (NESHAPS), 4-79, 14-2, 14-7
National Environmental Policy Act (NEPA), xii, 2-5, 14-2, 14-7
National Flood Insurance Act of 1968, 4-26
National Historic Preservation Act, 2-5, 4-53, 5-52, 5-54
Section 106, 2-5, 4-53, 5-52, 5-53, 5-54
National Pollutant Discharge Elimination System (NPDES), 4-21, 4-27, 4-120, 14-3, 14-7
National Priorities List (NPL), 4-121, 14-3
National Register of Historic Places (National Register), 2-5, 4-53, 4-61, 4-62, 5-52, 13-1, 14-3, 14-7
National Trails Systems, 4-114
Native American Grave Protection and Repatriation Act (NAGPRA), 2-6
Native Hawaiian or other Pacific Islander, 4-87
Natural Resources Conservation Service (NRCS), 2-8, 4-23, 14-3
No-action alternative, xii, 3-13, 7-2
Noise, 9, 2-4, 4-82, 4-83, 4-84, 4-85, 4-109, 5-39, 5-42, 5-45, 5-48, 5-66, 5-67, 5-70, 5-71, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 7-3, 7-4, 8-5, 9-1, 13-10, 14-1, 14-5
Nonattainment, 2-7, 4-78, 4-80, 14-6, 14-7
North Center Street Landfill (City of Mesa), 4-123, 4-125
North Center Street Landfill (SRPMIC), 4-123, 4-124
Northern flicker, 4-33
Northern harrier, 4-32
Northern mockingbird, 4-40
Northern pintail, 4-36
Nutrients, 4-14, 4-15, 4-16, 5-9
Occupational Health and Safety Administration (OSHA), 4-84
Open water, 1, 2-1, 3-12, 4-36, 4-37, 4-48, 4-68, 4-69, 4-70, 5-36, 5-39, 5-40, 5-42, 5-43, 5-45, 5-46, 5-48, 5-50, 5-57, 9-1
Operations and maintenance (O&M), ES-2, 6, 9, 3-8, 3-45, 5-6, 5-10, 5-12, 5-14, 5-15, 5-39, 5-40, 5-42, 5-45, 5-48, 5-50, 5-51, 5-59, 5-60, 5-61, 5-66, 5-70, 5-71, 5-75, 5-84, 5-85, 5-86, 5-87, 5-88, 5-98, 5-100, 5-101, 5-103, 5-104, 8-1, 8-3, 8-4, 8-6, 14-3
Osprey, 4-35
Ozone, 2-7, 4-75, 4-77, 4-80, 5-59, 5-60, 7-3, 14-3, 14-7
Painted Rock Dam, 4-8, 4-24, 4-114
Painted Rock Lake, 4-8
Paleoindian period, 4-54
Papago Park, 4-13, 4-113
Paradise Valley, 4-14, 4-17, 13-4
Partial Wetland Assessment Areas (PWAAS), 4-41
Peregrine falcon, 4-43, 4-50, 4-51, 5-38, 5-42, 5-45, 5-47, 5-50
Pesticides, 4-14, 4-17, 4-22, 4-45
Phainopepla, 4-35
Phoenix, 1, 2, x, xii, 1, 2-1, 2-2, 4-1, 4-3, 4-6, 4-7, 4-8, 4-9, 4-10, 4-11, 4-12, 4-14, 4-16, 4-17, 4-21, 4-24, 4-25, 4-26, 4-27, 4-36, 4-37, 4-44, 4-48, 4-49, 4-50, 4-51, 4-54, 4-55, 4-56, 4-58, 4-59, 4-64, 4-74, 4-75, 4-79, 4-83, 4-89, 4-102, 4-104, 4-113, 4-114, 4-128, 5-67, 7-4, 13-1, 13-2, 13-3, 13-4, 13-5, 13-6, 13-7, 13-8, 13-9
Phoenix Active Management Area (AMA), 4-12, 13-1
Phoenix Basin, 4-1, 4-3, 4-54, 4-56, 13-3, 13-6
Pioneer period, 4-55, 4-64
Planning Aid Letter (PAL), 4-51
Pliocene period, 4-1
PM10, 2-7, 4-75, 4-76, 4-77, 4-78, 4-79, 4-80, 5-59, 5-60, 5-61, 5-62, 5-63, 5-64, 5-65, 7-3, 8-4, 14-3, 14-8
Pocket gopher, 4-35
Pre-American Sovereign Indian Tribes, 4-104
Preferred action alternative, xii
Protohistoric/early historic period, 4-58
Public health and safety, 2-4, 4-120, 5-102, 5-103, 7-5, 9-1
Quailbush, 4-38, 4-42, 5-19, 5-20, 5-21, 5-23, 5-24, 5-25, 5-27, 5-29, 5-30, 5-32, 5-33, 5-34
Quaternary period, 4-1, 4-3, 4-5
Queen Creek, 4-14, 13-7
Rabbit brush, 2-1, 3-12, 3-13, 4-38, 4-39
Raccoons, 4-36, 4-38
Radiological substances, 4-14

Rainfall, 4-7, 4-12, 4-13, 4-74, 4-75, 4-124, 5-98, 5-100, 5-101, 5-103, 5-104, 8-6
Reach 1, ES-6, 3-17, 3-20, 3-23, 3-25, 3-27
Reach 2, 3-16, 3-19, 3-20, 3-22, 3-23, 3-25, 3-27, 5-8, 5-99, 5-100
Reach 3, 3-16, 3-19, 3-22, 3-25, 3-27, 5-13
Reach 4, 3-16, 3-19, 3-22, 3-25, 3-27, 5-99, 5-100, 5-102
Reach 5, ES-6, 3-15, 3-19, 3-22, 3-24, 3-27, 5-8, 5-11, 5-12, 5-13, 5-15
Reach 6, ES-6, 3-14, 3-15, 3-18, 3-21, 3-24, 3-26, 5-3
Reach 7, 3-14, 3-18, 3-21, 3-24, 3-26, 5-3
Reaches 9 and 8, 3-14, 3-18, 3-24
Recreation, ES-1, 2-2, 2-4, 3-40, 3-43, 3-45, 3-47, 4-14, 4-37, 4-71, 4-112, 4-113, 4-115, 4-116, 4-117, 4-118, 4-119, 5-70, 5-76, **5-83, 5-84,** 8-5, 9-1, 11-1
Recreational options
Option A, 3-46
Option B, 3-46
Option C, 3-46
Recreationists, 5-66, 5-76, 5-99, 5-100, 5-101, 5-103, 5-105
Recyclable materials, 4-127, 13-10
Red Mountain, 3-46, 4-25, 4-55, 4-59, 4-63, 4-64, 4-69, 4-70, 4-96, 4-115, 5-56, 13-4, 13-6
Red Mountain site, 4-59
Red-tailed hawk, 4-32, 4-33, 4-40
Red-winged blackbird, 4-34
Regulation 200-2-2, 2-5
Regulatory compliance, 2-4
Resource Conservation and Recovery Act (RCRA), 2-8, 4-126, 14-3
Rio Salado Oeste Project, 2-3
Rio Salado Project, 2-3, 4-115
Riparian habitat, 1, 2-1, 2-2, 2-8, 3-9, 3-40, 4-9, 4-11, 4-14, 4-21, 4-28, 4-32, 4-33, 4-34, 4-41, 4-45, 4-46, 4-48, 4-49, 4-107, 4-108, 4-109, 4-113, 5-36, 5-37, 5-40, 5-41, 5-43, 5-44, 5-46, 5-47, 5-57, 5-83, 5-84, 11-1, 11-3, 13-7
River bottom (RB), 3-11, 3-13, 4-30, 4-38, 4-42, 5-20, 5-21, 5-24, 5-25, 5-28, 5-31, 5-32, 5-34
Roadway segment level of service, vii, 4-96
Rohrig School, 4-61
Roosevelt Lake, 4-8
Russian thistle, 4-40
Saguaro, 4-30, 4-34, 4-47, 4-49
Saguaro Lake, 4-8, 4-114
Salt River, vi, vii, ix, x, xii, 1, 2-1, 2-2, 2-3, 3-10, 3-12, 3-13, 3-14, 3-15, 3-16, 3-17, 3-19, 3-22, 3-24, 3-40, 4-1, 4-3, 4-4, 4-7, 4-8, 4-9, 4-10, 4-11, 4-12, 4-13, 4-14, 4-15, 4-16, 4-17, 4-18, 4-21, 4-23, 4-24, 4-25, 4-26, 4-28, 4-32, 4-33, 4-34, 4-35, 4-36, 4-37, 4-38, 4-40, 4-44, 4-45, 4-46, 4-47, 4-48, 4-49, 4-51, 4-54, 4-55, 4-57, 4-58, 4-59, 4-60, 4-61, 4-62, 4-65, 4-68, 4-69, 4-70, 4-71, 4-72, 4-73, 4-85, 4-86, 4-95, 4-97, 4-100, 4-102, 4-104, 4-107, 4-112, 4-113, 4-115, 4-116, 4-119, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-128, 5-53, 5-57, 5-83, 5-84, 5-85, 5-99, 7-1, 7-2, 7-3, 7-4, 8-3, 9-1, 10-1, 11-1, 11-3, 13-1, 13-2, 13-4, 13-5, 13-6, 13-7, 13-8, 13-9, 13-10, 14-3
Salt River Pima-Maricopa Indian Community (SRPMIC), xii, 1, 7, 1, 2-2, 2-4, 3-7, 3-17, 3-20, 3-40, 3-43, 3-47, 4-28, 4-52, 4-62, 4-65, 4-66, 4-67, 4-70, 4-71, 4-73, 4-95, 4-97, 4-101, 4-103, 4-104, 4-105, 4-112, 4-113, 4-116, 4-123, 4-124, 4-125, 4-127, 5-8, 5-9, 5-52, 5-54, 5-55, 5-75, 5-84, 5-85, 5-98, 5-100, 5-101, 5-103, 5-104, 6-1, 7-2, 7-4, 8-6, 10-1, 11-1, 11-2, 11-3, 14-3
Salt River Project (SRP), 2-1, 3-24, 4-8, 4-11, 4-16, 4-24, 10-1, 13-1, 13-9, 14-3
Salt River Valley, x, 4-1, 4-3, 4-4, 4-7, 4-12, 4-13, 4-14, 4-18, 4-34, 4-54, 4-55, 4-58, 4-59, 4-60, 4-65, 4-68, 13-4, 13-6, 13-9
Saltbush, 4-38, 4-40
Saltcedar, ES-1, 4, 3-10, 4-11, 4-30, 4-33, 5-36, 5-49
San Carlos Lake, 4-8
Sand and gravel mining, 2-1, 4-23, 4-69
Santan Mountains, 4-14
Sawik Terrace, 4-60, 4-61
Scoping, 2-4, 11-2
Public scoping meetings, 11-2
Section 401, xi, 2-4, 2-6, 4-23, 4-26
Sedentary period, 4-56, 4-65
Sediment removal, 3-10, 5-6, 5-39, 5-42, 5-45, 5-50, 8-3
Seismic zone map of the contiguous states, 4-5
Sensitive noise receptors, 4-84
Short-term impacts, 4-79, 5-2, 5-37, 5-38, 5-39, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-47, 5-49, 5-50, 5-56, 5-57, 5-58, 5-72, 5-83, 7-4
Side-blotched lizard, 4-34, 4-35

Sky Harbor International Airport, 4-7, 4-26, 4-58, 4-74, 4-83, 4-102, 5-67, 5-74, 13-2
Snaketown, 4-55, 4-57, 4-64, 13-3
Social and economic resources, 2-4, 4-86, 5-72, 5-73, 7-4
Solid waste landfills, 4-122, 4-123
Sonora earthquake, 4-6
South Canal, 3-46, 4-9, 4-59, 4-63
Southern basin and range physiographic province, 4-1
Southwestern willow flycatcher, xii, 2-2, 4-34, 4-36, 4-43, 4-45, 4-46, 4-48, 4-49, 4-52, 5-36, 5-38, 5-39, 5-41, 5-42, 5-44, 5-45, 5-47, 5-48, 5-49, 5-50, 8-3, 9-1, 13-9
Sparrows, 4-32, 4-37
Spotted sandpiper, 4-36
State of Arizona Water Quality Revolving Assurance Fund (WQARF), 4-16
State parks, 4-114
Stewart Mountain Dam, 4-8
Stormwater Pollution Prevention Plan (SWPPP), 4-22, 5-7, 8-2
Stormwater runoff, 4-19, 4-21, 4-22
Striped skunk, 4-40
Study area, defined, xii, 1, 2-1, 2-2, 2-3, 2-7, 3-13, 3-40, 4-1, 4-3, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9, 4-10, 4-12, 4-21, 4-23, 4-24, 4-28, 4-32, 4-33, 4-34, 4-35, 4-36, 4-37, 4-38, 4-39, 4-40, 4-43, 4-44, 4-45, 4-46, 4-47, 4-48, 4-49, 4-50, 4-51, 4-61, 4-68, 4-69, 4-70, 4-74, 4-75, 4-78, 4-80, 4-82, 4-83, 4-84, 4-85, 4-86, 4-87, 4-88, 4-90, 4-93, 4-94, 4-95, 4-97, 4-102, 4-104, 4-105, 4-106, 4-107, 4-109, 4-113, 4-115, 4-116, 4-120, 4-121, 4-122, 4-123, 4-126, 4-127, 5-5, 5-18, 5-37, 5-38, 5-41, 5-42, 5-44, 5-45, 5-47, 5-50, 5-57, 5-66, 5-67, 5-70, 5-84, 5-99, 5-100, 5-101, 5-103, 5-105, 7-2, 7-3, 9-1, 11-1, 13-3
Subsidence, 4-6
Sun Circle Trail, 4-113, 4-114
Superfund Amendment and Reauthorization Act (SARA), 4-121, 14-3
Superfund sites, 4-16, 4-121, 4-122, 14-1, 14-3
Surface water, ES-1, 3-7, 3-9, 3-12, 3-14, 3-15, 3-16, 3-17, 3-18, 3-19, 3-21, 3-22, 3-24, 3-25, 3-27, 4-14, 4-15, 4-16, 4-17, 4-23, 4-26, 4-77, 5-8, 5-9, 5-11, 5-13, 5-15, 5-97, 5-99, 5-101, 5-102, 5-104, 8-2, 10-1, 14-7, 14-8
Talley Industries, 4-83
Tempe Butte, 4-13, 4-58
Tempe Town Lake, 4-115
Tertiary period, 4-1, 4-3
Theodore Roosevelt Dam, 4-8, 4-9
Threatened and endangered species, xii, ES-1
Title III, 4-79, 4-80, 4-121
Tobacco, 4-39
Tolleson, 4-21
Total dissolved solids (TDS), 4-15, 4-16
Total maximum daily load (TMDL), 4-26, 14-3
Toxic air contaminants (TACS), 4-79, 14-9
Traffic, 3-41, 4-38, 4-82, 4-85, 4-91, 4-93, 4-96, 4-101, 4-102, 5-66, 5-70, 5-71, 5-75, 5-76, 5-77, 5-78, 5-79, 5-80, 5-81, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 7-3, 7-4, 9-1, 14-2, 14-5, 14-7
Trail amenities, 3-40
Trail visitation rates, 3-42
Transportation, 2-4, 4-4, 4-31, 4-35, 4-58, 4-80, 4-91, 4-93, 4-95, 4-102, 4-108, 4-116, 4-118, 4-126, 5-75, 13-9, 14-3
Treatment, storage, and disposal facilities (TSD), 4-126
Tree lizard, 4-34
Tree swallow, 4-34
Tres Rios Project, 2-3
Triangle bursage, 2-1, 3-12, 4-68
Tri-City Landfill, ES-12, 3-16, 3-19, 3-22, 3-25, 3-28, 3-29, 3-30, 3-31, 3-32, 3-35, 3-36, 3-39, 4-123, 4-124, 5-96, 5-97, 5-99, 5-100, 5-102
Tule, 3-12, 4-35
U.S. Army Corps of Engineers (Corps), 1, 2, ix, xii, 1, 7, 1, 2-3, 2-5, 2-6, 2-7, 2-8, 3-9, 3-13, 3-21, 3-41, 3-43, 3-44, 3-45, 3-47, 4-1, 4-7, 4-9, 4-10, 4-11, 4-12, 4-24, 4-25, 4-26, 4-28, 4-41, 4-51, 4-52, 4-70, 4-78, 4-79, 4-81, 4-105, 4-108, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-52, 5-53, 5-54, 5-55, 5-61, 5-62, 5-70, 5-76, 5-84, 5-97, 5-98, 6-1, 7-2, 8-1, 8-2, 8-3, 8-4, 8-5, 8-6, 11-1, 11-2, 11-3, 13-4, 13-5, 13-7, 14-1
U.S. Bureau of Reclamation (USBR), 4-12, 4-13, 4-24, 14-3
U.S. Fish and Wildlife Service, 2-5, 2-7, 4-50, 4-51, 4-52, 14-3, 14-8
U.S. Geological Survey (USGS), 4-7, 4-9, 4-12, 4-16, 4-17, 4-21, 13-8, 14-4
Unavoidable significant impacts, 6-1
Upper alluvial unit (UAU), 4-12, 14-3

Usery Mountains, 4-60, 4-70, 4-113
Va Shly'ay Akimel, 1, 2, vi, vii, xi, xii, 1, 2-2, 2-3, 3-14, 3-16, 4-1, 4-3, 4-5, 4-7, 4-28, 4-30, 4-41, 4-43, 4-44, 4-62, 4-68, 4-70, 4-80, 4-82, 4-83, 4-85, 4-87, 4-95, 4-102, 4-104, 4-113, 4-115, 4-116, 4-120, 4-127, 5-60, 5-76, 5-86, 5-87, 5-88, 5-89, 7-1, 7-3, 7-5, 11-3, 13-5, 13-7, 13-8
Va shly'ay Akimel hydraulic sediment analysis, 3-14, 3-16
Vector control, 13, 3-8, 3-9, 4-121, 4-127, 5-39, 5-42, 5-45, 5-50, 5-96, 5-98, 5-100, 5-101, 5-103, 5-104, 8-6, 13-9
Vegetation, xii, 1, 2, 12, 2-1, 2-3, 6, 3-7, 3-8, 3-9, 3-10, 3-11, 3-12, 3-13, 3-14, 3-15, 3-16, 3-18, 3-19, 3-20, 3-21, 3-22, 3-24, 3-25, 3-26, 3-28, 3-29, 3-30, 3-31, 3-32, 3-33, 3-34, 3-35, 3-36, 3-37, 3-38, 3-39, 4-11, 4-25, 4-28, 4-32, 4-33, 4-35, 4-37, 4-38, 4-39, 4-40, 4-41, 4-44, 4-50, 4-68, 4-69, 4-70, 4-72, 4-107, 4-108, 4-111, 4-116, 5-2, 5-3, 5-4, 5-6, 5-8, 5-10, 5-12, 5-14, 5-16, 5-18, 5-36, 5-37, 5-38, 5-39, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-47, 5-49, 5-53, 5-57, 5-58, 5-60, 5-77, 5-78, 5-79, 5-80, 5-81, 5-96, 5-97, 5-99, 5-100, 5-103, 6-1, 8-1, 8-3, 9-1, 10-1, 10-2, 11-1, 11-3, 13-2, 14-5, 14-8
Vegetation planting palettes, ES-1
Vehicle trips, 5-59, 5-60, 5-70, 5-74, 5-76
Velvet mesquite, 1, 2-1, 3-11, 3-12
Verde fault, 4-5
Verde River, 4-7, 4-8, 4-9, 4-17, 4-46, 4-48
Verdin, 4-34, 4-35, 4-38
Visitation rates for cultural center, 3-45
Volatile organic compounds (VOCS), 4-14, 14-9
Waddell Dam, 4-8
Wastewater, 1, 3-7, 4-16, 4-120, 5-9, 13-9, 14-4, 14-6
Wastewater treatment plants (WWTPS), 4-16
Water distribution system for irrigation, ES-1
Water quality, 2-6, 3-9, 3-13, 3-16, 3-25, 3-28, 3-29, 3-30, 3-31, 3-32, 3-35, 3-36, 3-39, 4-7, 4-14, 4-16, 4-17, 4-22, 4-23, 4-24, 4-26, 4-27, 4-109, 5-5, 5-7, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-96, 5-97, 5-99, 5-100, 5-102, 5-104, 7-2, 7-5, 8-3, 13-5, 13-7
Water Quality Technical Committee (WQTC), 4-17, 4-20, 13-7
Waters of the United States, 2-6, 4-23, 4-26, 4-27, 5-39, 5-40, 5-42, 5-45, 5-48, 5-50, 8-3, 14-6, 14-9
West Salt River Valley (WSRV), 4-12, 13-8
Western diamondback rattlesnake, 4-34, 4-35
Western harvest mouse, 4-34
Western kingbird, 4-34
Western sandpiper, 4-36
Western screech owl, 4-33
Western whiptail, 4-34, 4-35
Western yellow-billed cuckoo, 4-33, 4-34, 4-43, 4-48, 4-49, 5-38, 5-41, 5-44, 5-47, 5-49, 5-50
Wetland (WT), ES-1, 2-1, 6, 3-9, 3-14, 3-15, 3-16, 3-17, 3-19, 3-21, 3-22, 3-23, 3-25, 3-34, 3-35, 3-37, 3-39, 4-28, 4-35, 4-36, 4-41, 4-42, 4-44, 4-51, 5-2, 5-8, 5-11, 5-12, 5-36, 5-38, 5-41, 5-44, 5-47, 5-49, 5-57, 5-58, 10-1, 11-1, 11-3, 13-5
Wetland marsh, ES-1, 2-1
White (ethnic caucasian), 4-87
White bursage, 4-30, 4-34
White-throated woodrat, 4-34
White-winged dove, 4-32, 4-35
Wildlife habitat, xii, ES-1, 3-13, 4-32, 4-33, 4-35, 4-36, 4-72, 4-107, 4-108, 4-109, 4-110, 4-114, 4-116, 4-118, 5-18, 5-84, 7-5
Yellow paloverde, 4-34
Yellow warbler, 4-34
Yellow-rumped warbler, 4-34
Yuma clapper rail, xii, 2-2, 4-34, 4-36, 4-43, 4-45, 4-46, 4-48, 4-49, 4-52, 5-36, 5-38, 5-39, 5-41, 5-42, 5-44, 5-45, 5-47, 5-48, 5-49, 5-50, 8-3, 9-1, 13-9

Appendix A

Section 404(b)(1) Evaluation and ADEQ Support Letter

APPENDIX A. CLEAN WATER ACT, SECTION 404(b)(1) COMPLIANCE EVALUATION

I. INTRODUCTION

This appendix evaluates compliance of the recommended plan (preferred alternative), Alternative O, with the Guidelines established under the Federal Pollution Control Act (Clean Water Act) Amendments of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), legislation collectively referred to as the Clean Water Act.

The Clean Water Act sets national goals and policies to eliminate the discharge of water pollutants into navigable waters. Any discharge of dredged or fill material into waters of the U.S. by the Corps requires a written evaluation that demonstrates that a proposed action complies with the guidelines published at 40 CFR Part 230. These guidelines, referred to as the Section 404(b)(1) Guidelines or "Guidelines," are the substantive criteria used in evaluating discharges of dredged or fill material under Section 404 of the Clean Water Act.

Fundamental to the Guidelines is the precept that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern."

The procedures for documenting compliance with the Guidelines include the following:

- Examining practicable alternatives to the proposed discharge that might have fewer adverse environmental impacts, including not discharging into a water of the U.S. or discharging into an alternative aquatic site
- Evaluating the potential short- and long-term effects, including cumulative effects, of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment.
- Identifying appropriate and practicable measures to mitigate the unavoidable adverse environmental impacts of the proposed discharge
- Making and documenting the Findings of Compliance required by §230.12 of the Guidelines.

This Clean Water Act, Section 404(b)(1) evaluation of compliance with the Guidelines is not intended to be a "stand alone" document; it relies heavily on information provided in the environmental impact statement (EIS) to which it is attached.

II. PROJECT DESCRIPTION

A. Authority: This study has been conducted under two separate authorities provided by Congress. The first and most recent authority is provided by House Resolution 2425 (HR 2425), dated May 17, 1994. HR 2425 states:

> The Secretary of the Army is requested to review reports of the Chief of Engineers on the State of Arizona...in the interest of flood damage reduction, environmental protection and restoration and related purposes.

The second authority is given in Public Law 761, 75th Congress, known as Section 6 of the Flood Control Act of 1938. This authority, dated June 28, 1938, states:

> The Secretary of War (now Secretary of the Army) is hereby authorized and directed to cause preliminary examinations and surveys . . . at the following localities: . . . Gila River and tributaries, Arizona.

B. Project Purpose and Need. The purpose of the project is to restore ecosystem functions and processes to improve overall ecological health and return the project area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species, and produce a viable, self-sustaining ecosystem that would require only minimal ongoing human intervention.

The Salt River was once a perennial watercourse in the project area, characterized by meandering flows throughout the river system. Scour-and-fill events have degraded the river bed in some areas and caused elevations to increase in other areas. The scour-and-fill transportation of sediment has produced numerous thick deposits within the fluvial system: cobble lag surfaces, sand sheets (macro-forms), channel sidebars, mid-channel bars, point bars, and overbank deposits. Channel shifts have distributed alluvial material across the entire width of the floodplain. Many of these deposits, however, have been disturbed by intensive sand and gravel mining. Flood control, in-river mining, and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological and sediment transport regimes. This alteration, as well as increased agricultural development and urbanization of the metropolitan Phoenix area, have eliminated almost most of the native cottonwood-willow, mesquite bosque, freshwater marsh, and willow woodland habitat types. Within the study area, the river is now a highly disturbed riverbed with minimal native vegetation.

Without restoration, habitat values in the study area are expected to further decline within the next 50 years. This will decrease the overall habitat value for wildlife and reduce potential habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, and other sensitive species.

This project is needed to provide an ecological connection between other riparian restoration projects that are currently underway along the Salt River. Additionally, there is a substantial need for additional recreation areas within the Phoenix metropolitan area. Restoration of the

area may provide new passive and active recreational opportunities by increasing the area of open space that is available to recreationists.

C. Location: The Salt River, a tributary of the Gila River, flows west into the Phoenix basin from the Superstition and Goldfield mountain ranges. The study area is located in Maricopa County, Arizona, and includes portions of the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. The approximately 17,435 acre-study area is approximately 2 miles wide and 14 miles long, extending east and west along the Salt River from the Pima Freeway (Loop 101) upstream to Granite Reef Dam

D. General Description: An initial array of 16 alternatives (including the No-Action Alternative) was developed by the Corps and the local sponsors (Salt River Pima-Maricopa Indian Community [SRPMIC] and the City of Mesa) during the alternatives formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water source, infrastructure). Alternatives were initially developed based on the Corps' federal planning objectives for water resource projects, specific planning objectives developed for the Va Shly'ay Akimel Ecosystem Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local and regional agencies.

After formulation and refinement of the project alternatives, alternatives were ranked and screened based on associated habitat benefits and implementation costs. The Hydrogeomorphic (HGM) wetland assessment method was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The HGM method assesses and quantifies the functional values of existing wetland habitat types (e.g., water storage, plant community characteristics) and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives.

Results of the HGM assessment were incorporated into the Corps' standard cost evaluation analysis (ICA) to identify the alternatives that provided the highest habitat benefits per unit cost.

The construction alternatives are Alternative F, Alternative N, Alternative O, Alternative E and Alternative A. The following ecorestoration and flood control features are common to all construction alternatives:

- construction of vegetated habitat
- eradication of saltcedar (*Tamarix* spp.)
- ground reshaping to alter significant features (e.g., reshaping the old Gilbert quarry to create new river bottom), install irrigation systems, or create topographic conditions needed to establish plantings
- Use of supplemental water sources, such as irrigation, groundwater, and/or effluent from the City of Mesa Wastewater Treatment Facility

- Water distribution systems (canals, diversion structures, etc.)

Project alternatives differ primarily in the types and amounts of vegetation types that would be created, the amount of flood protection provided, the extent of structural components, and the amount of site alteration that would occur. Project features would be constructed both in and adjacent to the river channel.

Operation and maintenance (O&M) activities will be needed for all alternatives after the project is constructed in order to keep project features functioning as designed. These activities may include:

- maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features;
- vector control;
- environmental monitoring; and
- periodic dredging to remove sediment deposited by floods; surface reshaping, or replanting of project features damaged by flood events.

III. PROJECT ALTERNATIVES

Section 230.10 of the Guidelines dictates that, except as provided under §404(b)(2), "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have significant adverse environmental considerations."]. While the NEPA process, through the EIS, extensively examines alternatives and discloses all of their environmental impacts, the 404(b)(1) Evaluation focuses on the impacts of alternatives to the aquatic ecosystem. The Guidelines require choosing for implementation the practicable alternative that has the least damage to the aquatic ecosystem, assuming that this alternative has no significant adverse environmental impacts to other components of the environment, such as endangered species that occupy upland habitat. A "practicable alternative" is defined as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."

The Guidelines also require that "where the activity associated with a discharge which is proposed for a special aquatic site does not require access or proximity to or siting within the special aquatic site in question to fulfill its basic purpose (i.e., is not "water dependent"), practicable alternatives that do not involve special aquatic sites are presumed to be available, unless clearly demonstrated otherwise." The basic purpose of this project—to produce a viable, more natural riparian ecosystem in this portion of the Salt River—is water dependent, since the project purpose cannot be fulfilled outside the river.

The Guidelines further specify that where a discharge is proposed for a special aquatic site, all practicable alternatives to the proposed discharge that do not involve a discharge into a special aquatic site are presumed to have less adverse impact on the aquatic ecosystem, unless clearly

demonstrated otherwise. Fresh water emergent wetlands are the only special aquatic site type in the project area. Although the project would not reduce the acreage of wetlands in the Salt River, these wetlands may be temporarily disturbed by construction activity. Since the project would increase the long-term functional value of the wetlands as well as the riparian areas of this ecosystem and these elements are physically adjacent as well as functionally interrelated, alternatives that do not temporarily impact wetlands would provide fewer long-term improvements in wetland and riparian habitat function.

For the purpose of a 404(b)(1) alternatives analysis, practicable alternatives[1] include:

- Offsite alternatives—i.e., discharges of dredged or fill material at other locations in waters of the United States.
- On-site alternatives—these include project designs that do not involve a discharge of dredged or fill material into waters of the United States as well as project designs that have different impacts to waters of the U.S.

OFF-SITE ALTERNATIVES

The location of this project was chosen based upon the availability of a large contiguous segment of the river corridor, the support of local sponsors, the proximity and contiguity of other restoration projects on the Salt River in the Phoenix metropolitan area and the technical feasibility of constructing a project at this location. The Va Shly'ay Akimel project is one of four ecosystem restoration projects that are at various stages of development by the Corps and local sponsors along the Salt River downstream from Granite Reef Dam. The Rio Salado project, just downstream from Va Shly'ay Akimel is currently under construction. The Rio Salado Oeste project is immediately downstream of the Rio Salado project and is currently on a parallel feasibility study schedule with Va Shly'ay Akimel. The Tres Rios project, just downstream from Rio Salado Oeste, is currently in the design stage. The proposed project location will provide an almost continuous series of habitat restoration projects from the most downstream dam on the Salt River (Granite Reef Dam) to the confluence of the Salt River with the Gila River (EIS, Figure 2.4-1). The nearest other potential location for a Salt River restoration project would be upstream of Granite Reef Dam. Such a location would not be near or contiguous with the other restoration projects, does not currently have local sponsorship support and, because of the series of upstream dams and associated legal constraints to project design, would be much more difficult, if not impossible, to design as a functioning habitat restoration project. Off-site alternatives therefore are not practicable at this time.

ON-SITE ALTERNATIVES

The five construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose

[1] The no-action alternative in the meaning of "no project" alternative would not accomplish the project purpose. Therefore, although the no action alternative must be analyzed in the EIS, it is not considered a practicable alternative as defined in the Guidelines. It is not, therefore, included in the comparison of practicable alternatives.

to varying extents, with varying levels of benefits and varying adverse impacts to the aquatic ecosystem.

The types of O&M activities necessary would generally be the same for each alternative, although the level of effort for O&M activity would be proportional to the amount of new habitat created (i.e., Alternative A would require the least amount of O&M and Alternative F would require the greatest amount of O&M effort and associated cost).

The following is a summary of project elements for each alternative. In general, Alternative F entails the greatest amount of vegetative and structural work. Alternative N includes most of Alternative F's vegetation features but lacks most of its structural features. Alternative O differs from Alternative N in the amount of acres of each vegetation type being created. It has the same structural features of N. Alternative E provides more vegetation and structural features than Alternative A but fewer than Alternatives N, F, and O. Alternative A entails the least amount of work in waters of the U.S., but creates only Sonoran Desert vegetation and river bottom habitat types. These alternatives are described in greater detail in Chapter 3 of the EIS.

Alternative F includes:

- Channelization of portions of 16,500 linear feet of the Salt River.
- Bank stabilization (armoring or hardening) in portions of several reaches (not Reach 1).
- Grade control structure across Salt River channel at old Gilbert quarry.
- Reshaping old quarry (including Gilbert Quarry) and river channels.
- Construction of new drainage channels, irrigation diversions, and/or spillways.
- Creation of 701.1 acres of CW; 602.9 acres of river bottom, including wetlands; 808 acres of mesquite; and 266.4 acres of Sonoran desert scrub-shrub. Revegetation efforts include plantings on site of former Tri-City Landfill.
- Replacing invasive plant species with native species.

Alternative N includes:

- No channelization.
- No bank stabilization.
- Grade control structure across Salt River channel at old Gilbert quarry.
- Reshaping old quarry (including Gilbert Quarry) and river channels.
- Construction of new drainage channels, irrigation diversions, and/or spillways.
- Creation of 853.1 acres of CW; 331.8 acres of river bottom, including wetlands; 379.7 acres of mesquite; and 23.6 acres of Sonoran desert scrub-shrub. Plantings at Tri-City Landfill site limited to a narrow strip of CW along the north bank of the river, at the edge of the main channel.
- Replacing invasive plant species with native species.

Alternative O includes:

- No channelization.
- Grade control structure across Salt River channel at old Gilbert quarry.
- Reshaping old quarry (including Gilbert Quarry) and river channels.
- Construction of new drainage channels, irrigation diversions, and/or spillways.
- Creation of 883.41 acres of CW; 425.1 acres of river bottom, including wetlands; 379.7 acres of mesquite; and 23.6 acres of Sonoran desert scrub-shrub. Plantings at Tri-City Landfill site limited to a narrow strip of CW along the north bank of the river, at the edge of the main channel. Replacing invasive plant species with native species.

Alternative E includes:

- No channelization.
- Bank stabilization (armoring or hardening) in portions of several reaches (not Reach 1).
- No grade control structure across Salt River channel at old Gilbert quarry.
- Reshaping old quarry (including Gilbert Quarry) and river channels.
- Construction of new drainage channels, irrigation diversions, and/or spillways.
- Creation of 286.4 acres of CW; 340.8 acres of river bottom, including wetlands; 296 acres of mesquite; and 808 acres of Sonoran desert scrub. Revegetation efforts include mesquite plantings on site of former Tri-City Landfill.
- Replacing invasive plant species with native species.

Alternative A includes:

- No channelization.
- No bank stabilization.
- No grade control structure across Salt River channel at old Gilbert quarry.
- Reshaping Gilbert Quarry to create new river bottom.
- Construction of new drainage channels, irrigation diversions, and/or spillways.
- Creation of 152.3 acres of river bottom, including wetlands and 495.8 acres of Sonoran desert scrub-shrub. No plantings at old Tri-City Landfill site.
- Replacing invasive plant species with native species.

Table A-1 summarizes the acreages of different habitat types that would be created under each alternative in areas considered to be waters of the United States.

Table A-1. New Riparian Areas Associated With Each Construction Alternative

Increase in Habitat Acreage over No-Action Alternative Over 50-Year Life of Project	Alternatives				
	F	N	O	E	A
New Cottonwood-willow	701.1	853.1	883.4	286.40	0.0
New river bottom (includes wetlands)	602.9	331.8	425.1	340.80	152.3
New Buffer	0.0	0.0	0.00	0.0	0.0
Mesquite	558	379.7	379.7	296	0.0
New Open Water	0.0	0.0	0.0	0.0	0.0
New Sonoran Scrub-Shrub	266.4	23.6	23.6	808	495.8
Total acreage created	2189.7	1588.2	1711.8	1822.0	748.6

COMPARISON OF ALTERNATIVES

Alternatives F, N, and O would provide the greatest amount of the particularly desirable cottonwood-willow, river bottom, and mesquite vegetation categories: 1,923.3 acres, 1,564.6, and 1,688.2 acres, respectively. Alternative F, however, entails much more structural work in waters of the U.S. than Alternatives N and O and therefore has greater adverse impacts to waters of the U.S. The primary differences between N and O are in the number of acres of each type of habitat being created 1588.2 versus 1711.8 respectively. N and O are similar in the amount of work entailed in waters of the U.S and thus are similar in the level of adverse impacts; however, Alternative O creates more of the desirable vegetation and habitat. Thus, Alternative O is considered the least environmentally damaging practicable alternative that meets the objective of the purpose and need for this project. This alternative provides the best combination of habitat restoration and cost and creates ecosystem benefits that far exceed the short-term effects to jurisdictional waters, and will have insignificant adverse environmental impacts to the surrounding ecosystem.

IV. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations

1. Substrate Elevation and Slope: The study area includes river channel and overbank areas. Topographic relief is generally very low to flat (0-2% slopes), ranging from an elevation of 1,300 feet in the Salt River bed at Granite Reef Dam at the upstream (east) end of the area,

gently sloping down to about 1,175 feet at the downstream (west) end. In the eastern portion of the project, low hills of the Usury Mountains form the banks and uplands south of the Salt River, and rise to 50 to 150 feet above the riverbed. The highest of these, Schlechts Butte on the southeast side of Granite Reef Dam, rises to 1,798 feet. The lower flanks of Mount McDowell extend into the northeast corner of the project area, where they rise about 100 feet above the riverbed at Granite Reef Dam.

Reshaping the river bottom and regrading to create areas suitable for supporting the desired vegetation will require changing the elevation and slope of the river channel and banks at many locations. The substrate of the river bottom will be permanently altered as a result. Materials will be discharged into waters of the U.S. in order to install some of the water distribution and irrigation systems, fill and reshape the abandoned Gilbert quarry, build a grade control structure, complete bank hardening and reshape the channel area to create wetlands or otherwise prepare the surface for planting. Construction will consist of native alluvial soils from the project area. No dredged or fill materials will be imported into the project site as part of this project. Any excess excavated materials will be transported from the project site. Offsite disposal of excavated materials would consist of either recycling, providing overburden to nearby gravel operators or, if required, transporting materials to an appropriate landfill.

Channel reshaping and vegetation planting activities have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. As part of the project planning process, the Corps conducted modeling (HEC-RAS) to analyze changes in hydraulic conditions associated with implementation of the project alternatives. Initial hydraulic modeling conducted for Alternative O demonstrated that an increase in the water elevation was likely to occur due to placement of vegetation within the active area of conveyance. Based on the modeling results, modifications were made to the alternative to increase the low flow channel in the lower and middle project reaches and offset increases in water surface elevation associated with the plantings.

2. Sediment Type: The soils in the vicinity of the river channel in the study area belong to the Hyperthermic Torrifluvents association, a group of well-drained to excessively well-drained soils that are found on nearly level or gently sloping surfaces. The texture of the surface layer ranges from gravelly sand or very gravelly sand to fine sandy loam. The material beneath the surface layer is very gravelly sand to very fine sandy loam or loam. Terraces above the river channel consist of thick, well cemented to non-cemented sand and gravel the terraces form gently sloping (0-2%), undulatory surfaces of low relief. Exposed bedrock is present near Granite Reef Dam, at the upstream end of the project area.

Reshaping will include moving soil to fill depressions or remove unwanted mounds as well as creating new river bottom from the old Gilbert quarry. Where existing sediments are used, sediment types will not be changed by the project. However, soils different from existing sediment types will be used in various areas to provide the necessary environment for new vegetation. Clay, mixed gravel, and cobble layers will be placed in areas of proposed wetland habitats.

3. Dredged/Fill Material Movement: Due to the limited flows of the Salt River system, substantial movement of the fill material from the locations in which it is placed for this project is expected to occur only under conditions of high flows. Operation and Maintenance (O&M) activities have been incorporated into the project to allow the removal or replacement of sediments to restore project features damaged by the transport of sediment. O&M activities will include repair work after major flooding events; dredging and reconstruction may be required in the restoration areas. This will temporarily change substrate elevations and compaction, as the substrate is restored to design configurations. Implementation of mitigation measure HWR-1 should minimize unintended movement of fill material (see paragraph 6).

The Surface Braided Irrigation Network (SBIN) will change the existing water runoff pattern, with consequent effects upon erosion and deposition within the channel. However, it is unlikely to cause functional changes in the river channel's current erosion and deposition patterns.

Continued quarrying at the Higley Plant has the potential to increase the rate of downstream sediment deposition in Reach 7, thereby decreasing the bedload material downstream in Reach 6. The lack of bedload material may affect the stability of the river channel in Reach 6. However, these potential changes are considered less than significant.

4. Physical Effects on Benthos: This project would affect portions of the river bottom to be excavated and/or filled during project construction. Site preparation for vegetation planting, channel excavation and reshaping, and the installation of grade control features as well as O&M activities such as sediment removal will result in soil disturbance and may cause temporary discharges of soil and sediment into the river channel. Soil discharged into the river channel may increase turbidity, stimulate algal growth, increase sediment deposition, and adversely affect aquatic organisms. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure HWR-1. In addition, benthic organisms (organisms that live at the bottom of a waterbody) are likely to occur in the project area only where there is permanent standing water, presently Reach 1 and Reach 9, which are the upstream and downstream limits of the project). The only measures that are proposed in waters of the U.S. at these locations are removal of invasive plants and possibly some new plantings. Any physical effects on benthos from these activities would be minor and temporary. If the project increases the amount of surface water in the project area, it may create new habitat for benthic organisms.

5. Other Effects: Project construction and restoration activities could result in accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents). Hazardous substances that enter the river channel could have temporary adverse effects on water quality and aquatic organisms. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2 (see paragraph 6).

6. Actions Taken to Minimize Impacts: Mitigation measures have been included in the EIS to reduce the magnitude of potential water quality effects described above. These include Mitigation Measures HWR-1, HWR-2, , and BR-3:

Mitigation Measure HWR-1: Implement Erosion Control Measures

The Corps and their contractors shall implement erosion control measures throughout the construction period and during implementation of O&M activities to minimize erosion and sediment input into the river. The Corps will oversee implementation of erosion control measures. The contractor selected for the project shall:

- conduct construction and O&M activities during the dry season;
- conduct all construction work in accordance with site-specific construction plans that minimize the potential for increased sediment inputs to the river;
- divert concentrated runoff away from channel banks;
- minimize vegetation removal;
- identify with construction fencing all areas that require clearing, grading, revegetation, or reshaping and minimize areas to be cleared, graded, reshaped or otherwise disturbed;
- grade and stabilize spoils and stockpile sites to minimize erosion and sediment input to the river;
- implement erosion control measures as appropriate to prevent sediment from entering the river channel or other watercourses to the extent feasible, including the use of silt fencing or fiber rolls to trap sediments and erosion control blankets to protect channel banks;
- mulch disturbed areas as appropriate and plant with appropriate species as soon as practicable after disturbance; and
- avoid operating equipment in flowing water by using temporary cofferdams or other suitable structures to divert flow around the channel and bank construction areas.

Mitigation Measure HWR-2: Implement Spill Prevention Measures

The Corps and their contractors shall prepare a spill prevention and response plan that regulates the use of hazardous and toxic materials, such as petroleum-based fuels and lubricants for construction equipment. The Corps will oversee development and implementation of a stormwater pollution prevention plan. Elements of the plan will ensure that:

- workers are trained to avoid and manage spills;
- construction and maintenance materials are prevented from entering the river channel;
- all spills are cleaned up immediately and appropriate agencies are notified of any spills and of the cleanup procedures employed;
- staging and storage areas for equipment, materials, fuels, lubricants, solvents, and other possible contaminants are located at least 100 feet away from the river's normal high-water area;
- vehicles are removed from the river's normal high-water area before refueling or lubricating;

- vehicles are immediately removed from the work area if they are leaking; and
- equipment is not operated in flowing water (if necessary, suitable temporary structures can be installed to divert water around in-channel work areas).

Mitigation Measure BR-3: Minimize Disturbance to Waters of the United States

During O&M activities, care would be taken to minimize any necessary disturbance to waters of the United States and to ensure that such activities comply with the provisions of Section 404 of the Clean Water Act and its associated regulations.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Effect on Water: Irrigation water sources include the construction of one new groundwater well. Approximately 3,600 acre-feet/year will be pumped from this new well and diverted to planting areas through distribution channels or pipelines. Although groundwater in sufficient quantity is available to supply water wells within the project area, it is uncertain if the installation of a new well and the pumping of sufficient groundwater for irrigation purposes will affect flows in nearby wells. Additionally, the installation of new wells and the pumping of groundwater are restricted and require permits. This alternative will require development of institutional arrangements between the Corps and SRPMIC, City of Mesa or SRP and ADWQ. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-4.

Agricultural return flows, surplus agricultural water and stormwater runoff from the Hennessey and Evergreen Drains, groundwater from a new well, and discharge from local storm drains will be diverted into newly constructed distribution channels and pipelines for irrigation purposes. These water sources may contain contaminants (e.g., VOCs, metals, ions, nutrients, herbicides) that could have adverse effects on water quality and aquatic organisms. In general, because of their sources, irrigation return flows and surplus agricultural water are of relatively high quality and are suitable for use as irrigation for restoration plantings. However, because stormwater discharges represent runoff from urban, rural, and agricultural areas, water quality varies greatly based on land use and the magnitude, duration, and timing of storm events. Sediment and pollutants tend to accumulate between storm events and the highest concentrations of pollutants are often washed into rivers, creeks, and streams during "first flush" events. It is difficult to assess potential adverse effects on water quality associated with the use of stormwater for irrigation because only limited water quality data are available for the project area. A review of existing water quality data showed that storm water runoff exceeded applicable standards for five trace metals including total recoverable lead, and dissolved copper, cadmium, silver, and zinc (Knight Piésold 2003). Because of the lack of existing data related to stormwater quality, this impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-5.

Effects on Current Drainage Patterns and Circulation: The Surface Braided Irrigation Network (SBIN) will change the existing water runoff patterns and lateral migration of the channel will occur for events greater than 5-year events, but also allows for the most flexibility when

irrigating large areas of new vegetation and the ability to modify irrigation patterns to respond to changes in the project area. Additionally, it mimics the natural conditions and helps in the recruitment of other native species.

Effects on Normal Water Level Fluctuations: Channel reshaping and vegetation planting activities proposed under Alternative F have the potential to increase 100-year water surface elevations and increase the potential for flooding in the project area. As part of the project planning process, the Corps conducted modeling (HEC-RAS) to analyze changes in hydraulic conditions associated with implementation of the project alternatives. Initial hydraulic modeling conducted for Alternative O demonstrated increases in water surface elevations in the lower and middle project reaches (Reaches 3, 4, 5, and 6) associated with the establishment of cottonwood/willow and wetland vegetation in the main channel. Based on the modeling results, modifications were made to the alternative to increase the low flow channel in the lower and middle project reaches and offset increases in water surface elevation associated with the plantings.

4. Action Taken to Minimize Impacts: Unavoidable impacts will be minimized through implementation of Mitigation Measure HWR-5.

Mitigation Measure HWR-5: Conduct Additional Storm Water Quality Sampling and Analysis. The Corps will develop a storm water quality sampling plan and conduct sampling and analyses to identify potential contaminants and adverse effects on water quality associated with using storm water as an irrigation source for restoration plantings. If the analyses show that constituents exceed applicable water quality standards, the Corps will identify other irrigation sources or implement water quality improvement measures (e.g., detention basins, treatment swales).

C. Suspended Particulate/Turbidity Determinations at the Disposal Site

1. Expected Change in Suspended Particulate and Turbidity Levels in the Vicinity of Disposal Site: Short-term increases in suspended particulate and turbidity levels may occur during construction. However, no long-term effects are anticipated.

2. Effects on Chemical and Physical Properties of the Water Column: Project construction and restoration activities could result in accidental spills of fuel or other toxic materials associated with the operation of construction equipment (e.g., gasoline, oils, lubricants, solvents). Hazardous substances that enter the river channel could have temporary adverse effects on water quality and aquatic organisms. This impact is considered potentially significant but can be mitigated through the implementation of Mitigation Measure HWR-2.

3. Effects of Turbidity on Biota. Soil discharged into the river channel may increase turbidity and adversely affect aquatic organisms. This would be a potentially significant impact but can be mitigated through the implementation of Mitigation Measure HWR-1.

4. Actions Taken to Minimize Impacts: Unavoidable adverse impacts will be minimized through implementation of Mitigation Measures HWR -1 and HWR-2.

D. Contamination Determination: The project study area was evaluated to determine the potential for encountering hazardous materials and wastes in areas that would be disturbed during construction (see Sections 4.12 and 5.12 of the EIS). Buried materials found during construction will be evaluated and disposed of in accordance with local, state and federal regulations.

E. Effect on Aquatic Ecosystem and Organism Determination: Alternative O would result in a substantial increase in the cottonwood/willow, new river bottom (including freshwater marsh), and open water communities compared to future conditions without the project. It would result in the creation of 883.41 acres of cottonwood; 425.1 acres of river bottom, including wetlands; 379.7 acres of mesquite; and 23.6 acres of Sonoran desert scrub-shrublands. It would also entail the physical removal of non-native saltcedar habitat in areas where the new habitat cells would be created. With implementation of erosion control measures and other measures identified in the EIS, no significant adverse effects on the aquatic ecosystem or aquatic organisms are anticipated. The only existing special aquatic sites in the project area are wetland areas in Reach 1 and Reach 9, the upstream and downstream ends of the project. The only work proposed for these areas entails removal of invasive plant species and possible planting of desirable species. These activities would have a beneficial effect on the habitat value of the aquatic ecosystem.

On a long-term basis, habitat value in the region would increase substantially for common and sensitive wildlife species. The primary benefit would be to riparian-obligate bird species due to increases in cottonwood/willow and mesquite communities. There would also be a substantial increase in habitat for shorebirds and waterfowl associated with the constructed wetlands. In addition, it is anticipated that amphibian species would benefit from implementation of Alternative O, and that this alternative would increase foraging habitat for raptors and mammalian carnivores. A substantial increase in nesting and foraging habitat for the southwestern willow flycatcher, the western yellow-billed cuckoo, and the Yuma clapper rail is also anticipated. Finally, implementation of Alternative O is expected to increase potential habitat for the cactus ferruginous pygmy-owl and increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle.

Implementation of Alternative O would also result in substantial short-term impacts on vegetation. The major disruption would be to saltcedar habitat, which would be removed in some areas. There is also the potential for other communities to be indirectly disturbed during grading and restoration. This potentially significant impact will be mitigated through implementation of Mitigation Measure BR -1.

Mitigation Measure BR-1: Minimize Disturbance of Vegetation during Construction

During the final design of the project, disturbances to areas of existing vegetation that are not within the project footprint can be minimized through careful phasing of the project construction. Areas of desirable vegetation can be delineated on construction plans as areas that are not to be disturbed. Additionally, vegetation removal would occur outside of the spring breeding season (usually late January to early April) to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Long-term maintenance activities would be needed to maintain flood protection capacity and retain the habitat values of the restored vegetation. However, the O&M activities have the potential to adversely affect the restored habitat and sensitive species through noise, increased human activity, and physical disturbance of habitat for channel and drainage maintenance, vector control, sediment removal from restoration features, and removal of saltcedar regrowth. The greatest potential impact would be the necessary removal of sediment from the open water and marsh habitat. Although this activity is necessary to maintain the habitat, there would be short-term loss of marsh vegetation and potential loss of Yuma clapper rail habitat. This activity may also disturb nesting southwestern willow flycatchers in cottonwood/willow habitat by creating substantial noise. Other activities may also create short-term disturbances to this habitat. However, implementation of Mitigation Measure BR-2 would reduce these impacts to a less-than-significant level.

Mitigation Measure BR-2: Conduct Long-Term Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

Sediment removal activities and other activities would only be conducted during non-nesting periods of the southwestern willow flycatcher, the yellow-billed cuckoo, and the Yuma clapper rail. In the case of sediment removal, these activities would be conducted on a rotating basis so that no more that 25% of the marsh area would be affected in any one year.

Construction and restoration activities also have a potentially significant short-term impact on common wildlife species. Of particular concern is the disruption of nesting and nesting habitat for riparian-obligate species. Even saltcedar, the exotic weed species proposed for removal, provides some nesting habitat for these species. Noise and other construction activities may also tend to cause wildlife to avoid the area. Although the short-term effects would be considerable, with the exception of species protected under the Endangered Species Act the species that would be affected are locally abundant and would be displaced on temporarily. In addition, Mitigation Measure BR-1 for listed wildlife species would also have benefits for common wildlife in the project study area. Therefore, this is not considered a significant impact.

Construction activities would have a potentially significant impact on nesting or foraging habitat of the Yuma clapper rail. Suitable habitat is present adjacent to the Loop 101/Loop 202 interchange. However, surveys conducted in 2003 of the wetland habitat in this location did not detect the presence of clapper rails. Prior to construction, the Corps will reevaluate the suitability of vegetation communities located within the project area to support Yuma clapper rail and other threatened and endangered species. If suitable habitat has developed that was not part of the original Section 7 consultation, the Corps will coordinate with USFWS to determine the necessity of surveys.

F. Proposed Disposal Site Determinations: The area to be affected during construction of this project will be confined to the minimum area necessary to construct the project features. The project is expected to be in compliance with applicable water quality standards. Implementation of the proposed mitigation measures should ensure that adverse impacts to waters of the U.S. are minimized.

G. Determination of Cumulative Effects of Disposal of Fill on the Aquatic Ecosystem: With implementation of mitigation measures, this project will not significantly contribute to adverse cumulative effects on the aquatic ecosystem of the Salt River. It will, however, directly contribute to the cumulative beneficial effects on the aquatic ecosystem anticipated to result from implementation of this and other ecosystem improvement projects on the Salt River, including Tres Rios, Rio Salado Oeste and Rio Salado. Together with these other restoration efforts on the Salt River, this project may also have the indirect beneficial effect of encouraging the implementation of additional efforts to improve this aquatic ecosystem.

H. Determination of Indirect Effects of Disposal of Fill on the Aquatic Ecosystem: Indirect effects are effects that are associated with a discharge of dredged or fill material, but do not result from the actual placement of these materials. Such effects would potentially in include increases in flood potential or changes in wildlife communities in responses to changes in vegetation growing in filled areas. The indirect effects of this project are generally overwhelming environmentally beneficial. Adequate mitigation is provided for the adverse impacts that may occur.

IV. FINDING OF COMPLIANCE

A review of the proposed project indicates the following findings:

1. The discharge represents the least environmentally damaging practicable alternative and, if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to or be located in the aquatic ecosystem to fulfill its basic purpose.

X Yes ___ No

2. The activity does not appear to: (1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the Clean Water Act; (2) jeopardize the existence of federally listed endangered or threatened species or designated marine sanctuary.

X Yes ___ No

3. The activity would not cause or contribute to significant degradation of waters of the United States, including adverse effects on human health; life stages of organisms dependent on the aquatic ecosystem; ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values.

X Yes ___ No

4. Appropriate and practical steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem.

X Yes ___ No

Note: A negative response indicates that the proposed project does not comply with the guidelines.

On the basis of the guidelines, the proposed disposal site for the discharge of fill material is:

___ (1) Specified as complying with the requirements of these guidelines; or

X (2) Specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem; or

___ (3) Specified as failing to comply with the requirements of these guidelines.

Prepared by: _____

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Date: September 2004

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: **Draft Environmental Impact Statement Va Shly'ay Akimel, Draft Salt River Ecosystem Restoration Study**

ar Ms. Eckert:

e Arizona Department of Environmental Quality (ADEQ), Water Quality Division has viewed the Va Shly'ay Akimel Draft Environmental Impact Statement, submitted by the U.S. my Corps of Engineers (ACOE), for the proposed ecosystem restoration project of a 14-mile g, 2-mile wide reach of the Salt River extending from Granite Reef Dam to the Pima Freeway ate Route 101). The proposed ecosystem restoration project includes portions of the Salt ver Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa. The project is being posed in partnership with the SRPMIC and the City of Mesa, the non-federal sponsors.

e objective of the proposed project is to improve and increase native vegetation and overall dlife habitat values, and to provide a greater diversity of habitat for threatened and dangered species such as the Yuma clapper rail and southwestern willow flycatcher. idental benefits would include passive and active recreational opportunities, general provement in the aesthetic quality of the project area and a slight reduction in the potential for od damage.

e selected restoration plan consists of the following activities:

- Vegetative planting of cottonwood-willow, mesquite, wetland, Sonoran Desert scrub-shrub and river bottom.
- Saltcedar Eradication.
- Development of a water distribution system to deliver water (surface water, groundwater, or wastewater) from the source to the vegetated areas.
- Construction of grade control structures within the channel of the Salt River.

pproximately 2% of the total project area lies within the city of Mesa, the remainder or the oject area is within the SRPMIC (Indian Lands). Proposed activities within the city of Mesa limited to vegetative planting.

ie ACOE or the city of Mesa are responsible for obtaining all other permits certifications and enses that may be required by federal, state or local authorities. Other approvals include, but not limited to: construction activities and dewatering of construction site to a surface water dy (AZPDES Stormwater Permit), use of reclaimed wastewater for dust control or irrigation eclaimed Water Permit), and discharges to the 25-year floodplain of the Salt River or butaries to the Salt River (AZPDES Discharge Permit).

e have determined that the proposed Va Shly'ay Akimel Ecosystem Restoration Project should mply with State surface water quality standards. The Va Shly'ay Akimel project should not ve a negative impact upon the chemical, physical or biological integrity of the Salt River. We refore concur with the 404(r) exemption for State 401 Water Quality Certification of that rtion of the proposed project occurring within the city of Mesa.

ir concurrence with the 404(r) exemption for these activities does not affect or modify in any ty the obligations or liability of any person for any damages, injury, or loss resulting from an pacted area discharge. The Department may modify or withdraw its determination if the ormation relied upon is inaccurate or if the project is not implemented as proposed. If, in the ure, the Department determines that discharges from the activities have caused or contributed a violation of surface water quality standards, the Department may withdraw concurrence with 404(r) exemption and require an Individual 401 Certification for the project. This ncurrence is not intended to waive any other federal, state or local laws.

ncerely,

Andrew Cajero Travers
Surface Water Permits Unit

9/13/04
Date

: U.S. EPA, Wetlands Regulatory Office

PU04:0408

Appendix B

Monitoring and Adaptive Management Plan

APPENDIX B. MONITORING AND ADAPTIVE MANAGEMENT PLAN

1.0 INTRODUCTION

The Monitoring and Adaptive Management Plan (MAMP) is an essential element in the overall implementation of the proposed restoration plan. It provides a mechanism to evaluate the effectiveness of the restoration measures implemented in this project and to implement adaptive changes, if required, to realize project objectives. As outlined in EC 1105-2-210 (21.b.), the MAMP is intended to ascertain whether the project is functioning per project objectives; determine whether adjustments for unforeseen circumstances are needed; and/or evaluate whether changes to structures or their operation or management techniques are required.

This MAMP document describes:

- The restoration goals and objectives as described by plan formulation and HGM;
- The success criteria evaluation procedure;
- Data collection methods for success criteria evaluation;
- Reporting requirements of success evaluation; and
- Methods to promote future flexibility and contingency plans for adaptive management.

The MAMP covers Corps related monitoring and adaptive management actions during the first five years after initial project construction is complete. After the first five years, monitoring and/or adaptive management becomes the responsibility of the local sponsors (i.e., the Salt River Pima-Maricopa Indian Community [SRPMIC] and the City of Mesa). However, the local sponsors can use this plan to help guide monitoring efforts and refine the project features such that project goals and objectives are achieved.

The data collection methods described in this MAMP was taken from the HGM Appendix for this project and "A Guide to Hydrogeomorphic Models for Arizona's Arid Riverine Waters and Wetlands, Draft Model Report" prepared by the U.S. Army Corps of Engineers, Engineer Research and Development Center.

2.0 GOALS AND OBJECTIVES

The driving force of a Feasibility Study is the identification of the project's primary goals and objectives. These are determined in coordination with the local sponsor(s), and guide the eventual project feature design. The Va Shly'ay Akimel Ecosystem Restoration project covers a large land area, and is locally sponsored by both the SRPMIC and the City of Mesa, therefore, the stated goals and objectives cover more than one area of interest.

The biological goals and objectives of the ecosystem restoration project as stated in the EIS are:

- Restore the riparian ecosystem to the degree that it supports native vegetation and wildlife through the Salt River from immediately downstream of the Granite Reef Dam to the Pima Freeway (SR 101).
- Establish a functional floodplain in unconstrained river reaches of the study area that is ongoing and mimics the natural processes found in other naturalized riparian corridors in Arizona.

Other goals and objectives as stated in the EIS are:

- Provide passive recreation opportunities for visitors of all ages, abilities, and backgrounds that are in harmony with the SRPMIC's management of its culture and native ecology.
- Create awareness through ongoing educational opportunities of the significance of the cultural resources relating to the Salt River.
- Create awareness through ongoing educational opportunities of the significance of the Salt River ecosystem.
- Create awareness through ongoing educational opportunities of the ecological connection between other ongoing riparian restoration projects along the Salt River.

Once the biological goals and objectives were identified, habitat value goals were determined using HydroGeoMorphic Assessment of Wetlands (HGM). Performance targets were established for both the acreages of desired cover types, or partial wetland assessment areas (PWAAs), and the functional capacity index (FCI) of those habitats. A detailed discussion of the development of the HGM models and how they were applied in this project can be found in the HGM Appendix.

Table 1 details the quantitative performance targets for each PWAA while Table 2 details the qualitative performance targets listed by FCI function for each pre-selected Target Year (TY).

Table 1. Partial wetland assessment areas (PWAAs) used in Va Shly'ay Akimel Restoration project and their performance target acres.

PWAA Description	PWAA Code	Target Acreages	Notes
Existing Cottonwood-Willow Forests in Active Channel	CTWWFOR	63.0	Accept 10% loss of Existing CTWWFOR Acreage
Existing Mesquite Woodlands-on the Terraces and in Active Channel	MESQUITE	4.0	Preserve/Protect Existing Mesquite
Newly Developed Cottonwood-Willow Forests	NEWCWWFOR	150.0	Convert from SANDGRAVEL
Newly Developed Mesquite Woodlands on Terraces and in Active Channel	NEWMESQUIT	300.0	Convert from SANDGRAVEL, DESERT
Newly Developed River Bottom Areas within the Active Channel-Largely Unvegetated (Includes Emergents)	NEWRVRBOTM	75.0	Convert from SANDGRAVEL
Newly Developed Scrub-Shrublands in the Active Channel	NEWSCRUB	1000.0	Convert from SANDGRAVEL
Existing River Bottom Areas within the Active Channel-Largely Unvegetated (Includes Emergents)	RIVERBOTTOM	334.0	Accept no net loss of RIVERBOTTOM
Existing Scrub-Shrublands in the Active Channel	SCRUBSHRUB	2056.0	Preserve existing SCRUBSHRUB

Table 2. FCI function models and performance targets for Alternative O2.

Function	Alternative O2 Target Year FCIs			
	1	6	26	51
Function 1: Maintenance of Channel Dynamics	0.374	0.374	0.374	0.374
Function 2: dynamic Surface Water Storage/Energy Dissipation	0.551	0.563	0.588	0.589
Function 3: Long Term Surface Water Storage	0.292	0.292	0.292	0.292
Function 4: Dynamic Subsurface Water Storage	0.225	0.225	0.225	0.225
Function 5: Nutrient Cycling	0.237	0.384	0.495	0.568
Function 6: Detention of Imported Elements and Compounds	0.305	0.352	0.385	0.391
Function 7: Detention of Particles	0.453	0.462	0.484	0.485
Function 8: Maintain Characteristic Plant Communities	0.643	0.624	0.767	0.763
Function 9: Maintain Spatial Structure of Habitat	0.494	0.567	0.624	0.641
Function 10: Maintain Interspersion and Connectivity	0.527	0.644	0.669	0.681

The quantitative and qualitative performance targets established during plan formulation will be used as the measure of success; these values and habitat improvement predictions were the basis for determining which project alternative was most economically justified. These habitat values were also derived from measurable variables that were selected to be used in the HGM model and can therefore be measured again in the future.

3.0 SUCCESS CRITERA EVALUATION

A key to properly determining the success or failure of a project is the ability to measure a parameter repeatedly and consistently, over time and then compare these results to a quantitative target. The project FCI values and performance target acreages will be the primary parameters measured to determine whether the goals of this restoration effort are being achieved. The quantitative values, acres, can be easily assessed at target year 0 (immediately after construction) and target year 1 (one year post construction). If all habitat features are planted during the same construction phase, the acreage criteria can be met immediately post-construction. The habitat acreage, once planted, is not expected to increase significantly given the limiting factors outside of the project feature areas (lack of supplemental irrigation, poorly graded surface, etc.). Further, the habitat acreage would not be allowed to decrease significantly without adaptive management. However, the expected success criteria for habitat acreage could change during the preliminary engineering design (PED) phase for a variety of reasons. They include, but are not

limited to: 1) If construction takes place in distinct phases, it would eliminate the opportunity for all acres of any particular habitat to be planted during the same year, 2) project site conditions may change in such a way that a particular area is no longer conducive to a previously planned vegetation type, and 3) the vegetation acreages were planned using GIS maps and shape files, therefore, may not reflect the exact acreages found on the ground. Because of these limitations, acreage success will be determined by meeting 90% of the projected acreage in any given project reach and by achieving a vegetation survival rate of 80% or more. Eighty percent survival rate is within the range of other previously documented riparian restoration efforts with ample irrigation (Goldner, 1984; Jack et al., 2002; http://weather.nmsu.edu/nmcrops/riparian-vegetation/bosque/bosquie-%20revegetation.htm)

Functional Capacity Indices are derived from field measurements taken from several different variables. While the methods of this data collection will be clearly outlined, see "Methods" below, it is inevitable that some human induced variation in measurement technique will occur within each year's data collection. Therefore, it is unreasonable to expect the FCI values to match exactly for any given target year. To account for this variation, success will be determined by meeting 80% of the projected FCI value in any given target year for any given function.

4.0 METHODS

The following discussion is taken primarily from the HGM Appendix for this project. While the intent here is to capture enough detail to conduct the field and non-field sampling, the HGM Appendix should be used as a reference for further detail or clarification, if necessary.

4.1 Variables to be Sampled

The HGM model is derived from multiple FCI models that use a number of variables depending upon the particular HGM model used. In the Va Shly'ay Akimel instance, the Arizona Riverine HGM model used twenty-seven (27) different variables. Table 3 provides a brief description of each variable used in this HGM model.

Table 3. Variable names and descriptions used in the Va Shly'ay Akimel HGM Assessment.

Variable Code	Variable Description
AGSA	Algal Growth Surface Area as an indicator of past inundation.
BUFFCOV	Percent of native vegetation cover in the buffer.
BUFFLENGTH	Percent of area with sufficient buffer.
BUFFWIDTH	With of buffer (m).
CONTIG	Contiguous vegetation cover between waters/wetlands and uplands (%).
CWD	Abundance of dead and down woody debris ≥ 2.5" in diameter (coarse)
DECAY	The presence of coarse woody debris in various stages of decomposition.
DEPSATSED	Depth of saturated sediments (m).
FPA	Floodprone area as defined by the projection of a horizontal plane at a level twice the bankfull thalweg depth.
FREQ	Frequency of inundation.
FWD	Abundance of dead and down woody debris < 2.5" in diameter (fine).
HERB	Abundance as measured through vegetation volume of herbaceous species.
INVASIVES	Abundance of invasive species.
LANDUSE	Type of adjacent landuse.
LITTER	Abundance of leaf litter and other detrital matter in the FPA.
PORE	Soil pore spaces available for storing subsurface water. Performance is related to soil texture and permeability.
Q	Alterations of hydro-regime that affect the assessment area.
SED	Extent of sediment delivery to the water/wetland from culturally accelerated sources.
SHRUB	Abundance as measured through vegetation volume of shrubs (multiple stems, woody species).
SPECRICH	Species richness.
SUBIN	Subsurface flow into the water/wetland via interflow and return flow.
SURFIN	Surface inflow to the wetland via sheetflow.
TOPO	Macro (large scale) and microtopographic (small scale) relief. Macrotopography generally refers to large-scale features such as secondary channels and in-channel ponds. Microtopography generally refers to small-scale features such as pit-and-mound and hummock-and-hollow patterns.
TREE	Abundance as measured through vegetation volume of trees.
TRIB	Presence of connected tributaries.
VEGSTRATA	Number of vegetation layers present.
WIS	Wetland indicator score.

Not all variables are used in all FCI models, and some variables are used in more than one FCI model.

4.2 Sampling Protocol

The variables to be collected can be divided into two groups; data that can be collected with field sampling, and data that can be collected without field sampling. Data that required field sampling included those variables related to water quality, geochemistry, hydrology, fluvial geomorphology, substrate, flora, and fauna. Data that does not require field sampling includes information on historical conditions, landscape scale habitat conditions, land use characteristics, ownership, pattern of ownership and jurisdictional boundaries.

4.2.1 Variables Measured in the Field

Certain variables in the HGM require field sampling to quantify. A variety of methods are used to obtain such data; a brief description of the field sampling protocol follows.

The sampling team consisted of 4 individuals. Each team had one member experienced with HGM data collection. Other team members had expertise in a field related to the sampling effort. Each team had a designated recorder for the sampling day to record data reported by team members. Prior to sampling, observers standardized their estimates of cover with each other, discussed the kinds of species present, and discussed their impressions of the site. To minimize observer error, the same observers estimated the same components on all transects.

Table 4 provides a brief description of the protocols used in obtaining the field collected data:

Table 4. Protocols for field data collection for the Va Shly'ay Akimel Ecosystem Restoration Project.

Variable Code	Protocol Description
AGSA	Measure the percent of a 1m quadrat with algae, algal remnants, or water present.
BUFFCOV	Measure percent cover of native vegetation vs. bare ground and/or non-native vegetation within a 1m quadrat.
CWD	Dead and down woody debris larger than or equal to 2.5 " in diameter measured as class data: 0= No data 1= CWD 9-15% 2= CWD 6-8% 3= CWD >15% 4= CWD 1-2% 5= CWD 0-<1%, recoverable 6= CWD 0-<1%, unrecoverable
FWD	Dead and down woody debris smaller than 2.5" in diameter measured as class data: 0= No data 1= FWD 38-68% 2= FWD 25-37% 3= FWD >73% 4 =FWD 13-24% 5= FWD 3-12% 6= FWD 0-2%, recoverable 7= FWD 0-2%, unrecoverable
HERB	Record the number of decimeter hits within each meter interval. A hit is defined as any vegetation within a 10cm radius of the rod, per vertical decimeter. Estimate volume above 10m as either three or seven hits per interval. These estimations can be based on comparison with lower intervals where hits can be directly measured.
LITTER	Litter is measured by the percent of leaf litter or other detrital material in data classes: 0= No data 1= 28-46% litter cover 2= 18-27% litter cover 3= <46% litter cover 4= 9-17% litter cover 5= 2-8% litter cover 6= 0-1% litter cover, recoverable 7= 0-1% litter cover, unrecoverable
SHRUB	Record the number of decimeter hits within each meter interval. A hit is defined as any vegetation within a 10cm radius of the rod, per vertical decimeter. Estimate volume above 10m as

	either three or seven hits per interval. These estimations can be based on comparisons with lower intervals where hits can be directly measured. 0= No data 1= 2547-4245 stems/acre 2= 1698-2546 stems/acre 3= >4245 stems/acre 4= 849-1697 stems/acre 5= 170-848 stems/acre 6= 0-169 stems/acre, recoverable 7= 0-169 stems/acre, unrecoverable
SPECRICH	Count (and if possible identify) the number of plant species present within the 10m wide belt transect. Herbaceous sampling should be done twice per year, once in the summer dry season (May-June) and once in the summer rainy season (Aug-Sep).
TOPO	Meassure the macro and microtopographic relief using the following class data: 0=No data 1=Macro and mircrotopo relief 2=Homogenous surfaces with macro and microtopo relief 3=Homogenous surface & lacks macro and microtopo relief 4=Steep bank, recoverable 5=Steep bank, not recoverable
TREE	Record the number of decimeter hits within each meter interval. A hit is defined as any vegetation within a 10cm radius of the rod, per vertical decimeter. Estimate volume above 10m as either three or seven hits per interval. These estimations can be based on comparisons with lower intervals where hits can be directly measured.
VEGSTRATA	Record the number of vegetation layers present. Layers include: Tall (>10m) broad-leaved tree Short broad-leaved tree Tall microphyllous tree Short Microphyllous tree Tall (>1m) broad-leaved shrub Short broad-leaved shrub Tall (>1m) microphyllous shrub Short microphyllous shrub Vine Epiphyte Bunch grass Non-bunch grass Forb Lichens or biotic soil crusts

To collect these data, at each PWAA, a 100m long transect will be established generally parallel to the river channel. In some PWAAs, the transect may have to curve or be broken into two 50m transects. Along the 100m transect, establish a series of 10m X 10m quadrats, creating a belt transect. Each 100m transect should have 10, 10m X 10m quadrats. At the center of the quadrat, the recorder should note the presence of rills on adjacent slopes. Within the 10m X 10m quadrat the following should be recorded as reported by team members and based on the methods stated above:

1. Number of vegetation layers
2. Species composition
3. Microtopographic features (small scale pits and hummocks)
4. Logs and stage of decay

Within the 10m quadrat, a 1m X 1m quadrat should be randomly located. Within this quadrat the following data should be recorded based on the methods stated above:

1. Percent coarse woody debris (% CWD)
2. Percent fine woody debris (% FWD)
3. Percent litter cover
4. Percent algal mat
5. Percent tree canopy
6. Percent shrub cover
7. Percent herbaceous cover

The percent cover of all components should be estimated occularly. Percent cover of coarse woody debris, fine woody debris, litter cover, algal mat, shrub and herbaceous components should be estimated by vertically projecting the cover of each onto the ground surface. Due to the multi-layered nature of vegetation, total vegetative cover can exceed 100 percent. An example of this is the occurrence of herbaceous species under shrub canopies. Tree canopy cover should be estimated by viewing the tree canopy upwards through a sighting tube. The sighting tube should be divided into quarters by a cross-hair. The percent of the sky obscured by tree canopy as viewed through the sighting tube should be determined and recorded. At the center of each 1m X 1m quadrat, a 9.5m pole graduated in meters and decimeters should be placed vertically within the foliage. The number of decimeter hits within each meter interval should be recorded. A hit is defined as any vegetation within a 10cm radius of the rod per vertical decimeter. Estimates of volume above 10m in height should be recorded as either three (3) or seven (7) hits per interval. Such estimates can be based on comparison with lower intervals where hits can be directly measured.

4.2.2 Variables Not Collected in the Field

Some variables can be obtained through various historical records, aerial photographs, or mathematical calculations rather than through active field sampling. Table 5 provides a brief description of those protocols used in obtaining the non-field collected data:

Table 5. Protocols for non-field data collection for the Va Shly'ay Akimel Ecosystem Restoration Project.

Variable Code	Protocol Description
BUFFLENGTH	Measure the percent of area with sufficient buffer length using data classes: 0= No data 1= 100% of the reach has right and left bank buffers 2= Only onside of the reach has 100% buffering 3= 75% of the reach has right and left bank buffers 4= Only one side has 75% buffering 5= 50% of the reach has right and left bank buffers 6= Only one side has 50% buffering 7= 25% of the reach has right and left bank buffering 8= Only one side has 25% buffering 9= 0% of the reach has right and left bank buffers
BUFFWIDTH	Measure the width of the buffer in meters using data classes: 0= No data 1= Reach has a 15m right bank buffer and a 15m left bank buffer 2= Only 1 bank has a 30m buffer 3= Reach has a 10m right bank buffer and a 10m left bank buffer 4= Only 1 bank has a 20m buffer 5= Reach has a 5m right bank buffer and a 5m left bank buffer 6= Only 1 bank has a 10m buffer 7= Only 1 bank has a 5m buffer 8= No buffer exists
CONTIG	Measure the percent of contiguous vegetation.
DEPSATSED	Measure the depth of saturated sediments using class data: For CTWWFOR: 0= No data 1= 0m 2= 1-3m 3= >3m For MESQUITE: 0= No data 1= 0m 2= 1-7m 3= >7m For RIVERBOTTOM (emergents): 0= No data 1= 0m 2= 0.01 – 0.25m 3= >0.25m

FPA	Measure the flood prone area as defined by the projection of a horizontal plane at a level twice the bankfull thalweg depth using class data: 0= No data 1= FPA not clearly defined 2= FPA confined on one side 3= FPA confined is <15x bankfull width 4= FPA confined is <15x bankfull width recoverable 5= FPA confined is <2x bankfull width not recoverable 6= FPA confined to concrete channel.
FREQ	Measure the frequency of inundation of a site using class data: 0= No data 1= Perennial flow 2= Intermittent flow 3= Saturated 4= Temporally flooded by seasonal high flow (Q1-Q2) 5= Temporally flooded at bankfull flow (Q2-Q10) 6= Temporally flooded at large flood (Q10-Q25) 7= Temporally flooded at major flood (Q25-Q100) 8= Temporally flooded at super flood (>Q100)
LANDUSE	Measure the type of adjacent land use using class data: 0= No data 1= Active sand and gravel operations 2= Commercial/Industrial 3= Paved roads 4= Multi-family residential (apartments and duplexes) 5= Single-family residential (individual houses) 6= Gravel roads, dirt roads, bike paths, and infrequently visited structures 7= Inactive sand and gravel operations 8= Agricultural cropland 9= Open space (parks, golf course, etc) 10= Pristine, uninhabited areas
PORE	Measure soil pore space available for storing subsurface water using class data: 0= No data 1= Soil texture is sand-sandy loam; no restrictive layer 2= Soil finer than sand-has restrictive layer 3= Soil texture is finer than a restrictive layer 4= Modal soil profile highly compacted in the upper 24" 5= Concrete channel
Q	Measure the alteration of the hydrologic regime in the assessment area using class data: 0= No data 1= No additions, diversions, or damming of flow affecting the assessment area (e.g., water harvesting, farming practices,

	stormwater management, etc.) 2= Evidence of additions, diversions, or damming of flow, but no evidence of significant impacts to channel pattern, dimension, and profile 3= Evidence of additions, diversions, or damming of low, and there is evidence of changes I vegetation abundance. No evidence of increase sediment or scour. 4= Evidence of additions, diversions, or damming of flow, and there is evidence of increase sediment or scour. 5= Evidence of additions, diversions, or damming of flow, and there is evidence of significant impacts to channel pattern, dimension, and profile. Variable is recoverable. 6= Permanent alterations to hydroregime are evident. Variable is not recoverable.
SED	Measure the extent of sediment delivery to the water/wetland from culturally accelerated sources using class data: 0= No data 1= No sediment disturbance 2= Disturbance evident 3= Disturbance and delivery evident 4= Disturbance extreme and vegetation mortality 5= Area filled
SUBIN	Measure surface flow into the water/wetland via interflow and return flow using class data: 0= No data 1= Undistributed, subsurface flow evident 2= Undisturbed and subsurface flow is observed 3= Disturbed soils and plant communities 4= Utilized for agricultural activities 5= Fill 6= Impervious 7= Concrete channel
SURFIN	Measure surface inflow to wetland using class data: 0= No data 1= Any of the following indicators are present and similar to the reference standard: rills on adjacent upland slopes; lateral tributaries entering floodplain and not connected to the channel 2= Both indicators are resent but less than the reference standard 3= Both indictors are absent 4= Both indicators are absent and channelization prevents sedimentation on wetland surface
TRIB	Measure the presence of connected tributaries using class data: 0= No data 1= All tributaries (channel and riparian corridor) are unmodified and connect to the mainstem

	2= Some tributaries are modified (consolidated, redirected, or channelized) but still connected to the mainstem 3= Tributaries are highly modified/channelized, or not connected to the mainstem
WIS	Measure the wetland indicator score for each species in SPECRICH using class data: 1= Obligate 2= Facultative wet 3= Facultative 4= Facultative upland 5= Upland

Once all field and non-field data are collected, the values can be entered into the Arizona Riverine HGM model, resulting in output that can then be directly compared to the projected output values. For the restoration project to be deemed successful, the actual Target Year results must meet or exceed 80% of the project Target Year results for each of the 4 Target Years.

4.3 Additional Monitoring Requirements

4.3.1 Insects

Monitoring insects should be done annually during the Operations and Maintenance period to address concerns regarding disease vector control. Mosquito monitoring should include establishing a baseline prior to construction of the project features. Such a baseline would consider routine sampling of both adult and juvenile forms of mosquitoes during the months of April through October at a minimum. Such information provides insight into the existing mosquito population dynamics and may be used to guide monitoring and management activities during and after construction.

4.3.2 Federally Threatened and Endangered Species

Habitat development for federally listed threatened and endangered (T&E) species is not listed as a goal and objective of this restoration project. However, because of the shortage of native riparian habitat in the southwest, there are a number of T&E species that are likely to migrate into the created habitat. In preparation for this, both the SRPMIC and the City of Mesa have expressed an interest in developing a Safe Harbor Agreement with the U.S. Fish and Wildlife Service (USFWS). This agreement allows the local sponsor to develop habitat that may be suitable and/or attractive to federally listed T&E species, without the future risk of activity limits as dictated by the Endangered Species Act. A Safe Harbor Agreement allows the local sponsor to conduct activities, such as maintenance related activities, without the need to apply for a take permit. However, part of the Safe Harbor Agreement is to conduct a thorough baseline condition survey for all T&E species that might be in the area. This effort is expected to provide the first monitoring requirement, target year (TY) 1.

The T&E species listed as part of the Endangered Species Act, Section 7 consultation determination of "may affect, not likely to adversely affect" are: bald eagle, southwestern willow flycatcher, Yuma clapper rail, cactus ferruginous pygmy-owl, and California brown pelican. These species will be of particular importance to monitor for as long as the project is authorized.

Monitoring of T&E species must follow USFWS approved protocol and should be conducted initially as part of the Safe Harbor Agreement procedure and subsequently during the Operations and Maintenance period. It will be important to coordinate with the USFWS regarding survey timing and frequency; coordination is essential if T&E species are found within the project area.

4.3.3 Wildlife Hazard Monitoring

The U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Wildlife Services (WS) program is authorized and directed to protect resources from damage associated with wildlife. WS provides assistance to the aviation community to assess and manage wildlife hazards at airports. They recommend a distance of 10,000 feet between any wildlife attractant and an airport's aircraft movement areas to avoid bird strikes. While the City of Mesa's Falcon Field Airport is more than 10,000 feet from the nearest project feature, recognizing the risks of wildlife related damage is important. During any regular operation and/or maintenance or monitoring activities, if there is evidence that wildlife, associated with the project features, may be infringing upon the 10,000 foot safety zone, the WS should be notified immediately. The WS, Corps, and local sponsors can then work together to resolve the issue.

4.4 Frequency of HGM Model Runs

The HGM performance target FCU values were computed for four Target Years: TY1, TY6, TY26 and TY51. Therefore, as part of the success criteria evaluation, the HGM model data collection and subsequent model runs should be conducted at those same years, at a minimum. These milestones will again allow for a direct comparison of the predicted FCIs and acreages versus the achieved habitat values and to quantify the extent of the failure(s).

Should a particular project feature, vegetation type, or area within the project footprint show signs of failure of any kind, the HGM model and associated data collection should be performed, regardless of time post-construction, to help identify the likely cause of the degradation.

5.0 DOCUMENTATION

Proper documentation of the monitoring efforts serves two primary purposes. First, the documentation should provide a clear picture of the project results so current conditions can be easily identified and the appropriate adaptive management measures can be applied, if necessary. Second, documentation should be easily assessable so that future

projects can reference the procedures used and learn from the planning or adaptive management measures taken.

The Corps, in cooperation with the local sponsors, will write an annual report at the end of each of the first five years post construction. This report should include a written description of current conditions as well as the results of any HGM runs, flora and fauna surveys conducted, geo-references and maps for the area covered in the report, topographic survey results identifying all significant features (planting sites, on-going mining operations, etc.) and a well documented photographic record including oblique photos from before, during and after construction. The exact photo point locations should be fixed using GPS coordinates so that an exact photograph can be repeated for all submissions. This report should be made available to the USFWS and all other interested resource agencies.

The photographic record should be explicitly documented using photo point data sheets, courtesy of the Arizona Water Protection Fund, as shown at the end of this MAMP. The exact photo point locations should be repeated for all submissions. Because of the expected vegetation growth, each photo point should be taken in the channel, or from some vantage point that will not be obscured by vegetation in the future.

After the first five years, the local sponsors will be responsible for preparing the monitoring reports and for funding and implementing any modifications necessary to ensure the success of the project.

A Technical Committee consisting, at a minimum, of representatives of the USFWS, U.S. Bureau of Reclamation, and Arizona Game and Fish Department will assist in collection of monitoring data, review monitoring data results and reports, and recommend possible adaptive management measures.

6.0 ADAPTIVE MANAGEMENT

The Technical Committee will recommend adaptive management measures to the existing project's design if either the acreage or quality of PWAAs does not achieve the identified goal and objectives. If the designated vegetation species composition is not achieved, replanting, additional irrigation, and/or removal of vegetation (especially exotics) may be necessary.

Flexibility is essential to adaptive management success. This should be in the form of design contingency plans and flexible funding availability. During PED, contingency plans should be developed for situations that, while not predicted to occur, may occur given varying environmental, social, or structural conditions. These may include accounting for a variety of site-specific soil conditions, changes in land use immediately outside of the project area, or changes in mining operations and quarry pits.

The allotted funding for monitoring is up to 1% of the total project cost. These funds are cost shared 65% to 35% between the Corps and the local sponsors, respectively.

Adaptive Management funds are authorized up to 3% of the total project costs, again, cost shared between the Corps and local sponsors. Should the local sponsors choose to, they might begin contributing to an escrow account early in the project construction phase to maximize the funding, which helps ensure maximum flexibility. If the entire 3% of the project cost authorized for Adaptive Management needs is not utilized in the first five years after construction, it too can be put into an escrow account to be used by the local sponsor for future adaptive management needs.

7.0 CONCLUSION

The Monitoring and Adaptive Management Plan is designed to provide guidance that will provide a means for cost effective, reliable, and effective monitoring of success of the ecosystem restoration project. The purpose of this monitoring is to ensure that the project is functioning as it was intended to. The HGM model will be used at the designated target years to evaluate the quantitative and qualitative condition of the project site with the expectation that the project features will meet or exceed 80% of the predicted FCI and acreage values.

Should the project fall below the 80% threshold of predicted acreages and/or FCI values, adaptive management strategies will be implemented. Adaptive Management is designed to alter any design feature necessary to help promote the meeting of design objectives, should monitoring indicate they are falling short.

8.0 REFERENCES

J.D. Jack, A. C. Parola, and W.C. Vesley. Assessment of channel and riparian restoration in an urban stream in Louisville, KY (USA). Presented at the North American Benthological Society Annual Meeting. Pittsburgh, PA. 2002.

Goldner, B.H. 1984. Riparian restoration efforts associated with structurally modified flood control channels. Pages 445-451 *in* R.E. Warner and K.M. Hendrix [eds]. California riparian systems: ecology, conservation, and productive management. California Water Resources Report No. 55. University of California Press, Berkeley.

http://weather.nmsu.edu/nmcrops/Riparian-vegetation/Bosque/bosque%20revegetation.htm

APPENDIX B: Photo Point Data Sheet (courtesy of Arizona Water Protection Fund)

INITIAL TAKE
PERMANENT PHOTO POINT RECORD

Photo Point No. _____
Project Name _____
Landowner/Management Unit _____ County_____
_____
Subject and Purpose of Photo _____
_____
_____
_____
Retake Frequency_____ Retake Due Dates _____
_____

Initial Photo Info: _____
Photographer _____ Date _____ Time _____
_____a.m. p.m.
Camera _____ Film _____ ASA _____

Weather Conditions

Photo Point Description (Describe access to point, point vicinity, and specific location; include sketch map below):

Legal Description _____
USGS Quad Map _____
Est. Position Coordinates (UTM's, Lat/Long) _____
_____

View 1	View 2	View 3
Camera Height_____	Camera Height_____	Camera Height_____
Compass Bearing_____	Compass Bearing_____	Compass Bearing_____
Lens_____Filter_____	Lens_____Filter_____	Lens_____Filter_____
F-stop_____Speed_____	F-stop_____Speed_____	F-stop_____Speed_____
Focus Distance_____	Focus Distance_____	Focus Distance_____

SKETCH MAP: Include background reference points to help with relocation.

Reference Point 1
Description_____
_____
Bearing and
distance_____
_____
Reference Point 2
Description_____
_____
Bearing and
distance_____
_____
Reference Point 3
Description_____

Bearing and
distance_____

RETAKE
PERMANENT PHOTO POINT RECORD

Photo Point No. _____ Date_____Time_____a.m. / p.m.
Project Name _____
Landowner/Management Unit _____County _____
Photographer _____
Camera _____Film _____ASA _____

View 1	View 2	View 3
Camera Height_____	Camera Height_____	Camera Height_____
Compass Bearing_____	Compass Bearing_____	Compass Bearing_____
Lens_____Filter_____	Lens_____Filter_____	Lens_____Filter_____
F-stop_____Speed_____	F-stop_____Speed_____	F-stop_____Speed_____
Focus Distance_____	Focus Distance_____	Focus Distance_____

Condition of Point Monument and references: _____

Weather conditions or recent events that may have influenced conditions at the site:

Appendix C

List of Plant and Animal Species Mentioned in the Text

Appendix C. List of Plant and Animal Species Mentioned in the Text

Common Name	Scientific Name
Plants	
Acacia	*Acacia greggii*
Agave and yucca	*Agave* spp.
Arrow weed	*Sagittaria* spp.
Barrel cactus	*Ferocactus* spp.
Bermuda grass	*Cynodon dactylon*
Blue paloverde	*Cercidium floridum* var. *floridum*
Brittlebush	*Encelia farinosa*
Bulrush	*Scipus* spp.
Burro brush	*Hymenoclea salsola*
Cholla	*Opuntia* spp.
Cattail	*Typha* spp.
Cottonwood	*Populus* spp.
Creosote bush	*Larrea tridentata*
Desert broom	*Baccharis sarothroides*
Desert thorn	*Lycium macrodon*
Desert willow	*Chilopsis linearis*
Dock	*Rumex* spp.
Elderberry	*Sambucus glauca*
Filaree	*Erodium cicutarium*
Fremont cottonwood	*Populus fremontii* ssp. *fremontii*
Goodding's willow	*Salix gooddingii*
Ironwood	*Olneya tesota*
Knotweed	*Polygonum* spp.
London rocket	*Sisymbrium irio*
Marsh fleabane	*Pluchea purpurascens* var. *purpurascens*
Mesquite	*Prosopis velutina*
Organ pipe cactus	*Cereus thurberi*
Quailbush	*Atriplex lentiformis* ssp. *lentiformis*
Rabbit brush	*Chrysothamnus* spp.
Russian thistle	*Salsola tragus*
Saguaro	*Carnegiea gigantea*

Appendix C. Continued

Common Name	Scientific Name
Salt heliotrope	*Heliotropium curassavicum*
Saltbush	*Atriplex* spp.
Saltcedar	*Tamarix* spp.
Sedge	*Carex* spp.
Tree tobacco	*Nicotiana glauca*
Triangle bursage	*Ambrosia deltoidea*
Tule	*Scirpus acutus*
Velvet mesquite	*Prosopis velutina*
Western honey mesquite	*Prosopis glandulosa*
White bursage	*Ambrosia dumosa*
Willow	*Salix* spp.
Yellow paloverde	*Cercidium microphyllum*
Reptiles and Amphibians	
Banded gecko	*Coleonyx variegatus*
Banded sand snake	*Chilomeniscus cinctus*
Common kingsnake	*Lampropeltis getulus*
Desert black-headed snake	*Tantilla nigriceps*
Desert spiny lizard	*Sceloporus magister*
Desert tortoise	*Gopherus agassizii*
Earless lizard	*Holbrookia texana*
Gopher snake	*Pituophis melanoleucus*
Lowland leopard frog	*Rana yavapaiensis*
Mexican garter snake	*Thamnophis eques*
Side-blotched lizard	*Uta stansburiana*
Tree lizard	*Urosaurus ornatus*
Western diamondback rattlesnake	*Crotalus atrox*
Western whiptail	*Cnemidophorous tigris*
Insects	
Mosquito	Family Culicidae

Appendix C. Continued

Common Name	Scientific Name
Birds	
Abert's Towhee	*Pipilo aberti*
American Coot	*Gallinula chloropus*
American Kestrel	*Falco sparverius*
Anna's Hummingbird	*Calypte anna*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Bald Eagle	*Haliaeetus leucocephalus*
Barn Owl	*Tyto alba*
Bell's Vireo	*Vireo belli*
Belted Kingfisher	*Ceryle alcyon*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Black-bellied Whistling Duck	*Dendrocygna autumnalis*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-throated Sparrow	*Amphispiza bilineata*
Brown-headed Cowbird	*Molothrus ater*
Cactus Ferruginous Pygmy-Owl	*Glaucidium brasilianum cactorum*
Canyon Towhee	*Pipilo fuscus*
Cinnamon Teal	*Anas cyanoptera*
Common Merganser	*Mergus merganser*
Curve-billed Thrasher	*Toxostoma curvirostre*
Dusky Flycatcher	*Empidonax oberholseri*
Elf Owl	*Micrathene whitneyi*
European Starling	*Sturnus vulgarus*
Gambel's Quail	*Callipepla gambelii*
Gila Woodpecker	*Melanerpes uropygialis*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Great Horned Owl	*Bubo virginianus*
Greater Roadrunner	*Geococcyx californianus*
Horned Lark	*Eremophila alpestris*
House Finch	*Carpodacus mexicanus*
House Sparrow (I)	*Passer domesticus*
House Wren	*Troglodytes aedon*

Appendix C. Continued

Common Name	Scientific Name
Killdeer	*Charadrius vociferus*
Loggerhead Shrike	*Lanius ludovicianus*
Lucy's Warbler	*Vermivora luciae*
Mallard	*Anas platyrhynchos*
Marsh Wren	*Cistothorus palustris*
Mountain Plover	*Charadrius montanus*
Mourning Dove	*Zenaida macroura*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Northern Pintail	*Anas acuta*
Osprey	*Pandion haliaetus*
Peregrine Falcon	*Falco peregrinus*
Phainopepla	*Phainopepla nitens*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Rock Dove (I)	*Columba livia*
Southwestern Willow Flycatcher	*Empidonax traillii extimus*
Spotted Sandpiper	*Actitis macularia*
Summer Tanager	*Piranga rubra*
Tree Swallow	*Tachycineta bicolor*
Verdin	*Auriparus flaviceps*
Western Burrowing Owl	*Athene cunicularia*
Western Kingbird	*Tyrannus verticalis*
Western Sandpiper	*Calidris mauri*
Western Screech Owl	*Otus kennicottii*
Western Wood-Pewee	*Contopus sordidulus*
Western Yellow-billed Cuckoo	*Coccyzus americanus*
White-tailed Kite	*Elanus leucurus*
White-winged Dove	*Zenaida asiatica*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Yuma Clapper Rail	*Rallus longirostris yumanensis*

Appendix C. Continued

Common Name	Scientific Name
Mammals	
Blacktail jack rabbit	*Lepus californicus*
Bobcat	*Lynx rufus*
Cactus mouse	*Peromyscus eremicus*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Desert cottontail	*Sylvilagus auduboni*
Gray fox	*Urocyon cinereoargenteus*
Ground squirrel	*Citellus* spp.
Hispid cotton rat	*Sigmodon hispidus*
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*
Muskrat	*Ondatra zibethica*
Opossum	*Didelphis virginianus*
Pocket gopher	*Pappogeomys castanops*
Raccoon	*Procyon lotor*
Striped skunk	*Mephitis mephitis*
Western harvest mouse	*Reithrodontomys magalotis*
Whitethroat wood rat	*Neotoma albigula*
Vole	*Microtus* spp.

Appendix D

Fish and Wildlife Coordination Act Documentation

United States Department of the Interior
U.S. Fish and Wildlife Service
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021-4951
Telephone: (602) 242-0210 FAX: (602) 242-2513

In Reply Refer to:

AESO/FA

August 2, 2004

Ms. Ruth Villalobos
Chief, Planning Division
Attn: Sarah Laughlin
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

The Fish and Wildlife Service (FWS) has reviewed the U.S. Army Corps of Engineers (Corps) proposed Va Shly' ay Akimel Feasibility Study. This report represents our evaluation of the Va Shly' ay Akimel Salt River ecosystem restoration project and is provided pursuant to Section 2(B) of the Fish and Wildlife Coordination Act (48 stat. 401, as amended; 16 U.S.C. 661 et seq.) (FWCA). This report is based on coordination with the Arizona Game and Fish Department (AGFD), local sponsors, literature research, file reviews, and information provided by the Corps including the Section 905(B) Analysis, the Draft Environmental Impact Statement (DEIS) (Corps, 2004), the Independent Technical Report Draft Alternative Formulation Briefing Feasibility Report (ITR) (Corps, 2003b), and comments on the draft FWCA report.

PROJECT DESCRIPTION

The Corps is investigating environmental restoration along the Salt River under authority of House Resolution 2425 of May 17, 1994, and Section 6 of the Flood Control Act of 1938. Together with the Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa, the local sponsors, the Corps is evaluating ecosystem restoration opportunities within an approximately 14 mile stretch of the Salt River from the Granite Reef Diversion Dam to the Pima/Price Freeway, Maricopa County, Arizona (Figure 1-1).

The Salt River originates in eastern Arizona and flows westward to its confluence with the Gila River west of downtown Phoenix. Prior to agricultural development and urbanization of the Phoenix metropolitan area in the 20th century, the Salt River was a perennial stream. Impoundments, diversions, and groundwater pumping eventually eliminated perennial flow below Granite Reef, causing significant changes in the riparian and wetland ecosystems along the Salt River.

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PLANNING DIVISION

The proposed action would restore ecosystem functions and processes, return the project area to a less degraded natural condition, increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of desirable species, and produce a viable, self-sustaining ecosystem requiring minimal maintenance. The proposed action would also provide a number of incidental benefits including an increase in recreation opportunities and improvement in water quality and supply. Without restoration, habitat values in the study area are expected to further decline within the next 50 years.

The feasibility study has planning objectives similar to and compatible with objectives established for other proposed restoration projects along the Salt River. Specific planning objectives developed for the Va Shly' ay Akimel project include the following:

- Restore and create conditions for sustainable riparian habitat in and around the study area by incorporating a channel configuration that would provide a functional floodplain to mimic natural processes found in other self-sustaining riparian corridors in Arizona.

- Identify water sources that can be used to sustain riparian restoration areas.

- Create a complete and diverse riparian system similar to the natural riparian habitat typical of this area by incorporating a diverse mix of riparian habitat types including mesquite, cottonwood-willow, wetland marsh, and open water.

- Increase environmental education and passive recreation opportunities incidental to the restoration effort.

EXISTING ENVIRONMENT

Dams along the Verde River and upper Salt River have significantly altered the hydrologic regime of the lower Salt River, changing the magnitude and timing of flows. Salt River Project (SRP) intermittently releases water from reservoirs prior to winter rains or when they are unexpectedly full. The system of dams along the Salt River has eliminated perennial flow and steady, high winter flows. Since Bartlett Dam began operating on the Verde River in 1938, the lower Salt River has contained water only as a result of controlled or uncontrolled releases from Granite Reef Diversion Dam. Granite Reef diverts reservoir releases into the Arizona Canal and the South Canal for water delivery to agricultural, municipal, and industrial uses. There are no releases during drier years and the riverbed is dry during those times except for stormwater runoff, groundwater emergence, and effluent discharges.

A biological community classification system was developed for this study and is described in detail in the DEIS. The classification system categorizes cover types in the project study area, by dominant vegetation cover. Agricultural lands are common in the project study area occupying 3262 acres. Generally, agricultural uses include irrigation for cattle grazing, citrus orchards, and crops such as cotton, small grains, and assorted vegetables. Parks and recreational areas occupy

279 acres and include turf-covered lands such as golf courses. These areas generally contain non-native ornamental trees and shrubs. Urban areas are common in the project study area, occupying 3000 acres in residential, commercial, and industrial uses. Sand and gravel operations occupy 1962 acres and have contributed to habitat alteration within the river channel.

Cottonwood/willow forest is uncommon in the study area, occupying only 40.2 acres in primarily early seral-stage stands. It is found in narrow, linear strands oriented in the main channel, particularly where effluent enters the river from the City of Mesa Wastewater Treatment Plant (WWTP). Fremont's cottonwood (*Populus fremontii*) and Goodding's willow (*Salix goodingii*) are the dominant canopy species. Understory vegetation includes salt cedar (*Tamarix* sp.), desert broom (*Baccharis sarothroides)*, desert willow (*Chilopsis linearis*), and marsh fleabane (*Pluchea purpurescens*). Additionally, another 31.2 acres has been classified as mixed salt cedar and CW forest. These areas are dominated by salt cedar but contain scattered cottonwood and willow trees throughout.

The most common cover type in the study area is described as Desert Areas in the DEIS and occupies 6008 acres. Desert areas are separated into two subtypes: creosote bush/white bursage, and Sonoran desert scrub. The creosote bush/white bursage subtype is 5226.4 acres characterized by mostly creosote bush (*Larrea tridentata*) with scattered white bursage (*Ambrosia dumosa*). This community type is variable, from monotypic stands of creosote bush to a more diverse canopy in the transition zone between it and Sonoran desert scrub. There are 782.1 acres of Sonoran desert scrub located in the uplands near Granite Reef. Characteristic species are typically more diverse and include creosote bush, saguaro (*Carnegiea gigantea*), paloverde (*Parkinsonia* sp.), cholla (*Opuntia* sp.) , and barrel cactus (*Ferocactus* sp.).

Emergent wetlands are scattered over 73 acres in the floodplain of the study area near the Mesa WWTP, Granite Reef Dam, and areas around abandoned gravel mining ponds that are not routinely cleared of vegetation. Emergent wetlands in the project study area are dominated by obligate wetland species such as cattails (*Typha* sp.), bulrush (*Scirpus* sp.), and dock (*Rumex* sp.).

The DEIS further describes another 1419 acres as scrub/shrublands. This cover type is present within the active channel of the river and dominated by combinations of burrobush (*Hymenoclea salsola*), rabbitbush (*Chrysothamnus* sp.), saltbush (*Atriplex* sp.), and creosote. Many of these areas have been highly disturbed from off-highway vehicle traffic and mining. Unvegetated river bottom occupies 251.8 acres of the project area.

These vegetation communities provide habitat for a variety of native wildlife species. Common mammals found in the study area include black-tailed jackrabbit (*Lepus californicus*), coyote (*Canis latrans*), desert cottontail (*Sylvilagus audubonii*), cotton rat (*Sigmodon* sp.), muskrat (*Ondatra zibethica*), wood rat (*Neotoma* sp.), and deer mice (*Peromyscus* sp.). Common avifauna include American coot (*Gallinula chloropus*), barn owl (*Tyto alba*), Bell's vireo (*Vireo belli*), black-crowned night-heron (*Nycticorax nycticorax*), black throated sparrow (*Amphispiza bilineta*), brown-headed cowbird (*Molothrus ater*), curve-billed thrasher (*Toxostoma*

curvirostre), Gambel's quail (*Callipepla gambelii*), mourning dove (*Zenaida asiatica*), red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), great blue heron (*Ardea herodias*), greater roadrunner (*Geococcyx californianus*), house finch (*Carpodacus mexicanus*), killdeer (*Charadrius vociferus*), and mallard (*Anas platyrhynchos*), to name a few.

Common herpetofauna include common kingsnake (*Lampropeltis getulus*), desert spiny lizard (*Sceloporus magister*), desert tortoise (*Gopherus agassizii*), gopher snake (*Pituophis melanoleucus*), tree lizard (*Urosaurus ornatus*), western whiptail (*Cnemidopherus tigris*), and western diamond rattlesnake (*Crotalus atrox*). Open water in the study area is limited to sand/gravel operation ponds and the groundwater recharge basins located north of the Mesa WWTP. Very little information exists regarding fish species in the study area, though non-natives such as mosquitofish (*Gambusia affinis*), tilapia (*Tilapia* sp.), and sunfish (*Lepomis* sp.) are present downstream.

Species listed as threatened or endangered under the Endangered Species Act are known to use the Salt River downstream and the Verde and Salt rivers upstream of the project area. Suitable habitat for the endangered Yuma clapper rail (*Rallus longirostris yumanensis*) exists in the downstream portion of the project area where marshy areas characterized by cattails and other wetland vegetation are established. However, these areas were surveyed in accordance with FWS protocol in May, 2003, and no rails were detected (Corps, 2003c). Suitable foraging habitat for the threatened bald eagle (*Haliaeetus leucocephalus*) exists in the downstream portion of the project area and eagles have been observed foraging along the Salt River near the project area (Corps 2003c). Riparian woodland characterized by cottonwood, willow, and salt cedar within the project area are generally sparse, patchy, and unsuitable for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) (Corps, 2003c). No habitat suitable for other threatened or endangered species exists within the project area.

ALTERNATIVES

An initial array of 14 alternatives was developed by the Corps and local sponsors during the alternatives formulation process. Alternatives were further refined based on coordination with the public and resource agencies. The Hydrogeomorphic (HGM) wetland assessment method was used by the planning team to identify and quantify anticipated benefits associated with alternatives. Benefits were quantified as Average Annual Functional Capacity Units (AAFCUs) which represent expected changes in ecological functions based on the model developed by the planning team. The five highest-ranking alternatives were selected for further evaluation and are presented here. For comparison purposes, the study area was divided into nine reaches (Figure 3-1). The following general descriptions are based on information presented in the DEIS.

No Action Alternative

Under the No-Action Alternative, the Corps would take no action to restore the ecosystem within the study area. Incidental benefits to provide recreation and improve water quality and supply

would not be provided. Although it is possible that local agencies would implement limited improvements, restoration efforts would be unlikely to occur on the scale of the proposed project. The No-Action Alternative would create no short-term adverse impacts associated with construction and restoration such as habitat fragmentation, sedimentation, and air quality degradation. There also would be no increase in flood protection downstream nor any improvement in water quality.

Features Common to all Action Alternatives

Water Sources: There are several water sources for the project including groundwater from existing and new wells, stormwater runoff, City of Mesa Wastewater Treatment Facility (WWTP) effluent water, irrigation tailwater, and SRP water available for use by the SRPMIC via existing water source locations. Alternatives rely primarily on surface water and groundwater from the SRPMIC and effluent from the WWTP. According to SRPMIC, 30,000 acre-feet/year of water can be allocated to the project.

Water Distribution System: The water distribution system includes infrastructure needed to deliver water from the source to vegetated areas, excluding the irrigation system. Surface water from the SRPMIC would be the primary source of water. Surface water would enter the project by way of irrigation canals controlled by the SRPMIC. A diversion structure would store and divert surface water from the irrigation channels to the water distribution drain, a 12-inch buried pipe. Diversion structures would divert water from SRPMIC system and the wastewater treatment sources to the distribution pipe. Stormwater and irrigation tailwater would be used when available. Diversion structures would be designed to divert both project water and excess water to the project area.

Irrigation Techniques: Surface water from stormwater sources, irrigation canals, and ditches would be diverted to various vegetated areas by a network of lined irrigation channels and buried pipes. Pumps may be used to distribute water. Vegetated areas would be irrigated by either surface braided irrigation network, flood irrigation, or drip irrigation. Surface braided irrigation network (SBIN) would distribute water through a network of shallow ditches, 6 inches deep and 2 to 3 feet wide. Flood irrigation would consist of inundating an area by overland flow. Water distribution would be manually controlled for the life of the project.

Reshaping: Many features would require channelization, surface reshaping, vegetation reshaping, and/or irrigation reshaping. Channelization refers to material that would be moved in the process of constructing the 200- foot-wide, low-flow channel. Surface reshaping refers to material moved to alter significant features such as large mounds, quarry pits, and side slopes. Vegetation

construction of irrigation ditches needed in flood or surface braided irrigation methods and construction of drainage ditches.

ALTERNATIVE F

Alternative F has the greatest number of project features. It is the only alternative that would involve channelization of portions of the Salt River and one of two that would include bank stabilization features in certain reaches. A total of 16,500 linear feet would be channelized under this alternative. The excavated material would be used to create benches along the channel, to fill quarry pits, and to vary the local topography to encourage vegetation growth and reduce flood damage on proposed vegetation areas.

Reaches 9 and 8: Invasive plant species, primarily saltcedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are associated with them, and native vegetation would be planted. No other changes to the current conditions are proposed.

Reach 7: No changes proposed due to the presence of the active Higley Quarry. To reduce effects from mining, quarry operators should be encouraged to preserve a narrow corridor within the existing main channel or create a channel at grade to convey flow and bed load material to Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reach 6: Large areas of cottonwood-willow (CW) and mesquite (MS) would be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and irrigated using groundwater. Water would be distributed by flood irrigation or SBIN.

On the south bank, CW would be planted in an abandoned quarry directly east of Gilbert Road. The area would be irrigated using surface water and stormwater through flood irrigation. A large abandoned quarry further upstream along the south bank would be reconnected to the Salt River with two spillways and partially filled. To ensure the quarry does not affect the current channel layout, the south bank of the river would be reestablished north of the quarry and hard-banked approximately 6,000 linear feet.

A wetland (WT) would be constructed in the riverbed near the existing Hennessey Drain outlet near the east end of Reach 6. A berm of coarse rock would be constructed on the upstream side of the WT to provide protection from scour during flooding to force flows away from the south

The WT would also serve as the upstream starting point of the low-flow channel. The larger wetland feature would fit within the channel. Channelization would continue downstream to approximately Gilbert Road (the western limit of Reach 6), with a total of two WT features within the channel. Sonoran desertscrub (SD) would be established on the benches.

Reach 5: The north bank of the Salt River in the vicinity of the Gilbert Quarry pit would be armored to prevent high flows from entering the Gilbert Quarry. Soil cement is recommended for bank stabilization.

The Gilbert Quarry pit would be reshaped and converted to river bottom. Two spillways would be constructed as part of the bank stabilization to allow water flow in and out of the pit from the river. CW, MS, and SD would be planted on the overbank area. The SD and MS would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from the drainage distribution channel via the SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to river bottom. WT and MS would be established at Evergreen Drain, on the north side of the channel. The MS would be irrigated using groundwater from the new well, and the WT would be supported by runoff from Evergreen Drain.

The south bank would be vegetated with CW and MS. Surface water and stormwater would be used to irrigate these areas. The south bank CW and MS would continue eastward, ending at Gilbert Road. Irrigation of the CW and MS would be SBIN.

A grade control structure is proposed to protect the Gilbert Road Bridge due to the extensive mining that has occurred downstream of the bridge. The grade control structure would help reduce the upstream migration and stabilize the river system, improving the likelihood of success of vegetation established upstream and downstream. The grade control structure would be placed in the main channel at the center point of the former Gilbert Quarry.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. MS, SD, and a small stand of CW could be established in this area if water quality is good and the soil layer over the landfill cap is sufficiently deep. The area would be irrigated using surface water and stormwater by way of the SBIN.

The area along the south bank would support CW, MS, and WT. Two surface water outlets on the south bank would supply water to the SBIN to irrigate the vegetation. The western outlet would support the WT as well as surrounding CW and MS. Since this southern area is relatively protected from the main channel, damage to the channel and the irrigation system has the potential to occur less frequently.

The western wetland feature would be the upstream starting point for the second section of channelized river bottom. In Reach 4, this channelized area would support two WT features within the channel and SD on the benches. Channelization would extend from this point in Reach 4 downstream through all of Reach 3 and Reach 2.
Reach 3: As indicated in the previous paragraph, the river would be channelized for the entire length of Reach 3, thus reshaping and creating new river bottom along this entire reach. A channel would be constructed to drain the southern portion of Reach 4 to supply water to a portion of the WT and CW vegetation to be established within the river channel in Reach 3. Water would be conveyed to the CW using the SBIN.

Reach 2: The river would be channelized for the entire length of Reach 2. It would support an in-channel WT that terminates in a larger wetland immediately downstream of Alma School Road. Bank stabilization with soil cement is recommended for the south bank between Country ClubRoad and Alma School Road.

The northern portion would support a WT feature surrounded by CW to the west, south, and east, and MS to the north. These features would be supported by surface water outlets and maintained using SBIN. Additional water may be supplied by a golf course located north of the Salt River, if the water is of sufficient quality.

The south bank would include a small WT and small areas of CW and MS. One stand of CW would surround the wetland; the second stand would be downstream of the first, with the stand of MS located between the two CW areas. The WT would be constructed near the Country Club Storm Drain on the existing river bottom and will need to withstand stormwater runoff. The WT would be surrounded by CW and irrigated using SBIN.

Reach 1: No work is proposed for Reach 1.

ALTERNATIVE N

Alternative N would include most of Alternative F's vegetation features but lacks most of its structural features. Most notably, it does not include channelization or bank stabilization.

Reaches 9 and 8: Invasive plant species, primarily saltcedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are associated with them, and native vegetation would be planted. No other changes to the current conditions are proposed.

Reach 6: Relatively large areas of CW and MS would be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and would be irrigated using groundwater from a new well. In both areas the water wouldl be distributed by flood irrigation or by SBIN. Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. On the south bank of the river, two areas of CW would be planted. One CW would be located in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain. The second CW would be a relatively narrow strip along the southern edge of the main channel. Both areas would be irrigated using surface water via flood irrigation.

A WT would be constructed in the riverbed near the existing Hennessey Drain outlet near the east end of Reach 6. A berm of coarse rock would be constructed on the upstream side of the WT to provide protection from scour. The WT would be lined with clay to help maintain surface water levels and the saturated soil conditions necessary for vegetation growth. The WT would be adjacent to a new CW stand at its upper (east) end, taking advantage of the saturated soil conditions, and would be irrigated using surface water from the Hennessy Drain and either SBIN or flood irrigation.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to river bottom. CW, MS, and SD would be planted on the overbank area. The MS and SD would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from an irrigation canal. The water would be distributed using SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to river bottom. WT and CW would be established at Evergreen Drain. The CW would be irrigated using groundwater from the new well, and the WT would be supported by runoff from Evergreen Drain.

The south bank would be vegetated with CW and a small stand of MS. Surface water and stormwater would be used to irrigate these areas, with the water distributed by a SBIN. A grade control structure would be placed in the main channel of the river at the center point of the former Gilbert Quarry help protect the Gilbert Road Bridge from head cutting.

Reach 4: A large portion of this reach is located on a terrace north of the channel at the site of the closed Tri-City Landfill. The majority of this area would be left unvegetated. A narrow strip of CW would be established along the north bank of the river, at the edge of the main channel. The area would be irrigated using surface and stormwater distributed by a SBIN.

Reach 3: A channel would be constructed to drain the southern portion of Reach 4 to supply water to a new CW stand along the south bank that would be a continuation of the CW stand at the western end of Reach 4. Water would be conveyed to the CW using the SBIN.

Reach 2: The northern portion would support a WT surrounded by CW to the west, south, and east and MS to the north. These features would be supported by surface water outlets and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River if the water is of sufficient quality.

The south bank would include a small WT and small areas of CW and MS. One stand of CW would surround the wetland; the second stand would be downstream of the first, with the stand of MS located between the two CW areas. The WT would be constructed near the Country Club Storm Drain on the existing river bottom.

Surface water would support two WT areas created at Alma School Road downstream of the old quarry. The western WT would be flanked by CW to the west and continue into Reach 1. The CW would be irrigated using SBIN. A small area south of the wetlands would be reshaped and converted to new river bottom.

Reach 1: The CW stand adjacent to the western WT of Reach 2 would continue westward into the main channel of the river. An old recharge area on the south side of the river would be planted with a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area is Mesa treatment facility water. No activity is planned for the north side of the river.

ALTERNATIVE O (PREFERRED ALTERNATIVE)

Under the Preferred Alternative, the Corps would vegetate large portions of the project area and provide minimal support or flood control structures.

Reach 9 and 8: Invasive plant species, primarily salt cedar (*Tamarix* sp.), would be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes were proposed in Reach 7 because of the Higley Quarry Plant. It is assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the affect of the Higley mining operations the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to

Reach 6. By reducing the deposition, bed load material would continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reach 6: Relatively large areas of CW and MS would be established along the north side of the river. The CW would be located south of the GRUSP site and irrigated using surface water from the Hennessey Drain. The MS would be north of the GRUSP site, immediately outside of the active channel and outside the 10-year floodplain, and would be irrigated using groundwater from a new well. In both areas the water would be distributed by flood irrigation or by a SBIN. Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation.

On the south bank of the river, two areas of CW would be planted. One CW would be located in an abandoned quarry depression directly east of Gilbert Road and within the 5-year floodplain. The second CW would be a relatively narrow strip along the southern edge of the main channel. Both areas would be irrigated using surface water and stormwater when available. Flood irrigation is the preferred method of irrigation.

A wetland (WT) would be constructed in the riverbed near the existing Hennessey Drain outlet near the east end of Reach 6. A berm of coarse rock would be constructed on the upstream side of the WT to provide some protection from scour during flow events and help force flows away from the south bank. The WT would be lined with clay to help maintain surface water level and the saturated soil conditions necessary for vegetation growth. The WT would be adjacent to a new CW stand at its upper (east) end, taking advantage of the saturated soil conditions, and would be irrigated using surface water from the Hennessy Drain and either SBIN or flood irrigation.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to new river bottom. CW, MS, and a small pocket of SD would be planted on the overbank area. The MS and SD would be irrigated using groundwater from a new well. The CW would be irrigated using surface water diverted from the irrigation canal via the SBIN.

The river channel in the western portion of this reach would also be reshaped and converted to new river bottom. WT and CW would be established at Evergreen Drain on the north side of the channel. The CW would be irrigated using ground water from the new well; and the WT would be supported by (run–off) from Evergreen Drain.

The south bank would be vegetated with CW and a small stand of MS. Surface water and stormwater would be used to irrigate these areas. Irrigation of the CW and MS would be done by SBIN. A grade control structure would be placed in the main channel at the center point of the former Gilbert Quarry to protect the Gilbert Road Bridge from head cutting.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. The majority of this area would be left unvegetated due to the

presence of the landfill. However, a narrow strip of CW would be established along the north bank, at the edge of the main channel. The area would be irrigated using surface and storm water via the SBIN.

The area along the south bank would support CW, MS and WT. Two surface water outlets on the south bank would supply water via SBIN. The western outlet would support the WT as well as surrounding CW and MS.

Reach 3: A channel would be constructed to drain the southern portion of Reach 4 to supply water to the CW vegetation in Reach 3 via SBIN.

Reach 2: The northern portion would support a WT feature surrounded by CW to the west, south, and east. These features would be supported by surface water outlets, and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River if it is of sufficient quality.

The south bank would support two wetland features and small areas of CW and MS. One small stand of CW would surround the wetland, while the second stand would be downstream of the first. The wetland would be constructed near the Country Club Storm Drain on the existing river bottom and would need to withstand storm water runoff.

Three wetland features would be created at Alma School Road downstream of the old quarry. The western WT would be flanked by CW to the north while one larger WT to the east and a second smaller WT located just south would be surrounded by a CW stand. The CW would be irrigated using SBIN. A small area south of the wetlands would be reshaped and converted to new river bottom.

Reach 1: This Reach would support four wetland features and three CW stands. One WT would continue from Reach 2 into Reach 1. A second smaller WT would be located to the north, within the main channel and connect with a CW stand to the north. The remaining two wetland features would be created to the west of the existing quarry, above the hardbank. At the far west end, a CW stand would be established within the main channel. Finally, a small CW stand would be established to the north of the existing quarry. The percolation ponds found immediately outside of the southern bank would be planted with CW. This area would be supported using the existing irrigation infrastructure.

ALTERNATIVE E

Reaches 9 and 8: Invasive plant species, primarily saltcedar, would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of invasive species, native vegetation would be planted in its place. Because of the relatively good quality of the existing habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes were proposed in Reach 7 due to the presence of the active Higley Quarry. It was assumed that any vegetation planted would be damaged due to in-channel mining operations.

Reach 6: The existing drainage channel along the north side of the GRUSP site would be extended past Gilbert Road to supply water to northern portion of Reach 5. This channel presently carries Salt River Project water from the Hennessey Drain to the GRUSP. CW would be planted south of the GRUSP site and MS and SD would be planted north of the GRUSP site. The CW would be irrigated using a SBIN. Water from the drainage channel would be diverted to the SBIN for CW use. MS and SD would be planted north of the drainage channel and irrigated using SBIN and/or a drip/bubbler system. Groundwater from a new well would be the source of water. Water that has infiltrated the ground near the GRUSP may support vegetation.

On the south bank, the former quarry would be reshaped and seeded to establish SD. MS would be planted upstream of the quarry outside of the 20-year floodplain, with the area irrigated using SBIN with water diverted from the Hennessey Drain. The south bank would be stabilized with soil cement or coarse rock to prevent headcutting that could compromise the establishment of vegetation.

A WT and CW area would be established at the Hennessey Drain and GRUSP diversion. A berm of coarse rock would be constructed on the upstream side of the WT to provide protection during flow events and contribute to forcing flow away from the south bank. The WT would be lined with clay to help maintain surface water level and the saturated soil conditions necessary for vegetation growth. The WT would be surrounded by CW, taking advantage of the saturated soil conditions, and would be irrigated using SBIN and or flood irrigation. Surface water from the Hennessey Drain would be used to irrigate this area.

Reach 5: The Gilbert Quarry pit would be reshaped and converted to river bottom. The north drain from Reach 6 would continue downstream to Reach 5 to provide water to CW, MS, and SD in and around the new river bottom. The MS and SD would be irrigated using SBIN with groundwater from a new well.

A WT would be created on a terrace at the Evergreen Drain outlet. Groundwater from a new well can be used for additional water, if necessary. The WT would be designed to handle stormflows and disperse stormwater laterally. Side drains would be constructed to disperse the stormwater. Irrigation of the CW and MS surrounding the WT will be provided by installing a SBIN. On the south bank, from Gilbert Road to Lehi Cemetery, SD would be established in the upland area and irrigated with a SBIN, using diverted surface water. The main channel of the river would be reshaped to allow the establishment of river bottom and to increase channel conveyance capacity.

Reach 4: A large portion of this reach is located on a terrace north of the channel that is the site of the closed Tri-City Landfill. MS could be established in this area if there are no water quality

issues and the soil layer over the landfill cap is sufficiently deep to allow trees to establish an adequate root system. The area would be irrigated using surface water or stormwater redirected from the Evergreen Drain to the terrace via SBIN.

Reach 3: No activity is planned in this area.

Reach 2: Along the north bank and within the channel between Alma School Road and Longmore Road, SD would be established and irrigated using SBIN and surface water. A WT and small CW stand would also be established and irrigated using runoff from a golf course. Along the south bank, a WT would be constructed near the Country Club Storm Drain on the existing river bottom. It appears that the wetland area is protected from main channel flow, but the WT will need to be able to withstand stormwater runoff. CW would be planted immediately adjacent to the WT, as would a small stand of MS and SD. This area would be located in a high velocity area and would suffer damage during flow events, on average once every 3 years. However, these flow events would also allow the transport of seeds and vegetative propagules further downstream, aiding establishment of vegetation in new areas. The old quarry at Alma School Road would be converted to new river bottom. Bank stabilization with soil cement is recommended for the south bank between Country Club Road and Alma School Road (Figure 3-4) to prevent a southerly migration of the river resulting in damage to project features and Highway 202. Soil cement bank protection in this area would be 3,000 feet long, 40 feet tall, and 6 feet deep.

Reach 1: An abandoned water recharge area on the south side of the river would be converted from ruderal vegetation to a CW stand. The irrigation system currently used for recharge purposes can be used or modified to irrigate the CW vegetation. The water source for this area is Mesa treatment facility water. The only measure that would be applied to the main channel of the river is the eradication of invasive vegetation species, provided that no threatened or endangered species are associated with them, followed by possible enhancement plantings to avoid reoccurrence of invasive plants.

ALTERNATIVE A

Reach 9 and 8: Invasive plant species, primarily saltcedar, would be removed if no threatened or endangered wildlife species are found associated with them. To prevent rapid reestablishment of invasive species, native vegetation would be planted in its place. Because of the relatively good habitat in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes are proposed in Reach 7 due to the presence of the active Higley Quarry. It is assumed that any vegetation planted would be damaged due to in-channel mining operations.

Reach 6: In the northern part of the reach, SD would be planted on both the north and south sides of the GRUSP site. The SD would be irrigated using a SBIN and water diverted from the drainage channel. Because the vegetated areas are near the GRUSP site, water that has infiltrated

can be used to support vegetation. In the southern part of the reach, SD would be established at the Hennessy Drain, where the north and south GRUSP channels diverge. This area would be irrigated using SBIN and/or flood irrigation. Surface water from the Hennessey Drain would be used as a water source.

Reach 5: The old Gilbert Quarry would be reshaped to create new river bottom. A new groundwater well would be drilled to provide water to SD planted in and around the new river bottom. The SD would be irrigated by SBIN. This water source can also be supplemented by overland flow from water diverted from the Evergreen Drain during storm events. On the western end of the south bank, a small area of SD would be established along the upland area. The SD would be irrigated with SBIN using diverted surface water.

Reach 4: No activity is planned for this reach.

Reach 3: No activity is planned for this reach.

Reach 2: No activity is planned for this reach.

Reach 1: No activity is planned for this reach.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, particularly the attainment of a secure water source, it is unlikely that significant wetland or hydro-riparian vegetation would become established within this reach of the Salt River. Due to river management above the Granite Reef Diversion Dam, it is unlikely that this stretch of the Salt River would ever be characterized by perennial flow. Water would flow in the project area during periods of flood release from the dam, storm water runoff from storm drains, and natural precipitation which falls directly into the river. As described in the No-Action Alternative, this scenario would create no short-term adverse impacts associated with construction and restoration such as habitat fragmentation, sedimentation, and air quality degradation. There also would be no increase in flood protection downstream nor any improvement in water quality.

WITH PROJECT PROJECTION

Alternative F

This would be the most expansive alternative. A low-flow channel would be created from Hennessey Drain to Gilbert Road and from Country Club Road to Alma School Road. Cottonwood-willow and mesquite would be the dominant vegetation types. Water demand would be approximately 8,300 acre-feet/year. Alternative F would produce the most habitat value at 1,035 AAFCUs. Four areas of bank stabilization are proposed and a grade control structure would be placed near the Gilbert Quarry.

Alternative F would result in the most significant increase in cottonwood-willow, freshwater marsh, and open water; substantially increasing native habitat. This alternative would include the physical removal of salt cedar in areas where new habitat would be created, causing a short-term reduction in wildlife habitat. This would be minimized through phasing of project construction. On a long-term basis, habitat value in the region would increase. Cottonwood-willow and mesquite communities are expected to benefit songbirds and raptors. Wetlands are expected to benefit shorebirds, waterfowl, and amphibians. Predatory mammals would likely utilize all vegetation types.

Alternative N

Alternative N would result in the a significant increase in cottonwood-willow, freshwater marsh, and open water. Water demand would be approximately 7,736 acre-feet/year. Habitat values would increase 913 AAFCUs. Short-term impacts of construction on vegetation would be minimized through phasing. O&M activities would be conducted on a rotating basis.

Alternative O

This alternative would provide a diverse vegetation plan including CW, wetland, mesquite, and scrub shrub. Water demand would be approximately 8,500 acrefeet/year. Habitat values would increase 963 AAFCUs. Short-term impacts of construction on vegetation would be minimized through phasing. O&M activities would be conducted on a rotating basis.

Alternative E

Alternative E would result in an increase in cottonwood-willow, freshwater marsh, and open water. Water demand would be approximately 4,568 acre-feet/year. Habitat values would increase 926 AAFCUs. Short-term impacts of construction on vegetation would be minimized through phasing. O&M activities would be conducted on a rotating basis.

Alternative A

This alternative would provide a vegetation plan requiring the least amount of water, approximately 1,001 acre-feet/year. Sonoran desert scrub shrub is the sole vegetation type planned and would be limited to areas near the Hennessey storm drain and the Tri-City landfill. Habitat value would increase by approximately 373 AAFCUs. Short-term impacts of construction on vegetation would be minimized through phasing. O&M activities would be

DISCUSSION

The Va Shly' ay project not only offers a tremendous opportunity to restore native biotic communities within the project area, but also an opportunity to enhance existing biota on the Salt River system. The proximity of perennial portions of the Salt and Verde rivers could complement the Va Shly' ay project by providing habitat contiguity and source populations of desired wildlife. These river corridors provide habitat for a variety of small and large mammals, waterfowl, songbirds, reptiles, amphibians, fishes, and invertebrates that would surely benefit from the availability of new habitat areas.

We are pleased to participate in a project aimed at restoring native vegetation communities, particularly valuable wetland and riparian environments. We believe the most important aspect of wetland and riparian restoration projects is the identification and attainment of a secure water source to ensure adequate hydrologic conditions to support the desired wetland and riparian biotic communities. Mitsch and Gosselink (1993) believe that hydrology is the most important variable in wetland creation and restoration activities and state that if proper hydrologic conditions are developed, the biological and chemical conditions will respond accordingly. They offer several useful parameters to describe hydrologic conditions of restored wetlands including hydroperiod, water depth, and seasonal flood pulses. Additionally, they conclude that most wetland creation and restoration activities that fail do so because of the lack of proper hydrology. We would support efforts to secure WWTP effluent discharge and groundwater as a source of water to sustain the biological resources in the study area.

We believe it would be beneficial to explore opportunities to introduce surface water directly from the Salt and Verde rivers. We encourage efforts to restore a natural hydrograph and scouring flood events to historic river channels such as the Salt River. The proper sequencing of flooding plays an integral role in the maintenance of healthy population structures of Fremont cottonwood and Goodding willow through the deposition of nutrient-rich alluvium, scouring of herbaceous cover, and moistening of riparian soils (Ward *et al.* 1985, Stromberg and Patten 1991) thereby promoting a sustainable ecosystem that would require minimal active management. Assessments should be conducted to evaluate the potential for native riparian vegetation to regenerate naturally. We suggest that project maintenance should not preclude or hinder natural regeneration of native riparian plant species through the removal of seed beds or established saplings. Native riparian regeneration should be encouraged to the greatest extent compatible with other project amenities

We are pleased with the level of information gathered regarding groundwater conditions in the study area. We are also pleased with measures that will be taken to minimize effects of the proposed removal of salt cedar vegetation and revegetation with cottonwood, willow, and emergent vegetation. Although we support efforts to restore native riparian vegetation, we believe it important to ensure that areas currently occupied by salt cedar would be suitable environments for establishment, regeneration, and survival by native vegetation. Prior to committing to a restoration program, consideration should be given to microhabitat conditions

such as depth to water table, soil texture, and salinity. Consideration should also be given to large-scale ecological processes such as floods, which species such as cottonwood and willow depend upon for seed-bed formation, seed dispersal, germination, seedling establishment, recruitment, and survival.

The majority of failed riparian restoration activities that included removal of salt cedar and subsequent replacement with native vegetation failed because of attempts to establish desirable species on degraded sites, typically with incompatible soil moisture or salinity (Briggs *et al.* 1994, Barrows 1998). In the absence of flooding at the time of seed production, it is unlikely that cottonwoods and willows would experience substantial reproduction or recruitment (Anderson 1998). If revegetation is unsuccessful, it is possible that removal of salt cedar could reduce habitat value for native wildlife. We suggest that a thorough assessment of site suitability for native vegetation be conducted before large-scale removal of salt cedar is performed. Consideration should be given to depth to groundwater, soil salinity and texture, flood frequency and intensity, groundwater fluctuations, site preparation, protection of plantings from herbivory, necessity of irrigation, potential for competition from undesirable species, and long-term management potential for the site. If assessments indicate that revegetation efforts have a high probability of success, we offer the following specific suggestions to hopefully improve the proposed project.

We encourage replanting with honey mesquite, because woodlands of honey mesquite have experienced significant decline. Seeds rather than rooted cuttings work best for producing mesquite container stock (Rorabaugh 1995).

We support examining soil quality and water table depth to determine the locations for restoration. Anderson (1995) indicates that where depth to the water table exceeds 2.5 meters, the growth of cottonwoods and willows is significantly restricted. This would be most important after irrigation ceases.

Plantings will likely need protection from mammals such as rabbits, gophers (*Thomomys* sp.), beavers, etc. which have been known to decimate revegetation projects. Where feasible, we suggest protecting trees with 3 foot by 18 inch, 1 inch mesh chicken wire baskets firmly supported with metal stakes. Honey mesquite may also be attacked by small insects known as psyllids (Psyllidae). Unfortunately, we know of no method to feasibly control psyllids.

The density of plantings will need to be decided. For southwestern willow flycatcher habitat, we would consider planting cottonwoods and especially willow trees only 10 feet from each other. It may be worthwhile to mix-up the density throughout the site. Up to 400 trees per acre may be reasonable. Use of pole plantings is an acceptable method for cottonwood and willow revegetation. Poles should be cut in late winter when plants are dormant. If groundwater is sufficiently shallow the Aknock-down@ method may be employed, whereby willow cuttings are placed horizontal to the ground to more closely mimic natural regeneration after flood events.

Irrigation should be conducted over the most important time frames or for as long a period as necessary. Irrigation should occur until the plants are dormant in the late fall or early winter. If many plants are found to have died, it may be necessary to increase irrigation (if irrigation is occurring) or to reinitiate irrigation (if irrigation has ceased). This may be a non-issue as the proposal contains a significant water distribution system.

It may be best to plant trees early in the growing season. If trees are planted in March or April, they should have a sufficient growing season and not be stressed from intense summer heat immediately after planting. Also, plants should be allowed to harden off prior to planting.

In addition to implementing strategies to improve the potential success of restored habitats, the Corps should proceed with restoration in a manner that minimizes or eliminates potential adverse effects on existing biological resources, particularly listed species. The conservation measures presented in the DEIS should be implemented, such as surveying salt cedar prior to removal and timing construction around breeding seasons. The Corps has initiated section 7 consultation under the ESA. Any additional measures produced from this consultation should be implemented as well. Additionally, it would be beneficial to time dredging and vegetation clearing outside of winter months when open water and wetlands would be expected to have a high density of waterfowl and shorebirds in the area (typically December through February). This could be closely coordinated with the AGFD.

We are pleased with conservation measures associated with the O&M plan that would be protective of endangered species and their habitats. We suggest the monitoring program include annual surveys and/or habitat assessments to track and evaluate the long-term status of threatened and endangered species and their habitats in the study area. The proposed project could eventually result in the establishment of habitats suitable for species listed as threatened and endangered or those that are candidates for listing. We encourage the local non-Federal sponsors to explore opportunities to develop Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans as appropriate to address future O&M activities that may affect listed species. Such an effort would greatly facilitate operation and maintenance while providing conservation benefits to listed species.

Finally, in regard to the HGM model, though we support the process and outputs generated for this project, we encourage the Corps to work with FWS and AGFD to evaluate opportunities to simplify the HGM methodology for future projects within Arizona.

RECOMMENDATIONS

1) Pursue efforts to secure effluent and groundwater as a source of water to support the biological resources within the study area. Explore opportunities to discharge all available effluent into the river channel in perpetuity.

2) Consider and evaluate opportunities to provide additional surface water to the project area directly from the Salt and Verde rivers by coordinating with water users, managers, agencies, communities, Tribes, and/or other parties interested in riparian habitat improvement (for listed and non-listed animal species) on the lower Verde River below Bartlett Dam from flows more consistent with the natural hydrologic regime.

3) Perform assessments to ensure that site specific microhabitat conditions would be conducive to establishment and growth of cottonwood, willow, and mesquite. Consider depth to groundwater, soil texture and salinity, and flooding. Implement the following specific suggestions if proceeding with revegetation:

a) Plant honey mesquite from containerized stock.

b) Examine soil quality and water table depth.

c) Protect plantings from mammals and other predators.

d) For flycatcher habitat, plant trees in tight dense patches.

e) Irrigate until plants are dormant.

f) Plant trees in the early growing season.

4) Complete section 7 consultation and implement any conservation measures developed during the process.

5) Encourage the local non-Federal sponsors to work with FWS to evaluate the need for Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans.

6) Work with FWS and AGFD on a programmatic basis to simplify the HGM methodology for future restoration within the state of Arizona.

We appreciate the opportunity to provide recommendations for the proposed project. If we can be of further assistance or you have any questions, please contact Mike Martinez (x224).

Sincerely,

for Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
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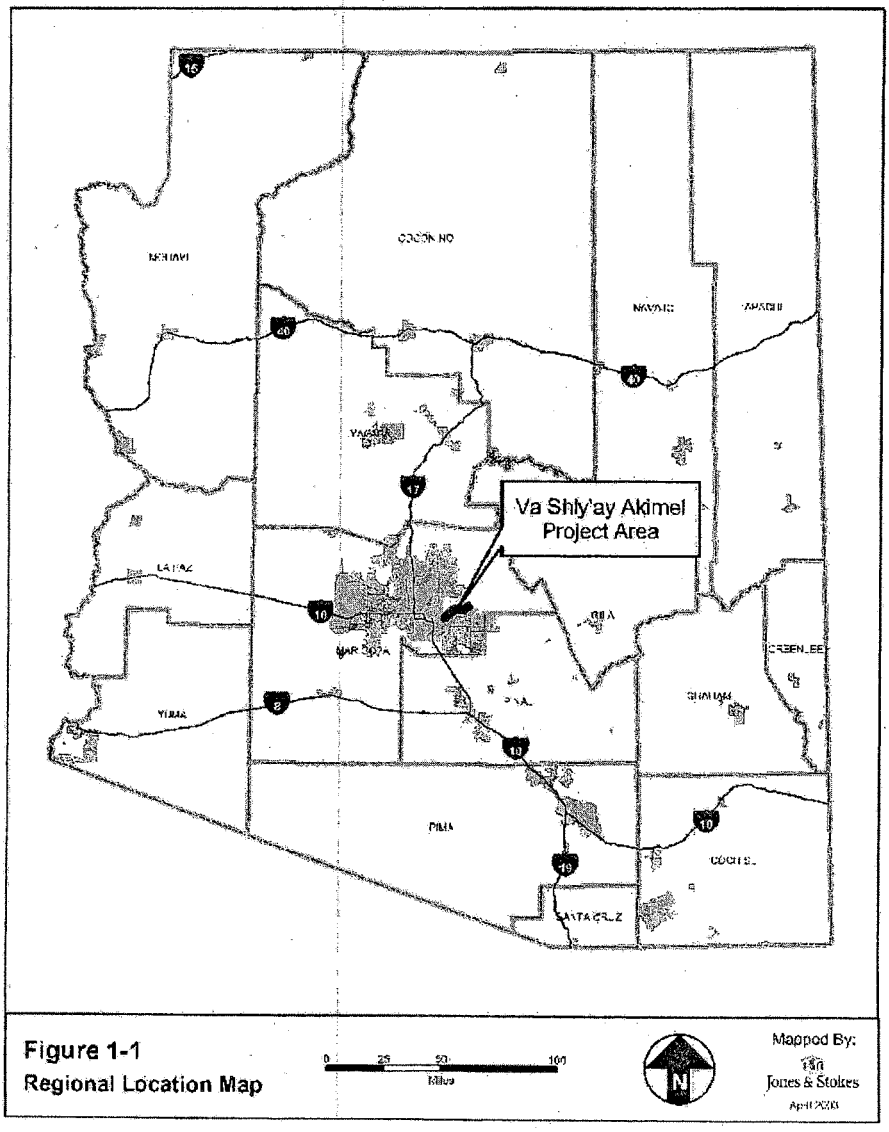
Va Shly'ay Akimel
Project Area
Figure 1-1
Regional Location Map
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Mapped By:
Jones & Stokes
April 2003

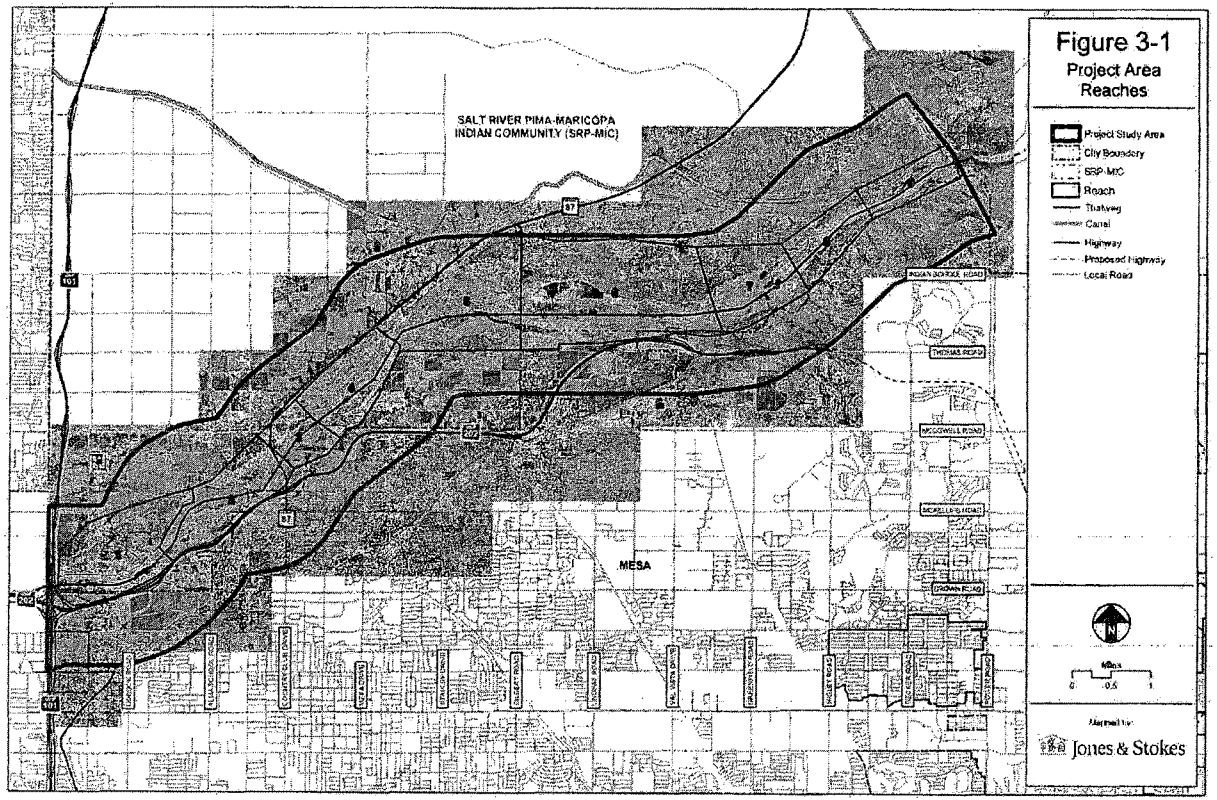
Figure 3-1
Project Area Reaches
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY (SRP-MIC)
MESA
Project Study Area
City Boundary
SRP-MIC
Reach
Thalweg
Canal
Highway
Proposed Highway
Local Road
Jones & Stokes

United States Department of the Interior
U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021-4951
Telephone: (602) 242-0210 Fax: (602) 242-2513

In Reply Refer to:
AESO/FA

March 25, 2003

Ms. Ruth Villalobos
Chief, Planning Division
Attn: Sarah Laughlin
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

This Planning Aid Letter (PAL) presents the Fish and Wildlife Service's preliminary evaluation of potential environmental effects and habitat benefits associated with the U.S. Army Corps of Engineers' proposed Va Shly' ay Akimel, Salt River Restoration project. It is provided pursuant to the Fish and Wildlife Coordination Act (FWCA)(48 stat. 401, as amended; 16 U.S.C. 661 et seq.) but does not constitute our report under Section 2(B) of the FWCA. This PAL is based on coordination with the Arizona Game and Fish Department, literature research, file reviews, and the Corps' Section 905(B) Analysis. More detailed information regarding application of the Hydrogeomorphic Functional Analysis, data on existing conditions, expectations of future without project, and supplemental field surveys will be incorporated into the 2(B) report.

PROJECT DESCRIPTION

The proposed project would provide ecosystem restoration within an approximately 17 mile stretch of the Salt River from the Granite Reef Diversion Dam to the Pima/Price Freeway, Maricopa County, Arizona. The Corps has been authorized to evaluate opportunities for environmental restoration on the Salt River under the Water Resources Development Act of 2001. The City of Mesa and the Salt River Pima-Maricopa Indian Community are potential local sponsors.

EXISTING ENVIRONMENT

Due to the capture, storage, and diversion of river flow by dams along the Salt River, the river bed in the project area is essentially dry, receiving water flow only during storm and flood events. Vegetation mostly includes scatterings of desert broom (*Baccharis sarothroides),* salt cedar (*Tamarix* sp.), and desert willow (*Chilopsis linearis*). The wildlife community is characterized by species adaptable to xeric landscapes, such as black-tailed jackrabbit (*Lepus californicus*), coyote (*Canis latrans*), mourning dove (*Zenaida asiatica*), red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), tree lizard (*Urosaurus ornatus*), and western whiptail (*Cnemidophorus tigris*)

We are unaware of the presence of any threatened or endangered species within the proposed project area. However, we are aware of the presence of suitable habitat for the Yuma clapper rail (*Rallus longirostris yumanensis*) and potentially suitable habitat for the southwestern willow flycatcher (*Empidonax traillii extimus*). A significant marsh community characterized by cattails (*Typha* sp.) and arrowweed (*Pluchea sericea*) is present at the downstream end of the project area near the Loop 101 Highway bridge crossing. Staff from our office have begun limited rail surveys this season. However, due to the size and extent of the marsh, a more extensive survey effort will be needed to adequately cover the site. This site also contains some dense willow (*Salix* sp.) and salt cedar vegetation that may be suitable for flycatchers. Additionally, riparian vegetation upstream near Granite Reef Diversion Dam should be more closely evaluated to determine its suitability for flycatchers.

ALTERNATIVES

The Corps' 905(B) Analysis provides a preliminary array of alternative plans. In addition to no action, these alternatives include: constructed wetlands, grade control structures, a water supply and distribution system, mesquite bosques, cottonwood-willow corridors, recreational amenities, and cultural mitigation.

WITHOUT PROJECT PROJECTION

In the absence of active restoration efforts, particularly the attainment of a secure water source, it is unlikely that significant wetland or hydro-riparian vegetation would become established within this reach of the Salt River. Due to river management above the Granite Reef Diversion Dam, it is unlikely that this stretch of the Salt River would ever be characterized by perennial flow. Water would flow in the project area during periods of flood release from the dam, storm water runoff from storm drains, and natural precipitation which falls directly into the river.

WITH PROJECT PROJECTION

Implementation of the proposed project could restore water and native vegetation to an otherwise barren stretch of the Salt River. The specific nature and configuration of water source and native vegetation has yet to be determined. However, the opportunity exists to provide habitat for a variety of fish and wildlife, particularly native species.

DISCUSSION

The Va Shly' ay project not only offers a tremendous opportunity to restore native biotic communities within the project area, but also an opportunity to enhance existing biota on the Salt River system. The proximity of perennial portions of the Salt and Verde rivers could complement the Va Shly' ay project by providing habitat contiguity and source populations of desired wildlife. These river corridors provide habitat for a variety of small and large mammals, waterfowl, songbirds, reptiles, amphibians, fishes, and invertebrates that would surely benefit from the availability of new habitat areas.

We believe the most important aspect of wetland and riparian restoration is the identification and attainment of a secure water source to ensure adequate hydrologic conditions to support the desired biotic communities. Several parameters are useful to describe proper hydrologic conditions including hydroperiod, water depth, and seasonal flood pulses. Accordingly, significant attention should be focused on securing a permanent and sufficient source of water.

According to the 905(B) Analysis, water to support the proposed project could come from groundwater pumping or the Salt River Project. We would prefer that water come directly from the Salt River rather than groundwater. However, regardless of which source of water is chosen, it would be imperative that an analysis be conducted to determine what effects the water delivery system would have on existing biotic communities above Granite Reef Diversion Dam.

Prior to committing to a restoration program, assessments should be conducted to ensure that proposed areas would be suitable environments for the establishment, regeneration, and survival of native riparian plants. Consideration should be given to microhabitat conditions such as depth to water table, soil texture, and salinity. Consideration should also be given to large-scale ecological processes such as flood regime, which species such as cottonwood and willow depend upon for seed bed formation, seed dispersal, germination, seedling establishment, recruitment, and survival. Other considerations may include groundwater fluctuations, site preparation, protection of plantings from herbivory, necessity of irrigation, potential for competition from undesirable species, and long-term management potential for the site.

The proposed project could eventually result in the establishment of habitats suitable for species listed as threatened and endangered or those that are candidates for listing. We encourage the local non-Federal sponsors to explore opportunities to develop Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans, as appropriate, to address future operation and maintenance activities that may affect listed species.

PRELIMINARY RECOMMENDATIONS

1) Opportunities to provide water to the project area from the Salt River, particularly through a direct surface connection, should be considered and evaluated.

2) The potential effects of groundwater pumping on existing biotic communities along the Salt and Verde rivers should be analyzed.

3) Assessments should be performed to ensure that site specific microhabitat conditions would be conducive to establishment and growth of native riparian plants such as cottonwood, willow, and mesquite.

4) The Corps should encourage local non-Federal sponsors to work with the Fish and Wildlife Service to evaluate the need for Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans.

Ms. Ruth Villalobos

We appreciate the opportunity to provide planning assistance for this proposed project. We look forward to working with you on continued project development and preparation of the FWCA 2(B) report. If we can be of further assistance or if you have any questions, please contact Mike Martinez (x224).

Sincerely,

Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Kayla Eckert, Planning Branch, Army Corps of Engineers, Phoenix, AZ

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Appendix E

Biological Assessment and USFWS Section 7 Concurrence Letter

BIOLOGICAL ASSESSMENT FOR

VA SHLY'AY AKIMEL ENVIRONMENTAL RESTORATION PROJECT

DRAFT

AUGUST 2003

Chapter 1.0
INTRODUCTION

In compliance with the Endangered Species Act of 1973, as amended, this Biological Assessment (BA) allows the U.S. Fish and Wildlife Service (USFWS) and the U.S. Army Corps of Engineers (Corps) to evaluate the potential effects of the Proposed Action on federally listed species or species proposed for listing. The analysis also evaluates the potential effect on designated and proposed critical habitat for those species. This document is used to determine whether a formal consultation or conference is required. Upon receiving an acceptable BA and a request for consultation from a Federal agency, the USFWS enters into consultation with the Federal agency. Should the determination of the effects of the Proposed Action be "may affect but not likely to adversely affect" then informal consultation begins and culminates with a letter of concurrence from the USFWS. Should the determination of the effects of the Proposed Action be "may affect, likely to adversely affect", formal consultation will begin and culminate with a written Biological Opinion (BO). The BO determines whether the action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat (i.e., a jeopardy opinion), or the action is not likely to jeopardize the continued existence of a listed species or result in adverse modification of critical habitat (i.e., a non-jeopardy opinion). Both forms of opinion shall include reasonable and prudent measures; if any, to be taken that will result in a reduction in the amount or extent of take.

The objective of this document is to provide the USFWS with the necessary information on the anticipated impacts to federally listed species occurring, or with the potential to occur, in the study area. The study area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

The Proposed Action involves the restoration of approximately 1500 acres of wetland, cottonwood/willow, mesquite, and Sonoran desert scrub shrub habitat along an approximately 17-mile reach of the Salt River in Maricopa County, Arizona. The Salt River Pima-Maricopa Indian Community (SRPMIC) and the City of Mesa are the local sponsors of this restoration effort.

Chapter 2.0
PROPOSED ACTION – VA SHLY'AY AKIMEL ECOSYSTEM RESTORATION PROJECT

2.1 PROJECT LOCATION

The study area is located in Maricopa County, Arizona, and includes portions of the SRPMIC and the City of Mesa. The study area is approximately 17 miles long, extending along the Salt River between the Pima Freeway and Granite Reef Dam. The study area is approximately 2 miles wide and comprises approximately 17,435 acres (Figure 1).

2.1.1 PROJECT AREA

The land surrounding the project area is made up of a patchwork of jurisdictional and political boundaries between the City of Mesa (the City), unincorporated areas of Maricopa County (the County), and the Salt River Pima-Maricopa Indian Community (SRPMIC).

Several gravel mining operations are located along the Salt River, with processing operations occurring along its banks. These facilities are expected to remain within the project area. The river also contains a large groundwater recharge basin in the central portion of the study area, just east of North Gilbert Road.

The land area north of the Salt River is generally within the SRPMIC reservation. Upland areas south of the river are generally within the City's jurisdiction, but islands of unincorporated areas of the County are also present. A clear contrast is evident between the rural and open character of the upland areas north of the river, within the SRPMIC reservation, and the more urbanized area south of the river, within the City's sphere of influence.

The SRPMIC consists of 52,600 acres, located 15 miles northeast of the City of Phoenix. The SRPMIC maintains 19,000 of its acres as natural preserve. The second most prominent land use is agriculture, which supports a variety of crops, including cotton, melons, potatoes, brown onions, and carrots (Salt River Pima-Maricopa Indian Community 2002). The majority of the central and eastern portions of the study area that are located directly north of the Salt River is a combination of natural preserve areas and agricultural lands. Gravel mining and processing, two closed landfills, and other industrial operations have a significant influence on land use patterns in the western portion of the study area that is located along the north banks of the river. Other land uses throughout the area along the north banks of the river include a shooting range, a recreational vehicle park, private farms, and a commercial golf course.

The west and central portions of the study area south of the river and within the City's sphere of influence are largely made up of very low-density rural residential uses to higher-density suburban residential uses. Industrial and commercial development, with some agricultural uses, has a strong influence on land use patterns in the eastern portion

of the study area. The south banks of the river are also scattered with gravel mining and processing operations.

The proposed project will not change the usage within the area significantly. The primary usage of the river to date has been the sand and gravel mining operations. While their future plans have not yet been determined, it is assumed they will remain in some capacity. Recreation is not expected to increase significantly due to the SRPMIC's wishes to limit non-Community member's access to Community property. A more in-depth analysis of the effects of the proposed action can be found in the preliminary draft EIS provided to your office.

2.2 PURPOSE AND NEED

The purpose of the proposed action is to restore ecosystem functions and processes to improve overall ecological health and return the project area to a less degraded, more natural condition. Implementation of the proposed action would increase the diversity of native plants and animals, enhance the ability of the area to sustain larger populations of key indicator species or more biologically desirable species, and produce a viable, self-sustaining ecosystem that would require only minimal ongoing human intervention. Additionally, the proposed action would provide other of incidental benefits, including improving water quality and supply.

Flood control and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological regime. This alteration, as well as increased agricultural development and urbanization of the metropolitan Phoenix area, has resulted in the substantial alteration of the native cottonwood/willow, mesquite bosque, freshwater marsh, and willow woodland habitat types. Without restoration, habitat values in the study area are expected to further decline within the next 50 years. This will decrease the overall habitat value for wildlife and reduce habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, and other sensitive species.

This project is needed to provide an ecological connection between other riparian restoration projects that are currently underway along the Salt River (See Section 2.4.2, "Relationship to Other Projects," of the Environmental Impact Statement). Restoration of the area may also provide limited passive recreational opportunities.

2.3 DESCRIPTION OF PROPOSED ACTION

The proposed project will likely be completed in stages due to its large size and number of individual features. Currently, it is expected to be completed over a 5-year time frame. Construction will consist of a variety of activities that will involve surface grading and reshaping on both large and small scales (abandoned sand and gravel mine reshaping and irrigation channels), localized excavation (for wetland features), and large-scale plantings of a variety of habitat types. It can be assumed that work will be conducted throughout the year, but will not be continuous. Following is a detailed description of the proposed project features (Figures 2 and 3).

Reach 9 and 8: Invasive plant species, primarily Salt Cedar (*Tamarisk sp*), will be removed if no threatened or endangered wildlife species are found associated with it. To prevent rapid reestablishment of the invasive species, native vegetation will be planted in its place. Because of the relative habitat health in this reach, no other changes to the current conditions are proposed.

Reach 7: No changes were proposed in Reach 7 because of the Higley Quarry Plant. It was assumed that any vegetation planted would be damaged due to in-channel mining operations. The continual quarrying of the Higley Plant would cause scouring to occur along the main channel downstream, particularly in Reach 6. This could potentially damage any attempts to establish vegetation along Reach 6. To reduce the affect of the Higley mining operations the quarry operators should be encouraged to preserve a narrow corridor unaltered by mining within the existing main channel or to create a channel at grade to convey flows and bed load material to Reach 6. By reducing the deposition, bed load material will continue to flow downstream, maintaining the stability of the channel within Reach 6.

Reach 6: Large areas of CW and MS will be established in Area 6.1. The CW is located south of the GRUSP site and will be irrigated using surface water from the Hennessey Drain. The MS is located on the north bank, immediately outside of the active channel, outside of the 10-year flood plain and will be irrigated using ground water from the new well. In both areas the water will be distributed using a flood irrigation method or the Surface Braided Irrigation Network (SBIN). Because the vegetated areas are near the GRUSP, water that has infiltrated can be used to support vegetation. How well the vegetation can rely on infiltrated water is not known at this time; a more detailed analysis is needed.

In Area 6.2, located on the south bank of the river, two areas of CW will be planted; one in an abandoned quarry depression directly east of Gilbert Road and within the 5-year flood plain, and a second narrow strip along the southern edge of the main channel. Both areas will be irrigated using surface water and storm water when available. Flood irrigation is the preferred method of irrigation.

Area 6.3 will have a wetland feature; it will be constructed on the riverbed near the existing Hennessey drain outlet. A berm of coarse rock will be constructed on the upstream side of the wetland. This will provide some protection during flow events and contribute to forcing flow away from the south bank. The wetland will be clay lined to maintain the surface water level and allow for vegetation growth. The wetland will be flanked by a relatively large CW stand to the east, taking advantage of the saturated soil conditions, and will be irrigated using surface water from the Hennessy drain and SBIN or flood irrigation.

Reach 5: The Gilbert Quarry pit will be reshaped and converted to new river bottom, in Area 5.2. CW and MS, and a small pocket of SD will be located on the overbank area. The MS and SD will be irrigated using groundwater from a new well. The CW will be

irrigated using surface water diverted from an irrigation canal. The water will be distributed using SBIN.

The channel in Area 5.1 and the western half of 5.3 will be reshaped and converted to new river bottom. A wetland feature at Evergreen drain will be established, as will CW. The CW will be irrigated using ground water from the new well, and the wetland will be supported by run off from Evergreen drain.

Area 5.3, located along the south bank, will be vegetated with CW and a small stand of MS. Surface water and storm water will be used to irrigate these areas. Irrigation of the CW and MS will be done by SBIN.

A grade control structure will be placed in Area 5.2, in the main channel at the center point of the old Gilbert quarry. This structure would help protect the Gilbert Road Bridge from head cutting due to the extensive mining that has occurred downstream. The structure would span the entire width of the riverbed, approximately 1500 feet, and be designed to the estimated scour depth.

Reach 4: The majority of Area 4.1 will be left unvegetated, due to the existence of the Tri-City Landfill. However, a narrow strip of CW will be established along the north bank, at the edge of the main channel. The area will be irrigated using surface and storm water by way of the SBIN.

Area 4.2, along the south bank, will support CW, MS and a large wetland feature. Two south bank surface water outlets will supply water to the SBIN used to irrigate the vegetation. The western outlet will support the wetland feature as well as surrounding CW and MS. Area 4.2 is relatively protected from the main channel so damages to the channel and the irrigation system would occur less frequently.

Reach 3: A channel will be constructed to drain Reach 4.2 to supply water to the CW vegetation of Area 3.1. Water will be dispersed using the SBIN.

Reach 2: Area 2.4 will support a wetland feature surrounded by CW to the west, south, and east. These features will be supported by surface water outlets, and maintained using a SBIN. Additional water may be supplied by a golf course located north of the Salt River, if it is of sufficient quality.

Along the south bank, Area 2.3 will support a two wetland features, and small areas of CW and MS. One small stand of CW will surround the wetland; a second larger stand will start in the eastern edge of Area 2.3 and extend into Area 2.2. The wetland will be constructed near the Country Club Storm drain on the existing river bottom and will need to withstand storm water runoff.

Three wetland features will be created in Area 2.2, at Alma School Road downstream of and within the old quarry. The western small wetland will be flanked by CW to the north while the larger wetland to the east will be surrounded by a CW stand. The CW will be

irrigated using SBIN. A small area, south of the wetlands, will be reshaped and converted to new river bottom.

Reach 1: Area 1.1 will support four wetland features, and three CW stands. One wetland will continue from Area 2.2. A second smaller wetland will be located to the north, within the main channel and will connect with a CW stand to the north. The remaining two wetland features will be created to the west of the existing quarry, above the hardbank. A CW stand will be established within the main channel, at the far west end of Area 1.1. Finally, a small CW stand will be established to the north of the existing quarry. The percolation ponds found immediately outside of the southern bank in Area 1.2, will be planted with CW. This area will be supported using the existing irrigation infrastructure.

Water Sources: 9 new irrigation diversions structures and 1 new well are proposed for this alternative.

2.4 OTHER ALTERNATIVES CONSIDERED

An initial array of 15 alternatives (including the No-Action Alternative) was developed by the Corps and the local sponsors (Salt River Pima-Maricopa Indian Community and the City of Mesa) during the alternatives formulation process. The alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel modification, water source, infrastructure). Alternatives were initially developed based on the Corps' federal planning objectives for water resource projects, specific planning objectives developed for the Va Shly'ay Akimel Ecosystem Restoration Project, and project-specific opportunities and constraints for implementing restoration activities. These alternatives were later refined based on input received through public meetings and coordination with local and regional agencies.

Following formulation and refinement of the project alternatives, the alternatives were ranked and screened based on associated habitat benefits and implementation costs. The Hydrogeomorphic (HGM) wetland assessment method was used by the Corps' planning team to identify and quantify the anticipated habitat benefits associated with the proposed restoration alternatives. The HGM method assesses and quantifies the functional values of existing wetland habitat types (e.g., water storage, plant community characteristics) and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives.

Results of the HGM assessment were incorporated into the Corps' standard cost evaluation analysis (ICA) to identify the alternatives that provided the highest habitat benefits per unit cost. The four highest-ranking alternatives were then evaluated in greater detail.

2.4 NO ACTION ALTERNATIVE

Under the No-Action Alternative, the Corps would take no action to restore the ecosystem and wildlife habitat within the study area. Plans with potential incidental benefits to improve water quality and water supply also would not be provided by the Corps. Although it is possible that local agencies would implement limited improvements, restoration efforts would not occur on the scale of the proposed project.

Chapter 3.0
SPECIES ACCOUNT

Viable habitat for most species of concern is limited to an area immediately downstream of the Granite Reef Dam and near the Pima Freeway and Highway 202 Loop interchange. The preferred alternative recommends only exotic species removal below the Granite Reef Dam, with potential replanting of native species to prevent reoccurrence; at the downstream end, new cottonwood/willow will be established on the eastern end of the existing habitat.

The following list of federally threatened, endangered, or proposed species was obtained from the USFWS, Arizona Ecological Services website (http://arizonaes.fws.gov).

Wildlife Species

Bald eagle (*Halieaetus leucocephalus*) – threatened
Yuma clapper rail (*Rallus longirostris yumanensis*) – endangered
Cactus ferruginois pygmy-owl (*Glaucidium brasilianum cactorum*) – endangered
Southwestern willow flycatcher (*Empidonax traillii extimus*) – endangered
Yellow-billed cuckoo (*Coccyzus americanus*) – candidate/wildlife species of concern
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – endangered
California Brown Pelican (*Pelecanus occidentalis californicus*) – endangered
Mexican spotted owl (*Strix occidentalis lucida*) – threatened
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – endangered
Desert pupfish (*Cyprinodon macularius*) – endangered
Razorback sucker (*Xyrauchen texanus*) – endangered
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – endangered
Gila chub (*Gila intermedia*) – proposed endangered

Plant Species

Arizona agave (*Agave arizonica*) - endangered
Arizona cliffrose (*Purshia subintegra*) - endangered

The assessment of species within the study area included a background literature search, discussions with resource agencies, and completion of site evaluations and in some cases, wildlife surveys. Literature used in this analysis includes: *Birds of Phoenix and Maricopa County, Arizona; Clearing of phreatophytic vegetation from the Salt and Gila Rivers, Ninety-first Avenue to Gillespie Dam, Maricopa County, Arizona: Draft environmental assessment; Salt-Gila River baseline ecological characterization; Wildlife of special concern in Arizona; Clapper rail (Rallus longirostris) In: The birds of North America*; *Coccyzus americanus*; *Glaucidium brasilianum*; *Bats of the United States; Amphibians and reptiles of western North America;* and *Threatened native wildlife in Arizona.*

3.1 SENSITIVE PLANT SPECIES

Sensitive plants include those species that are listed by Federal or state resource agencies. Species that are proposed to be listed by the USFWS are assessed in a manner similar to listed species by that agency; however, in the case of proposed species, recommendations of the USFWS are advisory rather than mandatory. There are two listed plant species of concern that occur within Maricopa County: Arizona agave (*Agave arizonica*) and Arizona cliffrose (*Purshia subintegra*).

3.1.1 Arizona agave – No effect

Arizona agave has bright green leaves with dark mahogany margins and yellow flowers. This species of agave is found in the transition zone between oak-juniper woodland and mountain mahogany-oak scrub between 3000 and 6000 feet in elevation. It is usually found on steep, rocky slopes in the New River Mountains and Sierra Ancha. It is possibly found in the Mazatal Mountains and can occur on drainage bottoms or relatively gentle slopes or saddles. This species has experienced a decline in habitat due to herbivory of flowering stalks and historic overuse by livestock, feral burros, and wildlife (http://arizonaes.fws.gov). The terrain that surrounds the project area is relatively flat with no significant or mountainous landforms in the near vicinity. The project elevation is roughly 1200 feet with no oak-juniper woodland or mountain mahogany-oak scrub present. Therefore, habitat does not exist for this species. The proposed project will have no effect on the Arizona agave.

3.1.2 Arizona cliffrose – No effect

The Arizona cliffrose is an evergreen shrub approximately 5 feet in height. The bark is pale gray and shreddy and the flowers have 5 white or yellow petals. It is found only on Teritiary limestone lakebed deposits at elevations below 4000 feet. The known site within Maricopa County is at Horseshoe Lake, although it may have the potential to occur at other sites where Teritiary limestone lakebed deposits occur. Threats to this species include its localized habitat, urbanization, mining, overuse by cattle and burros and off-road vehicle traffic (http://arizonaes.fws.gov). The project site occurs within a river channel bed and does not support the necessary soil substrate or habitat for this species. Therefore, the proposed project will have no effect on the Arizona cliffrose.

3.2 SENSITIVE WILDLIFE SPECIES

Sensitive wildlife species include those federally or state-listed threatened or endangered species, those species proposed for Federal or state listing, and Federal candidate species. There are thirteen federally listed species that occur within Maricopa County: bald eagle (*Halieaetus leucocephalus*), Cactus ferruginois pygmy-owl (*Glaucidium brasilianum cactorum*), California Brown Pelican (*Pelecanus occidentalis californicus*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), Yuma clapper rail (*Rallus longirostris yumanensis*), the proposed Yellow-billed cuckoo (*Coccyzus americanus*), Lesser long-nosed bat (*Leptonycteris*

curasoae yerbabuena), Sonoran pronghorn (*Antilocapra Americana sonoriensis*), Desert pupfish (*Cyprinodon macularius*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), Razorback sucker (*Xyrauchen texanus*), and the proposed Gila chub (*Gila intermedia*).

3.2.1 Birds

3.2.1.1 Bald eagle – May affect, not likely to adversely affect

The bald eagle was reclassified from endangered to threatened in July 1995 and in 1999 was proposed to be removed from the list of Endangered and Threatened Wildlife in the lower 48 states of the U.S. Although the nesting populations are increasing throughout the U.S., the bald eagle is still threatened by habitat loss, human encroachment on nesting sites, reduction in native fish species, illegal shooting, and heavy metals (http://arizonaes.fws.gov). Bald eagles nest in large trees near lakes and streams, and hunt for waterfowl and fish in wetlands and along rivers and lakes. They also feed on small mammals and carrion. Bald eagles have been reported nesting along the Salt River east of Phoenix since the 1930s (Witzeman et al. 1997). Although they do not nest in the project study area due to lack of suitable habitat, they occur in the area as winter visitors and migrants (Benham-Blair Associates 1980) and have been observed foraging along the rivers in the project study area (CH2M HILL et al. 1997). The open water marsh near the project study area (immediately downstream of the Pima Freeway and Highway 202 Loop interchange) may be suitable foraging habitat for bald eagles. However, the area of open water currently found at the furthest downstream portion of the study area is very small in size, approximately 1 acre and linear in shape (pers. Comm.. A. Gibbons, Jones & Stokes). A second open water area further upstream, but still within Reach 1 of the proposed project is approximately seven acres in size during the wet season. Due to the relatively small size and likely very low fish populations found within the open water currently on-site these areas are not likely a significant source of foraging habitat, considering the higher quality habitat further downstream. In the furthest downstream area of existing open water, exotic vegetation species will be removed and replaced with native vegetation. No other construction activity is planned within these areas. Multiple wetlands within the greater project area will increase the overall foraging habitat of this species by approximately 200 acres, providing a beneficial effect. Due to the temporary disturbance associated with the existing open waters and the significant increase in open water features, the proposed project may affect but is not likely to adversely affect any potentially existing bald eagles.

3.2.1.2 Cactus ferruginous pygmy-owl – No effect

The cactus ferruginous pygmy-owl is a small reddish-brown owl with a cream-colored belly streaked with reddish-brown. The pygmy-owl's diet includes birds, lizards, insects, and small mammals. It is non-migratory throughout its range. Historically, the cactus ferruginous pygmy-owl occurred as far north as the confluence of the Salt and Verde Rivers but recent observations have been limited to Pima and Pinal Counties. This species occurs in riverbottom woodlands, and palo verde cacti-mixed scrub associations

of the Sonoran desert. In southern Arizona, the pygmy-owl is currently found primarily in Sonoran desert scrub vegetation with some locations in riparian drainages and semi-desert grassland vegetation communities. It will nest in saguaro cacti or tree cavities below 4000 feet in elevation (http://arizonaes.fws.gov). Pygmy-owls have declined in part because of urban development, reduction of suitable habitat, and competition from other cavity-nesting birds (Arizona Game and Fish Department 1996, Arizona Game and Fish Department 2001a). The proposed project will establish approximately 24 acres of new scrub, 380 acres of new mesquite and 880 acres of new cottonwood/willow habitat; significantly increasing the suitable habitat for this species. Because the project site is currently limited to creosote dominated scrub shrub, only 4 acres of existing mesquite, little mature cottonwood, and no observations of cactus ferruginous pygmy-owls have been recently recorded within 50 miles of the project area (CH2M HILL et al. 1997, Witzeman et al. 1997), it can be determined that this project will have no effect on the cactus ferruginous pygmy-owl.

3.2.1.3 California brown pelican – No effect

The California Brown pelican is considered an uncommon transient in Arizona on many Arizona lakes and rivers. The pelican has recently been observed on Tempe Town Lake; and there are tentative plans to conduct a relocation effort to move the Tempe Town Lake pelicans back to habitat more suitable for their needs (pers. Comm., M. Martinez, USFWS). During a recent Yuma clapper rail survey conducted in May 2003, two pelicans were observed flying over the project sight. However, the pelicans were not seen using the habitat and are not expected to nest in the area. Because the California brown pelican was not seen using the project site and is known to use Tempe Town Lake, an area approximately 4 miles from the project site, it can be determined that the proposed action will have no effect on this species.

3.2.1.4 Mexican spotted owl – No effect

The Mexican spotted owl is a medium sized owl with large dark eyes and no ear tufts. It's plumage is brown with numerous white spots and posterior underparts have short, horizontal bars or spots. It generally nests in older forests of mixed conifer or ponderosa pine/gambel oak type, in canyons. In forested habitat, uneven-aged stands with a high canopy closure, high tree density, a sloped terrain and cool microclimates appear to be of importance. The spotted owl's nests are found in live trees, snags, and on canyon walls between 4100 and 9000 feet (http://arizonaes.fws.gov). Currently, the Mexican spotted owl is patchily distributed in Arizona and occurs in all but the arid southwestern portion of the state. The proposed project is found in the arid portion of Arizona and is completely void of the required habitat; therefore the project will have no effect on the Mexican spotted owl.

3.2.1.5 Southwestern willow flycatcher – No effect

The southwestern willow flycatcher is a small migratory bird with a grayish-green back and wings, a white throat, a light gray-olive breast, and a pale yellowish belly. Two wingbars are visible. It prefers nesting in dense willow riparian habitats and is also found

in areas of saltcedar in the Sonoran Life Zone (e.g., the lower Big Sandy River, lower Santa Maria River, Bill Williams Delta, upper Gila River, Grand Canyon, and middle Salt River). Nests are found in thickets of trees and shrubs about 13-23 feet in height, among dense and homogenous foliage at elevations below 8500 feet. Historically, the southwestern willow flycatcher nested along the Salt, Gila, and Agua Fria Rivers (CH2M HILL et al. 1997). Currently, there are just over 900 breeding pairs documented in the Southwest and recent statewide surveys indicate that fewer than five nesting pairs occupy most sites. Individuals in Arizona are found in the middle Salt River and upper Verde River, among sites along other rivers (http://arizonaes.fws.gov) and are currently considered an uncommon transient in Maricopa County, with only a few historic summer records (Witzeman et al. 1997). The flycatcher has declined for a variety of reasons, including habitat loss and fragmentation resulting from flood control projects, development, and intensive grazing. Brown-headed cowbird nest parasitism may also have contributed to the species' decline (Arizona Game and Fish Department 1996). The project area has approximately 130 acres classified as willow, cottonwood/willow, and willow saltcedar habitat in the project study area. However, these acres are sparse, patchy and almost exclusively a single row of trees (pers. Comm., A. Gibbons, Jones & Stokes). To date, focused surveys have not been completed due to lack of suitable habitat (pers. Comm., A. Gibbons, Jones & Stokes; T. Corman, AGFD). The proposed project will increase the cottonwood/willow habitat by approximately 880 acres, creating a significant positive benefit for this species. Because of the current lack of suitable habitat, and proposed increase in cottonwood/willow, the proposed project will have no effect on the southwestern willow flycatcher.

Yuma clapper rail – No effect

The Yuma clapper rail is a long marsh bird with long legs and a short tail. Its bill is long, slender, and curved downward slightly. It is mottled brown on a gray background; its flank and underside are dark gray with narrow vertical white stripes (http://arizonaes.fws.gov). This inland clapper rail occurs in cattail, sedges, and bulrush marshes along the Colorado River, the lower Gila and Salt Rivers below the Verde/Salt River confluence, and Pichacho Reservoir (Arizona Game and Fish Department 1996, Eddelman and Conway 1998) and is often associated with dense riparian and marsh vegetation. This species has declined because of the loss and fragmentation of river marshes. Toxic levels of heavy metals, such as selenium, could also have contributed to the species' decline (Arizona Game and Fish Department 1996). Its current distribution is along the Colorado River, from Lake Mead to Mexico; on the Gila and Salt rivers upstream to the area of the Verde confluence; at Picacho Reservoir; and on the Tonto Creek arm of Roosevelt Lake (http://arizonaes.fws.gov). The Yuma clapper rail is known to occur as a rare and local summer resident in cattail marshes in the Salt River south and west of Phoenix (Witzeman et al. 1997). There is sufficient marshland habitat for this species to occur within the downstream portion of the project study area, therefore, a USFWS protocol level survey was conducted in May 2003. A copy of the survey report can be found in Appendix A of this document. Surveys resulted in no Yuma clapper rails. Therefore, the proposed action will have no effect.

3.2.1.6 Yellow-billed cuckoo – No effect

The yellow-billed cuckoo is a medium-sized bird with a slender, long-tailed profile. It has a fairly stout and slightly down-curved bill, which is black with yellow on the basal half of the lower mandible. The bird is grayish-brown above and white below with rufous primary flight feathers. The tail feathers are boldly patterned with black and white below. In Arizona, the yellow-billed cuckoo is found locally in streamside cottonwood and willow groves, and prefers to nest in willow or mesquite thickets (Arizona Game and Fish Department 2001b). Historically, this species was widespread and locally common in Arizona; currently, based on preliminary results of a statewide survey, one hundred sixty-eight pairs and 80 individuals were located in Arizona in 1999 (http://arizonaes.fws.gov). The primary reason for population decline is the loss, degradation, and fragmentation of riparian habitat. Prior to 1998, approximately thirteen cuckoo territories were found along the Salt River, although none were located within this proposed project site. Additional surveys have been completed by state agencies since 1998. Results showed one pair of cuckoos between upstream of the Granite Reef Dam and the confluence of the Salt and Gila rivers (pers. Comm.., B. Wilson, Jones & Stokes). Consequently, the yellow-billed cuckoo is considered an uncommon local summer resident (Witzeman et al. 1997). Although candidate species do not benefit from the same protection as listed species, their current rarity warrants protection. Due to lack of suitable habitat, and no findings within the project area during recent surveys, it is determined that the proposed project will have no effect on the yellow-billed cuckoo.

3.2.2 Mammals

3.2.2.1 Lesser long-nosed bat – No effect

The lesser long-nosed bat, previously known as Sanborn's long-nosed bat, is medium-sized with yellowish-brown or pale gray above and cinnamon-brown below. It has a slender elongated nose with a small nose-leaf on the tip, and a minute tail. It is found mainly in desert scrub habitat, and roosts in caves, abandoned mines, and unoccupied buildings at the base of mountains where agave, saguaro, yucca, and organ pipe cacti are present (http://arizonaes.fws.gov; Harvey et al. 1999). It forages at night on nectar, pollen, and fruit of panicultate agaves and columnar cacti. Considerable evidence exists for the interdependence of *Leptonycteris* bat species and certain agaves and cacti (http://arizonaes.fws.gov). The lesser long-nosed bat population has declined for reasons that include: human disturbance at breeding and roosting sites, habitat loss, and excessive harvest of certain agaves and cacti; however, the population appears stable (Arizona Game and Fish Department 1996). This bat is a summer resident (April – September) of central and southeastern Arizona. Although there are records for this species from the Phoenix area, the project area does not support roosting sites, nor does it support the necessary foraging vegetative species. Desert areas within the project site are dominated by creosote bush with scattered white bursage and other small shrubs, and limited areas of creosote bush, saguaro, yellow paloverde, cholla and barrel cactus. Because the proposed project site does not support the necessary foraging species or roosting sites for the lesser long-nosed bat, the project will have no effect.

3.2.2.2 Sonoran pronghorn – No effect

The Sonoran pronghorn are long-legged, small-bodied artiodactyls (hoofed animals with an even number of toes on each foot). Their upper parts are tan; the underpart, rump and two bands across the neck are white. Both sexes have horns, although they are larger in males. All Sonoran pronghorn populations occur in Sonoran desert scrub vegetation communities; creosote and white bursage comprise the major vegetation in the Lower Colorado River Valley subdivision. Plant species along major watercourses include ironwood, blue palo verde, and mesquite; species in the Arizona Upland include foothill palo verde, catclaw acacia, chain fruit cholla, teddy bear cholla, buckhorn cholla and staghorn cholla. Typcial habitat ranges between 2,000 and 4,000 feet in elevation within broad intermountain alluvial valleys separated by block-faulted mountain and surface volcanic (http://arizonaea.fws.gov). Historical ranges within southwest Arizona included south of the Bill Williams River and east to the Santa Cruz River. Currently, an extant population exists in southwestern Arizona. The primary cause of pronghorn population decline includes barriers to movement caused by roads, canals, and fences, and conversion of habitat to other uses (http://arizonaes.fws.gov). The proposed project study site is at approximately 1200 feet in elevation and is surrounded by development and urban areas to the south. Therefore, the project site does not contain suitable habitat and will have no effect on the Sonoran pronghorn.

3.2.3 **Fish**

3.2.3.1 Desert pupfish – May affect, not likely to adversely effect

The desert pupfish is a small fish with a smoothly rounded body shape and narrow, vertical dark bars on its sides. Breeding males are blue on the tops and sides, and have yellow fins. Females and juveniles are tan to olive colored on their backs and silvery on their sides. These fish are found in shallow water of desert springs, small streams, and marshes below 5, 000 feet in elevation. The pupfish also tolerates high salinities and high water temperatures. This species was once common in desert springs, marshes, backwaters, and tributaries of several large rivers in Arizona but is currently restricted to one natural population in Quitobaquito Spring Pond in Pima County due to the introduction of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, stream channelization, and habitat modification (http://arizonaes.fws.gov). Reintroductions have been made in Maricopa County in the past but were unsuccessful. Additional reintroductions were made northwest of Lake Pleasant and others are planned (Pers. comm., J. Voeltz, AGFD). Although no known populations occur within the project area, it is possible that suitable conditions exist immediately downstream of Granite Reef Dam and at the Pima Freeway and Highway 202 interchange. The project proposes only to remove exotic vegetation from the Granite Reef area and replace with native species; the Pima Freeway/Highway 202 Loop interchange existing habitat will not be affected. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because suitable habitat may exist within the project area, the determination is that the project may affect the desert pupfish. However, because the existing potential habitat

will not be removed, and substantial new habitat will be added, the project will not adversely affect the pupfish.

3.2.3.2 Gila topminnow – May affect, not likely to adversely affect

The Gila topminnow is a small guppy-like, live-bearing fish that lacks dark spots on its fins. It occurs in small streams, springs, and cienegas below 4500 feet in elevation primarily in shallow areas with aquatic vegetation and debris for cover. This species can also tolerate relatively high water temperatures and low dissolved oxygen. Historically it was one of the most common fish found throughout the Gila River drainage in Arizona. However, due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification, it is restricted to the Santa Cruz River system and other small streams in several counties, including Maricopa (http://arizonaes.fws.gov). Although of lower quality, potential habitat exists immediately below the Granite Reef Dam and at the Pima Freeway and Highway 202 interchange. The project proposes only to remove exotic vegetation from the Granite Reef Dam area and replace it with native species; the Pima Freeway/Highway 202 Loop interchange existing habitat will not be affected. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat. Because suitable habitat may exist within the project area, the determination is that the project may affect the Gila topminnow. However, because the existing potential habitat will not be removed, and substantial new habitat will be added, the project will not adversely affect the minnow.

3.2.3.3 Razorback sucker – May affect, not likely to adversely affect

The Razorback sucker has a head that is flattened on top with a stout body with olive-brown above to yellowish on the belly. A long, high, sharp-edged keel-like hum is found behind the head. This fish is found in backwaters, flooded bottomlands, pools, side channels and other slower moving habitats below 6000 feet in elevation. Historically the sucker was found near strong currents in all major rivers and larger streams in the Colorado River Basin. Currently, in the Lower Basin, populations are isolated to Lakes Mohave, Mead, and the lower Colorado River below Havasu. Alteration of river conditions and loss of habitat caused by dam construction, irrigation dewatering and channelization, as well as the introduction of exotic fish, are all responsible for this species decline (http://arizonaes.fws.gov). Several areas of critical habitat have been designated but none are found within Maricopa County. Reintroductions have been done in the Salt and Verde rivers with ongoing introductions near Childs, AZ (Pers. Comm., J. Voeltz, AGFD). Because of the recent introductions and the potential for suitable habitat for the Razorback sucker, the proposed project may affect this species. However, the project proposes only to remove exotic vegetation from the Granite Reef Dam area and replace it with native species; the Pima Freeway/Highway 202 Loop interchange existing habitat will not be affected. The project also proposes to increase the wetland area by approximately 200 acres creating substantially more potential habitat, providing a beneficial effect. Therefore, the project will not adversely affect the Razorback sucker.

3.2.3.4 Gila chub – No effect

The Gila chub is a small-finned, deep-bodied chubby member of the minnow family. It is dark colored with diffuse lateral bands that are rarely present. They are commonly found in pools, springs, cienegas, smaller streams, and artificial impoundments between 2,000 and 3,500 feet in elevation. Common riparian plants associated with these populations include willow, tamarisk, cottonwoods, seep-willow, and ash. Historically, the chub's range likely included suitable habitat throughout the entire Gila River basin, except the Salt River drainage above Roosevelt Lake. Currently, they have been recorded in approximately 30 rivers, streams, and spring-fed tributaries throughout the Gila River basin, although none have been recorded in Maricopa County. Roughly 90% of suitable habitat has been degraded or destroyed due to extensive grazing, mining operations, increased recreation usage and the introduction of exotic species (http://arizonaes.fws.gov). Proposed critical habitat sites have been identified, but none exist within Maricopa County. Because the Gila chub has not been recorded in Maricopa County within recent surveys and its lowest habitat elevation range is approximately 800 feet above the elevation of the proposed project, it can be determined that there will be no effect on this species.

Chapter 4.0
CONCLUSIONS

As a result of ongoing coordination with the USFWS, project features that would most likely increase and improve habitat conditions for a variety of species, including those listed as federally endangered or threatened, were given greatest consideration. Given the rarity of riparian ecosystems within the arid southwest, the proposed project attempted to establish as many acres of wetland, and cottonwood/willow as was practicably feasible, given the limitations of available surface water and current land use. Additional acres of new mesquite and desert scrub shrub are also planned to complete the upper slopes of desert riparian systems.

Through examination of the project site, current literature searches and survey results, and discussions with resource agency personnel, the proposed project was determined to have either "no effect" or "no adverse affect" on the 15 federally listed threatened, endangered, proposed, or candidate species. The determinations are as follows:

Arizona agave (*Agave arizonica*) – No effect.
Arizona cliffrose (*Purshia subintegra*) – No effect.
Bald eagle (*Halieaetus leucocephalus*) – May affect, not likely to adversely affect
Yuma clapper rail (*Rallus longirostris yumanensis*) – No effect
Cactus ferruginois pygmy-owl (*Glaucidium brasilianum cactorum*) – No effect
Southwestern willow flycatcher (*Empidonax traillii extimus*) – No effect
Yellow-billed cuckoo (*Coccyzus americanus*) – No effect
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuena*) – No effect
California Brown Pelican (*Pelecanus occidentalis californicus*) – No effect
Mexican spotted owl (*Strix occidentalis lucida*) – No effect
Sonoran pronghorn (*Antilocapra Americana sonoriensis*) – No effect
Desert pupfish (*Cyprinodon macularius*) – May affect, not likely to adversely affect
Razorback sucker (*Xyrauchen texanus*) – May affect, not likely to adversely affect
Gila topminnow (*Poeciliopsis occidentalis occidentalis*) – May affect, not likely to adversely affect
Gila chub (*Gila intermedia*) – No effect

This Biological Assessment serves as the documentation of these determinations and will be accompanied by a cover letter asking for written concurrence by the USFWS. The Corps understands that should the project or project site conditions change in a way that may affect threatened or endangered species, or the determinations made in this document, the USFWS would be notified and Section 7 Consultation would be reinitiated.

Chapter 5.0
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In Reply Refer to:
AESO/SE
02-21-03-I-0171

February 20, 2004

Ms. Ruth Villalobos
Chief, Planning Division
Attn: Sarah Laughlin
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Ms. Villalobos:

Thank you for your October 22, 2003 letter requesting consultation under section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531-1544), as amended, for the proposed Va Shly' ay Akimel Environmental Restoration Project located along the Salt River in Maricopa County, Arizona. We have also received your October 2003 Biological Assessment (BA) and May 2003 preliminary Draft Environmental Impact Statement (DEIS). Subsequent coordination with your agency has indicated that the proposed action includes the 3-5 year construction phase and implementation of the 5 year monitoring and adaptive management plan (MAMP), presented in Appendix A of the DEIS. Based on discussion with your staff, the Corps has determined that the proposed action may affect, but is not likely to adversely affect, bald eagle (*Haliaeetus leucocephalus*), cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*), Yuma clapper rail (*Rallus longirostris yumanensis*), southwestern willow flycatcher (*Empidonax traillii extimus*), and California brown pelican (*Pelecanus occidentalis californicus*).

We have reviewed the BA and DEIS and have revisited our draft Fish and Wildlife Coordination Act Report. The detailed project description contained in those documents is rather lengthy and will not be repeated here. In general, the proposed action would include the removal of undesirable vegetation, delivery of water, and planting of native riparian plant species along the Salt River from Granite Reef Dam to the Loops 101 and 202 freeway crossings. The Corps would turn responsibility for operation and maintenance (O&M) over to the local non-Federal sponsors after the fifth year following completion of construction.

The following summarizes relevant information on each species:

Yuma clapper rail: Suitable habitat for the clapper rail is currently limited to the area where the Loop 101 Freeway crosses the Salt River. A large wetland community characterized by perennial water and cattail (*Typha* sp.) exists in this area. This wetland was surveyed extensively during May 2003, and no clapper rails were detected. Also, project construction would not entail native vegetation removal or dewatering within suitable rail habitats.

Southwestern willow flycatcher: Riparian woodlands characterized by cottonwood (*Populus fremontii*), willow (*Salix* sp.), and salt cedar (*Tamarix* sp.) within the project area are generally sparse, patchy, and unsuitable for the southwestern willow flycatcher. Additionally, prior to construction, if suitable habitat has developed in an area scheduled for disturbance (likely in the form of salt cedar thickets), the Corps will re-evaluate the situation in coordination with us, and conduct surveys for flycatcher if necessary.

Cactus ferruginous pygmy-owl: The species has not been detected within or near the study area since 1971 when an owl was heard near Blue Point on the Salt River. The species commonly occurred in the cottonwood forests near the confluence of the Gila and Salt Rivers until about 1900. Currently, riparian woodlands characterized by cottonwood and/or mesquite within the project area are generally sparse, patchy, and unsuitable for the pygmy-owls. Also, project construction would not entail removal of native riparian woodland communities that could potentially develop into pygmy-owl habitat.

Bald eagle: Bald eagles have been observed foraging within the project area. However, nesting does not occur in the project area. This may be due to lack of suitable nesting trees, inadequate fish prey base, and/or proximity to human population centers. A pair of breeding bald eagles is known to nest just upstream of Granite Reef Dam. Project construction would not entail removal of native riparian woodland communities that could potentially develop into suitable nesting habitat.

California brown pelican: Typically, brown pelicans only occur along the Salt River when they have been incidentally carried in from the coast by severe storms. Recently, immature pelicans have been observed at Tempe Town Lake. It is possible that these pelicans could forage within wetlands near the Loops 101 and 202 Freeway crossings. However, project construction would not entail native vegetation removal or dewatering within these areas.

Additionally, the following mitigation and monitoring measures, which are part of the proposed action, should be noted.

Minimize disturbance of vegetation during construction: During the final design of the project, disturbance to areas of existing vegetation that are not within the project footprint would be minimized through careful phasing of project construction. In addition, areas of desirable vegetation would be delineated on construction plans as areas that are not to be disturbed.

Conduct long-term maintenance activities on a rotating basis and only during non-nesting periods: Sediment removal and other activities would be conducted during non-nesting periods of the southwestern willow flycatcher, Yuma clapper rail, and the western yellow billed-cuckoo (*Coccyzus americanus occidentalis*). In the case of sediment removal, activities would be conducted on a rotating basis so that no more than 25% of the marsh area would be affected in any one year.

Implement the monitoring and adaptive management plan: The MAMP will track and evaluate the success of revegetation and habitat restoration. The plan includes success criteria and reporting requirements. The Corps and/or non-Federal sponsor would be responsible for collecting monitoring data and preparing annual reports. A technical committee consisting of at least the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, and Arizona Game and Fish Department will assist in collecting and reviewing monitoring data, and providing recommendations of possible adaptive management measures.

Furthermore, we have coordinated with your staff and jointly identified the following conservation measures to be incorporated into the proposed action.

1) Following adoption of the preliminary engineering design and prior to construction, the Corps will reevaluate the suitability of vegetation communities for threatened and endangered species. If suitable habitat has developed that was not considered in this consultation, the Corps will coordinate with FWS to determine the necessity of surveys.

2) The MAMP will be designed to quantitatively and qualitatively monitor the success of the proposed project goals and objectives through measurements of specific parameters that include changes in species abundance and shifts in vegetation cover or structure. The FWS will be provided all survey information and reports completed for the project.

3) The FWS and local non-Federal sponsors will continue to coordinate regarding the development and implementation of a Safe Harbor Agreement (SHA), Habitat Conservation Plan (HCP), or other appropriate mechanism to address potential effects to, and take of, listed species which may result from O&M. If possible, applicable elements of a SHA or HCP, such as baseline condition, mitigation, and/or monitoring provisions, should be developed prior to the local sponsor(s') acceptance of the project from the Corps to ensure that O&M activities may be conducted in a manner that satisfies the original project goals. Because a SHA or HCP would be agreements solely between the FWS and the local sponsor, the completion of such an agreement is not required for completion of the section 7 consultation process as it relates to Federal agencies.

Based on our review of the proposed action, including conservation measures, we concur that the Va Shly'ay Akimel Environmental Restoration Project may affect, but is not likely to adversely affect, the Yuma clapper rail, southwestern willow flycatcher, cactus ferruginous pygmy-owl, California brown pelican, and bald eagle. We appreciate your efforts to manage for threatened and endangered species as part of the Va Shly'ay Project. As a final note, copies of survey protocols and recovery plans for listed species are available from our web page at http://arizonaes.fws.gov.

Where discretionary agency involvement or control over the action has been retained (or is authorized by law) by the Corps Planning Division, reinitiation of consultation is necessary if: a) new information reveals effects of the action that may affect listed species or critical habitat in a

manner or to an extent not considered in this consultation, b) the action is subsequently modified in a manner that causes an effect to listed species or critical habitat in a manner not considered in this consultation, c) a new species is listed or critical habitat designated that may be affected by the action, or d) incidental take of a listed species is anticipated. In instances where incidental take occurs, any operation causing such take must cease pending reinitiation.

We thank the Corps and all cooperators for engaging in this habitat restoration effort. Should project plans change, or new information on the distribution or abundance of listed species becomes available, our determination of effects to listed species may need to be reconsidered. We also encourage you to continue to coordinate review of this project with the Arizona Game and Fish Department. If we can be of further assistance or you have questions, please contact Mike Martinez (x224).

Sincerely,

Steven L. Spangle
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Kayla Eckert, Planning Branch, U.S. Army Corps of Engineers, Phoenix, AZ

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Appendix F
Background Information on Acoustics

APPENDIX F.
BACKGROUND INFORMATION ON ACOUSTICS

SOUND TERMINOLOGY

Sound travels through the air as waves of minute air pressure fluctuations caused by some type of vibration. In general, sound waves travel away from the sound source as an expanding spherical surface. The energy contained in a sound wave is consequently spread over an increasing area as it travels away from the source. This results in a decrease in loudness at greater distances from the sound source. The following terms are commonly used in acoustics.

Decibel

Sound-level meters measure the pressure fluctuations caused by sound waves. Because of the ability of the human ear to respond to a wide dynamic range of sound pressure fluctuations, loudness is measured in terms of decibels (dB) on a logarithmic scale. This results in a scale that measures pressure fluctuations in a convenient notation and corresponds to our auditory perception of increasing loudness.

A-Weighted Decibels

Most sounds consist of a broad range of sound frequencies. Because the human ear is not equally sensitive to all frequencies, several frequency-weighting schemes have been used to develop composite decibel scales that approximate the way the human ear responds to sound levels. The "A-weighted" decibel scale (dBA) is the most widely used for this purpose. Typical A-weighted sound levels for various types of sound sources are summarized in Figure F-1.

Equivalent Sound Level

Time-varying sound levels are often described in terms of an equivalent constant decibel level. Equivalent sound levels (L_{eq}) are used to develop single-value descriptions of average sound exposure over various periods of time. Such average sound exposure values often include additional weighting factors for annoyance potential attributable to time of day or other considerations. The L_{eq} data used for these average sound exposure descriptors are generally based on A-weighted sound-level measurements.

Day-Night Average Sound Level

Average sound exposure over a 24-hour period is often presented as a day-night average sound level (L_{dn}). L_{dn} values are calculated from hourly L_{eq} values, with the L_{eq} values for the nighttime period (10:00 p.m.-7:00 a.m.) increased by 10 dB to reflect the greater disturbance potential from nighttime noises.

Sound Source	Sound Level (dBA)*	Response
Carrier deck jet operation	140	
Civil defense siren (at 100 feet)	130	Painfully loud
Jet takeoff (at 200 feet)	120	Threshold of feeling pain
Riveting machine (at 1 foot) Rock music concert	110	
Pile driver (at 50 feet) Ambulance siren (at 100 feet)	100	Very loud
Heavy truck (at 50 feet)	90	
Pneumatic drill (at 50 feet) Freight train cars (at 50 feet) Garbage disposal in home	80	
Freight train cars (at 100 feet) Freeway traffic (at 50 feet) Vacuum cleaner (at 10 feet)	70	Moderately loud
Air conditioning unit (at 20 feet)	60	
Speech in normal voice (at 15 feet)	50	
Residence-typical movement of people, no TV or radio	40	Quiet
Soft whisper (at 5 feet)	30	
Recording studio	20	
	10	
	0	Threshold of hearing

* Typical A-weighted sound levels in decibels. "A" weighting approximates the frequency response of the human ear.

Figure F-1
Weighted Sound Levels and Human Response

Community Noise Equivalent Level

The community noise equivalent level (CNEL) is also used to characterize average sound levels over a 24-hour period, with weighting factors included for evening and nighttime sound levels. L_{eq} values for the evening period (7:00 p.m.-10:00 p.m.) are increased by 5 dB, while L_{eq} values for the nighttime period (10:00 p.m.-7:00 a.m.) are increased by 10 dB. For given set of sound measurements, the CNEL value will usually be about 1 dB higher than the L_{dn} value. In practice, CNEL and L_{dn} are often used interchangeably.

Percentile-Exceeded, Maximum, and Minimum Sound Level

The sound level exceeded during a given percentage of a measurement period is the percentile-exceeded sound level (L_x). Examples include L_{10}, L_{50}, and L_{90}. L_{10} is the A-weighted sound level that is exceeded 10% of the measurement period, L_{50} is the level exceeded 50% of the period, and so on. L_{50} is the median sound level measured during the measurement period. L_{90}, the sound level exceeded 90% of the time, excludes high localized sound levels produced by nearby sources such as single car passages or bird chirps. L_{90} is often used to represent the background sound level. L_{50} is also used to provide a less conservative assessment of the background sound level.

The maximum sound level (L_{max}) and the minimum sound level (L_{min}) are the maximum and minimum sound levels respectively, measured during the measurement period. When a sound meter is set to the "slow" response setting as is typical for most community noise measurements, the Lmax and Lmin values are the maximum and minimum levels measured over a one second period.

Ambient Sound

Ambient sound is the all-encompassing sound associated with a given community site, usually being a composite of sounds from many sources, near and far, with no particular sound being dominant.

EQUIVALENCIES BETWEEN VARIOUS SOUND DESCRIPTORS

The L_{dn} value at a site calculated from a set of measurements taken over a given 24-hour period will be slightly lower than the CNEL value calculated over the same period. Except in situations where unusually high evening sound levels occur, the CNEL value will be within 1.5 dB of the L_{dn} value for the same set of sound measurements.

The relationship between peak hourly L_{eq} values and associated L_{dn} values depends on the distribution of traffic over the entire day. There is no precise way to convert a peak hourly L_{eq} value to an L_{dn} value. However, in urban areas near heavy traffic, the peak hourly L_{eq} value is typically 2-4 dB lower than the daily L_{dn} value. In less heavily developed areas, the peak hourly L_{eq} is often equal to the daily L_{dn} value. For rural areas with little nighttime traffic, the peak hourly L_{eq} value will often be 3-4 dB greater than the daily L_{dn} value.

WORKING WITH DECIBEL VALUES

The nature of the decibel scale is such that the individual sound levels for different sound sources cannot be added directly to give the combined sound level of these sources. Two sound sources producing equal sound levels at a given location will produce a composite sound level that is 3 dB greater than either sound alone. When two sound sources differ by 10 dB, the composite sound level will be only 0.4 dB greater than the louder source alone.

Most people have difficulty distinguishing the louder of two sound sources if they differ by less than 1.5-2.0 dB. Research into the human perception of changes in sound level indicates the following:

- a 3-dB change is just perceptible,
- a 5-dB change is clearly perceptible, and
- a 10-dB change is perceived as being twice or half as loud.

A doubling or halving of acoustic energy will change the resulting sound level by 3 dB, which corresponds to a change that is just perceptible. In practice, this means that a doubling of traffic volume on a roadway, doubling the number of people in a stadium, or doubling the number of wind turbines in a wind farm will, as a general rule, only result in a 3-dB, or just perceptible, increase in noise.

OUTDOOR SOUND PROPAGATION

There are a number of factors that affect how sound propagates outdoors. These factors, described by Hoover and Keith (1996), are summarized below.

Distance Attenuation

As a general rule, sound from localized or point sound sources spreads out as it travels away from the source and the sound level drops at a rate of 6 dB per doubling of distance. If the sound source is long in one dimension, such as traffic on a highway or a long train, the sound source is considered to be a line source. As a general rule, the sound level from a line source will drop off at a rate of 3 dB per doubling of distance. If the intervening ground between the line source and the receptor is acoustically "soft" (e.g., ground vegetation, scattered trees, clumps of bushes), an attenuation rate of 4.5 dB per doubling of distance is generally used.

Attenuation from Barriers

Any solid structure such as a berm, wall, or building that blocks the line of sight between a source and receiver serves as a sound barrier and will result in additional sound attenuation. The amount of additional attenuation is a function of the difference between the length of the sound path over the barrier and the length of the direct line of sight path. Thus, the sound attenuation of a barrier between a source and a receiver that are very far apart will be much less than the attenuation that would result if either the source or the receiver is very close to the barrier.

Molecular Absorption

Air absorbs sound energy as a function of the temperature, humidity of the air, and frequency of the sound. Additional sound attenuation on the order of 1 to 2 dB per 1,000 feet can occur.

Anomalous Excess Attenuation

Large-scale effects of wind speed, wind direction, and thermal gradients in the air can cause large differences in sound transmission over large distances. These effects when combined result in anomalous excess attenuation, which can be applied to long-term sound-level estimates. Additional sound attenuation on the order of about 1 dB per 1,000 feet can occur.

Other Atmospheric Effects

Short-term atmospheric effects relating to wind and temperature gradients can cause bending of sound waves and can influence changes in sound levels at large distances. These effects can either increase or decrease sound levels depending on the orientation of the source and receptor and the nature of the wind and temperature gradient. Because these effects are normally short-term, it is generally not practical to include them in sound propagation calculations. Understanding these effects, however, can help explain variations that occur between calculated and measured sound levels.

GUIDELINES FOR INTERPRETING SOUND LEVELS

Various agencies have developed guidelines for evaluating land use compatibility under different sound-level ranges. The following is a summary of federal guidelines.

The federal Noise Control Act of 1972 (Public Law 92-574) established a requirement that all federal agencies administer their programs to promote an environment free of noise that jeopardizes public health or welfare. The U.S. Environmental Protection Agency (EPA) was given the responsibility for:

- providing information to the public regarding identifiable effects of noise on public health or welfare,
- publishing information on the levels of environmental noise that will protect the public health and welfare with an adequate margin of safety,
- coordinating federal research and activities related to noise control, and
- establishing federal noise emission standards for selected products distributed in interstate commerce.

The federal Noise Control Act also directed that all federal agencies comply with applicable federal, state, interstate, and local noise control regulations.

Although EPA was given major public information and federal agency coordination roles, each federal agency retains authority to adopt noise regulations pertaining to agency programs. EPA can require other federal agencies to justify their noise regulations in terms of the federal Noise Control Act policy requirements. The Occupational Safety and Health Administration retains primary authority for setting workplace noise exposure standards. The Federal Aviation Administration retains primary jurisdiction over aircraft noise standards, and the Federal Highway Administration (FHWA) retains primary jurisdiction over highway noise standards.

In 1974, in response to the requirements of the federal Noise Control Act, EPA identified indoor and outdoor noise limits to protect public health and welfare (communication disruption, sleep disturbance, and hearing damage). Outdoor L_{dn} limits of 55 dB and indoor L_{dn} limits of 45 dB are identified as desirable to protect against speech interference and sleep disturbance for residential, educational, and healthcare areas. Sound-level criteria to protect against hearing damage in commercial and industrial areas are identified as 24-hour L_{eq} values of 70 dB (both outdoors and indoors).

The FHWA has adopted criteria for evaluating noise impacts associated with federally funded highway projects and for determining whether these impacts are sufficient to justify funding noise mitigation actions (23 CFR 772). The FHWA noise abatement criteria are based on peak hourly L_{eq} sound levels, not L_{dn} or 24-hour L_{eq} values. The peak 1-hour L_{eq} criteria for residential, educational, and healthcare facilities are 67 dB outdoors and 52 dB indoors. The peak 1-hour L_{eq} criterion for commercial and industrial areas is 72 dB (outdoors).

The U.S. Department of Housing and Urban Development has established guidelines for evaluating noise impacts on residential projects seeking financial support under various grant programs (44 FR 135:40860-40866, January 23, 1979). Sites are generally considered acceptable for residential use if they are exposed to outdoor L_{dn} values of 65 dB or less. Sites are considered "normally unacceptable" if they are exposed to outdoor L_{dn} values of 65-75 dB. Sites are considered unacceptable if they are exposed to outdoor L_{dn} values above 75 dB.

REFERENCE

Hoover, R. M., and R. H. Keith. 1996. Noise control for buildings and manufacturing plants. Houston, TX: Hoover and Keith, Inc.

Appendix G

Air Quality Assumptions and Calculations

APPENDIX G.
ASSUMPTIONS USED TO GENERATE AIR EMISSION ESTIMATES FOR THE VA SHLY'AY AKIMEL PROJECT

The following assumptions were used to estimate emissions associated with each of the Va Shly'ay Akimel project alternatives. Detailed assumptions and emission factors for each calculation are presented in the attached spreadsheets. To calculate construction and O&M emissions, emission factors developed by EPA's AP-42, Compilation of Air Pollutant Emission Factors, have been used to calculate exhaust and fugitive dust emissions. Calculations are also based on earthwork quantity and import fill quantity information provided in the feasibility study. The following types of air pollutant emission sources were included in the calculations:

- Fugitive dust emissions from haul trucks and passenger cars on unpaved roads were estimated based on the assumed number of vehicle trips and travel distance, using AP-42 emission factors applicable for the western United States. Truck travel on unpaved roads was calculated for the following types of vehicles: worker commute vehicles; haul trucks carrying import fill; haul trucks carrying concrete and rebar for diversion structures; and haul trucks carrying plants for revegetation. For the construction phases, it was assumed unpaved haul roads would be aggressively watered to reduce dust emissions in accordance with Maricopa County Air Quality Regulation 310, thereby providing an assumed 80% reduction in dust emissions. During the restoration phases and operational (recreational) phases it was assumed the unpaved access roads would not be watered.
- Fugitive dust emissions from excavating, loading, dumping, and spreading of bulk soil during channel excavation and bank stabilization were estimated based on the assumed earthwork volumes, using AP-42 emission factors for surface mining operations. The assumed silt content of the excavated material was reduced from the default AP-42 values to account for the fact that the material excavated from the river channel consists mainly of depositional soil with coarse sand and gravel, rather than silty overburden typically encountered at surface mines.
- Fugitive dust emissions from bulldozer operations to spread excavated material over the site were estimated using AP-42 emission factors, with a reduction in the assumed silt content to account for the predominant soil type consisting of coarse sand and gravel.
- Emissions from construction equipment tailpipes were estimated based on the type and number of equipment, using recent emission factors for off-road equipment.

BANK STABILIZATION/CONSTRUCTED WETLANDS CONSTRUCTION

- Equipment used for construction (assuming 10 hours/day, 200 days per year):
  - front end loader
  - two dump trucks

- scraper
- dozer
- grader
- backhoe
- water truck
- roller

- Bank stabilization materials will be obtained from the constructed wetland excavation sites. Any additional materials needed for the bank stabilization will be obtained from the other proposed restoration sites within the river channel.
- Construction will occur approximately 200 days per year.
- For employee trips, assumed a 40-mile round-trip commute per day.

Table G-1. Assumptions for Channel Excavation and Bank Stabilization Emission Estimates

Alternative	Years of Heavy Earthwork Construction	Total Earthwork Volume (CY)	Daily Employee Trips	Employee Commute Distance (round trip miles)
O	5	4,161,000	15	40
F	5	8,400,000	25	40
N	5	4,678,500	15	40
E	5	5,605,000	15	40
A	1	23,000	10	40

RESTORATION AND MAINTENANCE

- Construction will occur approximately 200 days per year.
- Restoration implementation will consist of three general steps: clearing and grubbing, excavation, and preparation for planting.
- Vegetation removal emissions based on dozer emissions only.
- Saltcedar removed during initial implementation will be disposed of by burning.
- Equipment used for construction (assuming 10 hours/day, 200 days per year).
  - front end loader
  - two dump trucks
  - dozer
  - backhoe

- For employee trips, assumed a 40-mile round-trip commute per day.

Table G-2. Assumptions for Construction Emissions Associated with Restoration and Maintenance

Alternative	Annual Dump Truck Trips on Unpaved Roads	Daily Employee Trips	Truck Distance on Unpaved Roads (round trip miles/load)	Employee Commute Distance (round trip miles)
O	300	15	2	40
F	500	25	2	40
N	300	15	2	40
E	300	15	2	40
A	200	10	2	40

RECREATIONAL USE

Vehicle trips were based on the revised study prepared by the Va Shly'ay Akimel recreation technical committee (see Table H-3). In addition, 25 employees would work onsite traveling 40 miles round trip. Recreational trip emissions were assumed not to vary by alternative.

Table G-3. Estimated Traffic Associated with Recreational Use

Period	Daily Recreationist Trips (round trips)	Daily Employee Trips (round trips)	Total Daily Trips (round trips)
Summer			
Prime	273	25	298
Non-prime	69	25	94
Winter			
Prime	409	25	434
Non-prime	137	25	162

Appendix H

Va Shly'ay Akimel Phase I Environmental Site Assessment

PHASE I ENVIRONMENTAL SITE ASSESSMENT

APPROXIMATE 17-MILE PORTION OF THE SALT RIVER
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY

PREPARED FOR:

SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY
10005 EAST OSBORN ROAD
SCOTTSDALE, ARIZONA 85256

JUNE 21, 2002

LIESCH PROJECT NUMBER 52734.00

Liesch Companies
Minneapolis, MN • Madison, WI • Scottsdale, AZ

PHASE I ENVIRONMENTAL SITE ASSESSMENT

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PREPARED FOR:
Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
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PREPARED BY:

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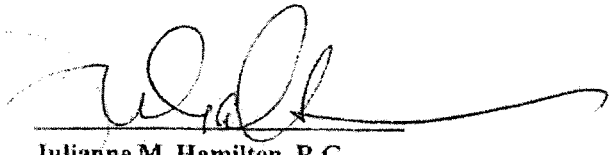
June 21, 2002
Project #52734.00

This report was prepared by me
or under my direct supervision.



Julianne M. Hamilton, R.G.
Project Manager

TABLE OF CONTENTS

Section Page

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1

2.0 SCOPE OF WORK 1

3.3 CURRENT OWNERSHIP 16
3.4 PRIOR USE 16
3.5 ADJACENT PROPERTIES 17

4.0 PROPERTY HISTORY 17

4.1 AERIAL PHOTOGRAPH REVIEW 17
4.2 TOPOGRAPHIC MAPS, CITY DIRECTORIES, AND SANBORN MAPS 18
4.3 INTERVIEWS 19

5.0 ASSESSMENT INFORMATION 20

5.1 REGULATORY FILE SEARCH 20

Salt River Sand & Gravel 23

6.0 PHYSICAL SETTING 24

6.1 TOPOGRAPHY 24
6.2 SOILS 24
6.3 REGIONAL GEOLOGY 25
6.4 SURFACE AND GROUNDWATER HYDROLOGY 25

7.0 WALK-OVER SURVEY 25

7.1 VEGETATION AND STAINED SOIL 26
7.2 CHEMICALS AND RAW MATERIALS 26
7.3 POLYCHLORINATED BIPHENYLS (PCBS) 26
7.4 ASBESTOS-CONTAINING MATERIALS (ACMS) 26
7.5 HAZARDOUS WASTES AND HAZARDOUS SUBSTANCES 27
7.7 PITS, WELLS, SUMPS, DRYWELLS, CATCH BASINS 27
7.8 ON-SITE STORAGE TANKS (ABOVEGROUND AND UNDERGROUND) 28

8.0 PREVIOUS ENVIRONMENTAL REPORTS 28

9.0 QUALIFICATIONS 28

10.0 CONCLUSIONS 28

11.0 REFERENCES 31

APPENDICES

Appendix A Figure 1 – Topographic Map
Appendix B Client Supplied Information
Appendix C Historic Aerial Photographs
Appendix D Regulatory Database
Appendix E EPA UST/LUST Database
Appendix F Site Photographs
Appendix G Qualifications/Certifications

EXECUTIVE SUMMARY

Liesch Southwest, Inc. (Liesch) was retained by Salt River Pima-Maricopa Indian Community (SRPMIC) to perform a Phase I Environmental Site Assessment (ESA) of the Property identified as an approximate 17-mile stretch of the Salt River from Highway 101 to the Granite Reef Dam including about ¼ mile area on each side of the center of the river. The purpose of this assessment is to provide general information with regard to environmental issues as part of the initial stage for a proposed Salt River Restoration Project that is being led by the Army Corp of Engineers.

The Property consists of approximately 17-miles of the Salt River that is bordered by the SRPMIC on the north, Highway 101 to the west, Highway 202 and the City of Mesa to the south, and the Granite Reef dam near the confluence of the Salt and Verde Rivers to the east. Developed and/or utilized portions within and/or on the north side of the river include: Salt River Sand and Rock (SRSR) (quarry operations with subleases to Vulcan, Chandler Ready Mix, Hanson, and United Metro), five recharge ponds operated by the SRPMIC which receive treated water from the City of Mesa, several irrigation run-off ponds, Arizona Propane, Saddleback Communications, Cypress Landfill (old Tri-Cities Landfill/Country Club Landfill), Cypress golf course, RV Storage facility, JR's Convenience Store, United Metro quarry operations, Tri-Cities Landfill and SRP methane gas power plant, Granite Reef Underground Storage Project (GRUSP) recharge ponds, the Arizona Canal, South Canal, Salt River Sand and Rock (Higley quarry operations with subleases to Vulcan, Hanson and United Metro) and the Granite Reef dam. Developed and/or utilized portions within and/or on the south side of the river include: four recharge ponds operated by the City of Mesa, the Mesa northwest wastewater treatment plant, Cemex quarry operations, various commercial businesses (including, but not limited to, Car Smart, Little Dealer, Little Prices, Superstition Springs Crushing, Pete's Diesel Repair, Heritage Trucking, Redburn Tire Company, Carports Etc., Allpride Marble and Granite, Artistic Ice Creations, and Alumi-Cover Inc.), residential properties, ADOT storage yard, Mesa storage yard, Mesa Police Department Firing Range, North Center Street Landfill, Tri-Cities Landfill, Vulcan demolition debris landfill, agricultural land, Lehi Cemetery, Highway 202 Construction and storage area, Chandler Ready Mix quarry, horse farm, southern canal, Salt River Sand and Rock (Higley operations – offices), primate research center, and the Granite Reef Dam. Access to private properties within the City of Mesa on the south side of the River; private allotments within the SRPMIC; and, to the Cypress golf course, RV storage facility, JR's Convenience Store, and Saddleback Communications were not provided at the time of Liesch's site visit, therefore, only the portions of these areas visible from public right-of-ways were observed.

Based on Liesch's assessment, the following environmental issues were identified for the Property.

Salt River Sand and Rock

- Maintenance shop – wash rack, chemical/waste storage
- Lube shop – staining and chemical/waste storage practices
- Sand blasting/paint area – bare ground
- Vehicle repair and storage area – bare ground
- Large quantities of debris (disposal practices)
- Cement dump area
- Former leaking UST (historic)

Chandler Ready Mix at SRSR

- Maintenance shop –storage practices, staining
- Wash down area – corrosion, staining

Hanson/United Metro/Vulcan Cement Batch Plants at SRSR and Higley

- Wash down areas – staining, corrosion
- Vehicle maintenance – staining, storage practices
- Chemical storage – leakage, some without secondary containment

Vulcan Maintenance Yard and Asphalt Batch Plant

- Wash down chemical storage area - staining
- Former USTs – (historic)
- Four existing USTs
- 1999 Explosion (historic)
- Debris/parts storage area

CEMEX Operations (and associated operations)

- Assumed issues same as other quarries

Arizona Propane

- Former site operations (Forest Homes)
- Stockpile of debris/waste
- Maintenance sump

Various Commercial Businesses

- Chemical/waste storage
- References to spills/releases in the database
- USTs/ASTs

United Metro

- Chemical storage area (numerous drums and staining)
- Cement batch plant chemical storage
- Cement/asphalt dump area – extending over hard bank
- Wash down area – corrosion, staining, pond water
- Former USTs (historic)

Enviro-Systems

- Soil contamination clean-up (historic)
- Former site operations (unknown)

Tri-City Landfill (north and south sides)

- Groundwater contamination
- Methane migration

North Center Street Landfill

- No information available

Cypress Landfill

- Known contamination currently requesting brownfield pilot study funding

Mesa Firing Range

- Lead contamination
- Berms constructed of debris/soil mixture

Vulcan Demolition Debris Landfill

- Unknown

Chandler Ready Mix – at Gilbert Road

- Assumed issues same as other quarries

1.0 INTRODUCTION

Liesch Southwest, Inc. (Liesch) was retained by Salt River Pima-Maricopa Indian Community (SRPMIC) to perform a Phase I Environmental Site Assessment (ESA) of the Property identified as an approximate 17-mile stretch of the Salt River from Highway 101 to the Granite Reef Dam including about ¼ mile area on each side of the center of the river. The purpose of this assessment is to provide general information with regards to environmental issues as part of the initial stage for a proposed Salt River Restoration Project that is being led by the Army Corp of Engineers.

An experienced ESA investigator conducted a reconnaissance of the Property on March 20, 22, 25, 26, and April 15 through 19, 2002. This report presents the information obtained by Liesch during the course of this ESA investigation. Access to properties, which are located within the boundaries of the SRPMIC, was provided by Mr. Morris Paukgana, Ms. Dawn Daw, Ms. Debra Frein and Mr. Rich Allen of the SRPMIC. Mr. Gordon Haws and Ms. Christine Zielonka with the City of Mesa provided access to the City of Mesa firing range and wastewater treatment plant.

Figure 1 (Appendix A) shows the Property and indicates the approximate location of the relevant sites within the Property. In addition, included in **Appendix B** is client-supplied information. Within these documents there are various figures and diagrams showing specific site boundaries that were provided by SRPMIC or individual site representatives.

2.0 SCOPE OF WORK

The scope of work conducted by Liesch for this ESA includes the following items:

- A visual walkover assessment of the referenced property, identifying existing surface conditions and any obvious signs of contamination.
- A visual survey of adjacent properties for current land use and any obvious signs of contamination.
- Personal contacts with state, county and city regulatory agencies to determine if any environmental problems or spills have been reported on or adjacent to the site under investigation.
- Review of the USGS quadrangle map for locations of canals, wells, pipelines and other features that may potentially affect the Property.
- Review of available plans and specifications, drawings, site plans, surveys and similar documents concerning the Property.
- Review of historical aerial photographs and Sanborn Maps (if available).
- Review of historic property records made available by the property owner.

- Assessment of the possible presence of PCBs at the Property.
- Review of a regulatory database search (FirstSearch Report).
- Personal interviews with persons knowledgeable of past and present activities on the Property.
- Preparation of a report summarizing the factual findings of the assessment.

Due to the extensive nature of this project, Liesch has focused on identifying general environmental issues that may be of concern to the project study team as part of the proposed Salt River Restoration project. Access to private properties within the City of Mesa on the south side of the River and to the Cypress golf course, RV storage facility, JR's Convenience Store, Saddleback Communications, and private allotted land within SRPMIC was not provided at the time of Liesch's site visit. Therefore, only the portions of these areas visible from public right-of-ways were observed. More detailed assessment of individual areas within the Property may be necessary depending upon the specific proposed restoration. This site assessment does not include a comprehensive compliance analysis regarding local, state or federal environmental laws, rules or regulations. The following sections discuss the information obtained for this project. **Section 10.0** presents Liesch's conclusions.

3.0 PROPERTY BACKGROUND

3.1 Property Location

The Property is located within Township 1 North, Range 5 East, Sections 3, 4, 7, 8 and 9, Township 2 North, Range 5 East Sections 25, 26, 33, 34, and 35, and Township 2 North, Range 6 East, Sections 13, 14, 22, 23, 24, 27, 28, 29, and 30 of the Gila and Salt River Baseline and Meridian.

3.2 Property Description

The Property consists of approximately 17-miles of the Salt River that is bordered by the SRPMIC on the north, Highway 101 to the west, Highway 202 and the City of Mesa to the south, and the Granite Reef dam near the confluence of the Salt and Verde Rivers to the east. Developed and/or utilized portions within and/or on the north side of the river include: Salt River Sand and Rock (quarry operations with subleases to Vulcan, Chandler Ready Mix, Hanson, and United Metro), five recharge ponds operated by the SRPMIC which receive treated water from the City of Mesa, several irrigation run-off ponds, Arizona Propane, Saddleback Communications, Cypress Landfill (old Tri-Cities Landfill/Country Club Landfill), Cypress golf course, RV Storage facility, JR's Convenience Store, United Metro quarry operations, Tri-Cities Landfill and SRP methane gas power plant, Granite Reef Underground Storage Project (GRUSP) recharge ponds, the Arizona Canal, South Canal, Salt

River Sand and Rock (Higley quarry operations with subleases to Vulcan, Hanson and United Metro) and the Granite Reef dam. Developed and/or utilized portions within and/or on the south side of the river include: four recharge ponds operated by the City of Mesa, the Mesa northwest wastewater treatment plant, Cemex quarry operations, various commercial businesses (including, but not limited to, Car Smart, Little Dealer, Little Prices, Superstition Springs Crushing, Pete's Diesel Repair, Heritage Trucking, Redburn Tire Company, Carports Etc., Allpride Marble and Granite, Artistic Ice Creations, and Alumi-Cover Inc.), residential properties, ADOT storage yard, Mesa storage yard, Mesa Police Department Firing Range, North Center Street Landfill, Tri-Cities Landfill, Vulcan demolition debris landfill, agricultural land, Lehi Cemetery, Highway 202 Construction and storage area, Chandler Ready Mix quarry, horse farm, southern canal, Salt River Sand and Rock (Higley operations – offices), primate research center, and the Granite Reef Dam.

The following is a description of the various areas of the Property:

Salt River Sand and Rock – Mesa Operations (Including Vulcan, Hanson, United Metro cement batch plants, maintenance areas, and wash down areas; Chandler Ready Mix operations; and, Salt River Sand and Rock Construction)

Liesch Southwest, Inc. toured this portion of the Property with Mr. Morris Paukgana of the SRPMIC on March 25, 2002. We were unaccompanied by a representative from SRSR during our walkover. However, prior to our walkover Mr. Vern Wilson and Mr. Wayne Hills provided general information regarding site operations.

The Salt River Sand and Rock (SRSR) – Mesa Operations is an SRPMIC enterprise business that operates a sand and gravel quarry. SRSR encompasses over 150 acres of developed land between approximately Dobson and Alma School Roads and McKellips Road and the Salt River. In addition, SRSR-Mesa Operations have active mining operations ongoing with two portions of the River, including just south of the developed portion and further east between Mesa Drive and Gilbert Road. Within the developed portion of SRSR, there are subleased areas that include Vulcan, Hanson, United and Mega-Mix, and Chandler Ready Mix (RMC) cement batch plants, maintenance areas, and cement truck wash down areas. SRSR also subleases space to Salt River Sand and Rock Construction. This company has several storage trailers and stores large sections of pipe used for highway road construction projects. A one million-gallon aboveground storage tank (AST) containing fly ash is also present on the property. Phoenix Cement owns this AST.

SRSR operational areas include an office complex, a testing lab, a maintenance shop, a lube shop, welding shop, equipment storage areas, a sand blasting area, a fueling area, aggregate crusher area, a cement dump area and water distribution pond. At the lube shop, Liesch observed numerous 55-

gallon drums and various sized ASTs containing new and used automotive chemicals. Significant staining was observed in this area and the containers appeared to be stored in a haphazard manner. The maintenance shop also included several areas where drums and small quantities of new and used automotive chemicals were stored. In addition, a wash rack was observed on the north side of the shop. The wash rack water reportedly drains to a containment basin and is periodically pumped out. Petroleum based staining was observed in the area of the wash rack. The sand blasting and equipment storage areas were at various locations at the site. These areas are situated on bare soil and sand blasting material and petroleum stained soils were observed in these areas.

The subleased areas operated by Vulcan, United Metro, Hanson and RMC each included a cement mixing area, a vehicle maintenance area (except Vulcan), and a truck wash down area. Each batch plant was similar in construction and each stored cement admixture chemicals in ASTs. There were approximately 8 to 12 ASTs of various sizes at each location. With the exception of the Hanson Plant each had secondary containment structures. The vehicle maintenance and wash down areas (Vulcan is located in a separate leased area) are relatively small and are for conducting minor repairs on the cement trucks. The wash down areas are for washing the exterior of the cement trucks prior to leaving the site. Typical observations in maintenance areas included one or more AST fuel tanks and various quantities of new and used automotive chemicals. At the wash down areas, Liesch observed high-pressure washers along with rinse wax, an acid based solution to remove cement, and a neutralizing chemical. Most of the ASTs and some of the smaller quantities of stored chemicals and waste were within containment structures. Some soil staining was observed in areas where secondary containment was not present. In the wash down areas, pooled water was observed and corrosion of the ground surface from the acid solution was visible in these areas.

To the southeast of the developed portions of the SRSR site, Liesch observed numerous areas of stockpiled soils, empty containers, construction debris, large pieces of metal, and other debris. Reportedly some of this material is the result of a washout from the upstream landfill. Mr. Paukgana also reports that there have been complaints of illegal dumped materials, possibly drums, in this area. Also in this area, Liesch observed an area where irrigation run-off water from the agricultural fields to the north drain to this area. Also along the southern portion of the site is a cement dump area where excess cement from the trucks is dumped. Pond water in this area appeared to be a blue-green color.

A previous underground storage tank (UST) had been located at this facility. The UST had leaked and remedial activities consisting of excavation were implemented. According to Mr. Paukgana remediation and closure was granted.

A complete Phase I ESA was prepared for this site titled "Phase I Environmental Site Assessment, Proposed TSA Multipurpose Facility SE of McKellips Road and Dobson Road, Maricopa County, Arizona". The report was prepared for SRPMIC by Geotechnical and Environmental Consultants, Inc. (GEC) and is dated March 8, 2002. According to the report, "a portion of the Site is being offered to the Tourism and Sports Authority (TSA) for development of a new multipurpose facility".

Vulcan Asphalt Batch Plant and Maintenance Yard – Mesa Operations

Liesch toured this portion of the Property with Mr. Morris Paukgana of the SRPMIC on March 22, 2002. Mr. Kevin Derossett and Mr. Eddie Centers of Vulcan accompanied us along with their environmental consultant.

The Vulcan asphalt batch plant and maintenance yard is located just east of the SRSR operations and encompasses approximately 40 acres. In the area of the asphalt batch plant, Liesch observed four large ASTs containing diesel fuel, asphalt oil and burner fuel. All ASTs were in secondary containment structures and appeared to be in good condition. Also in this area, several small ASTs, 55-gallon drums and various sized containers of lubricants used for the asphalt plant operations were observed. Some minor staining was associated with these storage containers. The asphalt batch plant is only a few years old. Reportedly, this batch plant was constructed following an explosion that occurred at the former batch plant that was just west of the current location. The explosion occurred in 1999. Mr. Paukgana has indicated that there were some petroleum-contaminated soils associated with the explosion that required clean up. Mr. Paukgana further noted that the clean up was completed to the satisfaction of the SRPMIC.

According to records provided by the SRPMIC, there were six USTs located at this facility. Two USTs were removed and leaks were reported. Mr. Paukgana indicated that all leak incidents with respect to these USTs have been resolved. There are currently four existing USTs on the site which are no longer in use but once were used to contain asphalt mixtures.

The maintenance area consisted of a shop, a 10,000-gallon AST fueling area, and a wash down area-space. Within and surrounding the shop there were numerous small quantities of automotive chemical/fluids and wastes. These containers appeared to be in good condition and within a secondary containment structure. The wash down chemicals, which are similar to those at the cement batch plants at SRSR, were stored on a platform without secondary containment. The storage location immediately adjoins the hard bank of the river. Leakage from the chemical containers was observed along the hard bank. In addition, corrosion from the acid was observed on the ground surface. In the areas surrounding the maintenance shop and wash down area, Liesch observed several areas where large quantities of debris were stored. Some of the debris appeared

to be associated with former cement batch plant operations in this area. Other debris included concrete, old ASTs and/or USTs, scrap vehicles and other equipment.

City of Mesa Northwest Wastewater Treatment Plant and Recharge Ponds

Liesch toured this portion of the Property with Ms. Dawn Daw and Ms. Debra Frein of the SRPMIC on April 15, 2002. Mr. Gordon Haws, Mr. Collum Hunter and Ronnie Lopez of the City of Mesa accompanied us.

The Mesa northwest wastewater treatment plant is located on the south side of the River, south of Highway 202, and east of Highway 101. The site has existed since the 1940s and began reuse of wastewater activities in the 1960s. The eastern portion of the plant has been in existence since 1990. They are currently constructing a large expansion on the western portion of the site. The wastewater effluent from this treatment plant is reclaimed into nine recharge ponds. Four of the ponds are located on the south side of the south bank of the river and five are located north of the north bank of the river. The treatment plant also discharges to the river on occasion. They conduct discharge monitoring in accordance with their Aquifer Protection Permit.

Waste treatment chemicals stored on site include sodium hydroxide, sodium hypochlorite, hydrochloric acid, methanol, and ferrous chloride. A diesel tank for fueling is also present on site. All chemicals are stored in ASTs and are within secondary containment structures and no indications of leaks were observed. Small quantities of laboratory chemicals are also used and stored on the site. Liesch observed a 30,000-gallon gas recovery AST on the site. This tank is used to collect gas generated within the digesters and is used for energy.

CEMEX Operations (Including various associated operations)

Liesch observed the CEMEX operations from publicly accessible areas. CEMEX is located on the south side of the River, on either side of Alma School Road. CEMEX appears to be primarily within the City of Mesa. However, Mr. Bill Garrard with the SRPMIC – Economic Development Office indicated that they lease a small portion of the River from SRPMIC. The operational activities appeared similar to those observed at the SRSR operations. There appeared to be various associated businesses within the general area. In addition, Liesch observed signs with the name Johnson and Stewart. Johnson and Stewart appears to be the name of the company prior to CEMEX. Liesch assumes that similar environmental issues, such as those at SRSR exist for this facility.

Arizona Propane

Liesch toured this portion of the Property with Mr. Morris Paukgana of the SRPMIC on March 26, 2002. Mr. Martin Dawson, the owner of Arizona Propane, accompanied us.

Arizona Propane is located near the intersection of Alma School Road and McKellips Road. Arizona Propane is a commercial supplier of propane and has been located at this site for approximately 5 years. Prior to occupancy by Arizona Propane, this site was utilized by Forest Homes, a company that manufactured pre-fabricated cabins. Arizona Propane occupies approximately 2.5 acres of land and includes an office building, a shop, two canopy covered storage areas, a propane storage area, a fuel storage area, and a sand blasting and paint booth shed. Small quantities of automotive chemicals and wastes were present near the shop in containers ranging in size from less than one gallon to a 500 gallon AST. Some significant staining was observed in the area surrounding these containers. The floor drains within the shop area reportedly connected to a sump that is periodically pumped out. Liesch also observed a 6,000 and 10,000-gallon diesel ASTs. These ASTs were in secondary containment and no signs of leakage were observed.

To the south of the Arizona Propane site, Liesch observed a large stockpile of soil and debris that included cement and asphalt. According Mr. Dawson, this material was scrapped from the surface of the Arizona Propane site prior to their occupancy to remove the debris that had been left by the former tenant. Mr. Dawson also indicated that there were some materials they had disposed of off-site.

Prior to occupancy of the site by Arizona Propane, an Environmental Assessment (EA) was conducted at the site by SRPMIC. A draft copy of the EA report, dated March 1995, was available for review within the lease file at the SRPMIC Economic Development Office (EDO). According to this document "no evidence of distressed vegetation or accidental or intentional dumping of hazardous waste was observed". However, Liesch also reviewed several documents within the file that pre-dated the EA. These documents indicate that the previous tenant had left numerous materials including drums of solvent, barrels of waste and transmission oil and barrels of stains and varnish. These documents further indicated consideration of a clean-up fee/reimbursement to be written into the Arizona Propane lease. It is assumed that this material was disposed of by Arizona propane.

Saddleback Communications

Saddleback Communications is the telecommunication company for the SRPMIC. This facility is located near the intersection of Alma School and McKellips Road. Liesch observed this site from

publicly accessible areas. No indications of chemical or hazardous waste storage were observed. In addition, Mr. Paukgana is not aware of any environmental concerns at this facility.

JR's Convenience Store

JR's Convenience Store is a gasoline station and convenience store that is owned by a SRMPIC community member. It is located at the northeast corner of the Country Club Drive and McDowell Road. According to SRMPIC database records, three 10,000-gallon USTs were installed at this site in 1987. No indications of releases have been reported for this site.

RV Storage Yard

A RV Storage Yard, owned by a SRPMIC community member, is located at the southwest corner of Country Club Drive and McDowell Road. Liesch observed this site from publicly accessible areas. No indications of chemical or hazardous waste storage were observed. In addition, Mr. Paukgana is not aware of any environmental concerns at this facility

Cypress Golf Course

The Cypress Golf Course is located at the west Country Club Drive and south of McDowell Road. Liesch observed this site from publicly accessible areas. Mr. Paukgana is not aware of any environmental concerns at this facility. This site is listed on the FirstSearch database as a spill site. The database indicates that a release of 60-gallons of an unknown material was released on April 10, 2001.

Various Commercial Businesses - South of River at Country Club Drive

Various commercial businesses were observed south of the River at Country Club Drive. These businesses were all observed from publicly accessible areas. To the north of Highway 202 and east of Country Club Drive, Liesch observed Superstition Springs Crushing, Pete's Diesel Repair, Heritage Trucking, Redburn Tire Co. and the Arizona Department of Transportation (ADOT) maintenance/storage yard. On the south side of Highway 202 and west of Country Club Drive, Liesch observed Car Smart, Little Dealer Little Prices, Carports Etc. All Pride Marble and Granite, Artistic Ice Creations, and Alumi-Cover Inc. Several of these facilities are listed on the FirstSearch Database as having USTs or LUSTs. In addition, Liesch observed the presence of several ASTs, maintenance areas, welding shops, and other operations that could be considered environmental issues.

City of Mesa Firing Range/Storage Yard/North Center Street Landfill

Liesch toured this portion of the Property with Ms. Dawn Daw and Ms. Debra Frein of the SRPMIC on April 15, 2002. Mr.Gordon Haws, Mr. Collum Hunter, and Christine Zielonka with the City of Mesa accompanied us.

The site is located on the south side of the River at North Center Street. The firing range has been in operation since the 1960's and initially consisted of one range, which is now utilized as a retention basin. There are currently 5 operational ranges that are used for training, two classroom buildings, an office, an armory, and a car impoundment lot. Chemicals used on site include small quantities of gun cleaning solutions and lubricating oils. They also maintain a parts washer that utilizes a citrus-based solvent. Some investigations have been conducted at the firing range with regard to the presence of lead dust. This has resulted in the asphalt pavement covering of the firing range surface to minimize dispersion of lead dust. At the current time, there is no lead recovery system in place at the firing range. However, the City of Mesa has indicated that a system will be installed in the near future to recover lead. The lead recovery system will include recovery of existing lead within the embankments.

To the south and of the firing range is a City of Mesa storage yard. The storage yard included empty trash dumpsters, vehicles, and a large pile of ground asphalt (roto-mill). Other items of note include: the side embankments of each firing range appear to be constructed of fill soil material (including a large percentage of waste debris) and the facility is on a septic system.

Prior to use of the site as firing range and storage yard, this area was utilized for disposal of waste by the City of Mesa. The City of Mesa has referred to this landfill as the North Center Street Landfill. This landfill should be distinguished from an adjoining landfill located immediately east of North Center Street that was operated by the SRPMIC. The landfill to the east of North Center Street has also been referred to as the North Center Street Landfill in some documents but typically is referred to as Tri-Cities Landfill (an extension of the Tri-Cities landfill located on the north side of the River). According to Ms. Christine Zielonka virtually no information exists for this landfill. Within the City of Mesa records there is reference to this landfill, as a part of an overall discussion of the landfills in the area, including a map showing the approximate extent of the waste boundaries. However, no investigations have been conducted specifically for this landfill. Based upon discussion with Ms. Christine Zielonka and Mr. Rich Allen and given the fact that the firing range has been in existence since the 1960s, this landfill may have pre-dated the Cypress and Tri-Cities landfills on the north side of the River.

SRPMIC Cypress Landfill (old Tri-Cities Landfill/old Country Club Landfill) and Tri-Cities Landfills

There are three landfills located within the SRPMIC near the Salt River. These landfills include the Cypress Landfill (also known as the old Tri-Cities Landfill and the old Country Club Landfill), the Tri-Cities Landfill on the north side of the River, and the Tri-Cities Landfill on the south side of the River (referred to as North Center Street landfill in some documents). The Cypress Landfill is located north of the River and south of the Cypress Golf Course between Alma School Road and Country Club Drive. This landfill operated from at least the early 1960s until approximately 1980. This landfill was never permitted nor have closure procedures been initiated. Investigations conducted at the site included a 1990 inspection by Ecology and Environment, Inc. on behalf of the US Environmental Protection Agency. This investigation was conducted in response to the discovery of the visible presence of 60 to 65 drums in various stages of decay. Fourteen of the drums were removed under emergency procedures through the ADEQ WQARF program. No additional investigations have been conducted since that time. According to the SRPMIC, they are currently in the process of submitting the site into US EPA Brownfield Pilot Project program. It is the intent of the SRPMIC to clean up the site for future development.

The Tri-Cities Landfill on the north side of the River operated from 1972 until 1993 and contains approximately 40 million cubic yards of waste. Tri-Cities Landfill on the south side of the River operated from approximately 1979 to 1980 and contains approximately 3 million cubic yards of waste. This landfill was used by the SRPMIC when flow in the River restricted access to the Tri-Cities Landfill on the north side of the River. The landfills accepted residential waste, commercial construction and demolition materials, landscaping waste, and some inert soil, asphalt, and concrete.

Information regarding these landfills was obtained from discussions with Mr. Rich Allen and a report titled "Final Closure Report and Post Closure Maintenance Plan, Tri-Cities Landfill and North Center Street Landfill" dated September 1994 and prepared by CH2M Hill. According to the information, both landfills are unlined but were closed with final grading, a barrier layer, and a vegetative layer. Historically, there had been concerns regarding methane generation and migration and groundwater contamination from the landfills. To control methane gas migration, each landfill has a methane gas collection system. The landfill on the south side of the River has a perimeter system with a flare. The landfill on the north side of the River has a collection system that is currently being directed to the SRP methane gas power generation system. Previously the gas was flared.

Groundwater monitoring has been on going with regard to these landfills since approximately 1980. The monitoring system includes five wells. The most recent round of sampling (February 2002)

included sampling of two wells at SRSR. According to Mr. Rich Allen, volatile organic compounds (VOCs) in the groundwater had posed a concern several years ago. Since, the installation of the methane gas extraction systems, the groundwater quality has drastically improved. Therefore, suggesting that the groundwater contamination was the result of landfill gases rather than leaching. According to the summary of the February 2002 groundwater quality data, no Maximum Contaminant Levels (MCLs) for VOCs were exceeded.

A UST was formerly located at the maintenance shop at the Tri-Cities landfill on the north side of the River. This UST has been removed and no releases were reported.

SRP Methane Gas Power Plant

The SRP Methane Gas Power Plant has been in operation for approximately 6 months. The plant utilizes landfill gas extracted from the adjoining Tri-City landfill. Chemical and waste storage at the plant includes new oil stored in a 2,600 gallon AST and a 1,500 gallon waste oil AST. The oil is used for the generating engines. Liesch also observed the presence of an AST used to collect condensed water from the system. The ASTs were stored in secondary containment structures. No indications of leakage were observed.

Vulcan Demolition Debris Landfill

The Vulcan demolition debris landfill is located south of the River and south of the Tri-City landfill on the east side of North Center Street. This site is located in area that is within an unincorporated portion of Maricopa County. Liesch viewed this site from publicly accessible areas.

United Metro

Liesch toured this portion of the Property with Mr. Morris Paukgana of the SRPMIC on March 26, 2002. We met with Mr. Russ Hampton, Manager of United Metro. During the site visit, Mr. Joe Delarosa, an employee of United Metro, accompanied us.

United Metro operations are located on the southeast side of Highway 87 and approximately ¼ mile north of McDowell Road. United Metro's lease encompasses approximately 170 acres. The operational portion of United Metro's leased space includes a cement batch plant, an asphalt batch plant, office area, a maintenance shop with fueling area, a distribution pond, a chemical/waste chemical storage area, a welding area, a asphalt soap down area, a cement truck wash down area, and a cement/asphalt dump area. Operations at the facility began in approximately 1954 as Union Rock. United Metro took over operations in 1995.

At the maintenance shop area, Liesch observed numerous containers of new and used automotive chemicals including lubricants, new and used oil, new and used antifreeze, parts cleaner, and oil filters. These chemicals/waste were stored in various size containers. A 1,000-gallon waste oil tank along with 15 empty 55-gallon drums were observed to be in a secondary containment structures. The remaining containers were on bare ground. The fueling areas consisted of two ASTs (15,000 gallons and 2,000 gallons) that were within secondary containment. Prior to the ASTs, the facility utilized two underground storage tanks for fuel containment. These USTs were removed in 1991. Releases were detected from both USTs and remediation efforts were initiated. Mr. Paukgana indicated that clean up has been completed to the satisfaction of SRPMIC.

Both the cement truck wash down and asphalt soap down areas utilize release agent chemicals. In the cement truck wash down area, corrosion and staining from the acid solution was visible on the ground surface.

Liesch observed an area of chemical/waste storage adjoining the welding area. Reportedly this was the former maintenance shop area. In this area, there were over 50 55-gallon drums of used oils and solvents, numerous buckets of oils, and various other containers. Most of these containers were haphazardly stored within a secondary containment structure. Extensive staining was observed within and surrounding the containment structure.

Toward the southern and southeastern portion of the site (near the River), Liesch observed an area where excess asphalt and cement are dumped. This area is also utilized to dispose the fine sediments that are removed from the clarifier that handles the process water. The water is recycled back to the distribution pond. In some areas, the cement/asphalt has extended beyond the River embankment. Also in this general area, Liesch observed pond water. According to Mr. Delarosa, this water is from run-off from the cement truck wash down and cement dump areas.

The cement and asphalt batch plants both stored chemicals/materials in ASTs. Approximately eight ASTs containing admixtures were observed in a secondary containment structure at the cement batch plant area. Chemicals/materials at the asphalt batch plant included two ASTs with burner fuel and two ASTs containing hot oil. Small quantities of release agents and lubricant oils were also observed in the asphalt batch plant area.

Former Enviro-Systems

Enviro-Systems formerly occupied a site located just west of the United Metro Facility. Enviro-Systems is a pre-cast concrete operation that occupied the site from approximately 1978 until approximately 2001. Prior to their occupancy, the site was reportedly occupied by Defiance of

Arizona from approximately 1968 to 1978. No information regarding the operations performed by Defiance of Arizona was available. According to information provide by SRPMIC, Enviro-Systems utilized form oil as part of their operations. In 1999, four areas of stained soil were identified at the site. At the request of the SRPMIC, an investigation, followed by removal activities, was performed to address the stained areas. A report titled "Stained Soil Excavation Former Enviro-Systems Facility", dated October 21, 2001, prepared by Terrane Engineering Corporation, documents the activities performed. According to Mr. Paukgana clean up has been completed to the satisfaction of the SRPMIC.

Private and Allotted Residential Land

Some private and SRPMIC allotted land parcels were observed throughout the Property. The majority of the SRPMIC allotted land was located south of Thomas Road and east of Mesa Drive. Several trailer parks were observed near Country Club Drive and the River. A horse farm is present on the south side of the River at approximately the Val Vista Road alignment. Liesch assumes minimal environmental issues would exist for these properties.

Lehi Cemetery

The Lehi Cemetery is located on the south side of the River, north of Thomas Road and east of Stapley Drive. The cemetery is used by the SRPMIC. According to Mr. Bob Ronzo with the SRPMIC Public Works Department, this is a tribal cemetery and no chemicals are utilized in the burial process. There is a small shed on site, which is utilized for the storage of lawn equipment.

Granite Reef Underground Storage Tank Project

The Granite Reef Underground Storage Project (GRUSP) is headed by SRP and includes the Cities of Mesa, Scottsdale, Tempe and Gilbert as participants. The SRP leases land from the SRPMIC to implement the project. The project consists of banking water originating from the Arizona, South, and Central Arizona Project (CAP) Canals for future utilization. The water is recharged into a series of ponds within the River that extend from Gilbert Road east to approximately the Val Vista Road alignment. The project was originated in approximately 1994 with a total of 5 ponds. The two ponds located furthest east were constructed approximately 1.5 years ago. No chemicals are utilized on the water, and vegetation within the ponds is removed by hand.

According to information provided by Mr. Rich Allen, localized groundwater levels have increased drastically since the project was initiated. In addition to monitoring conducted by GRUSP, the

SRPMIC landfill personnel continue to monitor water levels to ensure that the proper separation distance between the base of the operating Salt River Landfill and the water table is maintained.

Chandler Ready Mix Operations

Liesch observed the Chandler Ready Mix Operation located south of the River and on the east side of Gilbert Road from publicly accessible areas. It is Liesch's understanding that these operations are within the City of Mesa. The operational activities appeared similar to those observed at the SRSR operations. Liesch assumes that similar environmental issues exist.

Talley Defense Systems

Liesch observed the northern most portion of the Talley Defense Systems (Talley) property from publicly accessible areas. Talley is located south of the SRSR-Higley operations. Talley is an industrial complex designed for the development of testing and manufacturing of propellant-based products. Talley is listed as a RCRA Generator and is noted on the RCRA Corrective Action database. Based upon the fact that this facility is listed as a RCRA Correction Action site is an indicator that contamination has occurred. During Liesch's inspection of the SRSR-Higley operations, the explosive testing which occurs at Talley Defense Systems was capable of being heard and vibrations experienced.

Salt River Sand and Rock – Higley Operations (Including Vulcan, Hanson, United cement batch plants, maintenance areas, and wash down areas; Vulcan asphalt batch; and, JD Excavating)

Liesch toured this portion of the Property with Mr. Morris Paukgana of the SRPMIC on March 25, 2002. We were accompanied Mr. Bob Mackey, Manager for SRSR-Higley.

The Salt River Sand and Rock (SRSR) – Mesa Operations is an SRPMIC enterprise business that operates a sand and gravel quarry. SRSR encompasses over 160 acres of land within and on the south side of the River between approximately the Val Vista Road and Higley Road alignments. Operations in this area began in approximately 1985. Within the developed portion of SRSR, there are subleased areas that include Vulcan, Hanson, and United Metro cement batch plants, Vulcan asphalt batch plant, and J&D Excavating (equipment and dynamite storage). Other areas within the developed portion of the site include maintenance areas, fueling areas, distribution pond, and cement truck wash down areas.

J & D Excavating maintains an equipment yard, a dynamite storage unit, a separate unit for the dynamite caps, and a semi-trailer storage unit with fertilizer. No indications of leakage or soil staining were observed in this area.

Hanson, United Metro, and Vulcan each included a cement mixing area, a vehicle maintenance and fueling area, and a truck wash down area. Each batch plant was similar in construction and each stored cement add-mixture chemicals in ASTs. There were approximately 8 to 12 ASTs of various sizes at each location. The vehicle maintenance and wash down areas are relatively small and are for conducting minor repairs on the cement trucks. The wash down areas are for washing the exterior of the cement trucks prior to leaving the site. Typical observations in maintenance areas included one or more AST fuel tanks and various quantities of new and used automotive chemicals. At the wash down areas, Liesch observed high-pressure washers along with rinse wax, an acid based solution to remove cement, and a neutralizing chemical. Most of the ASTs and some of the smaller quantities of stored chemical and waste were within containment structures. Some soil staining was observed in areas where secondary containment was not present and/or within the containment structures. In the wash down areas, pooled water was observed and corrosion of the ground surface from the acid solution was visible in these areas. The wash down water from the United Metro wash rack is discharged to a cesspool.

The Vulcan asphalt batch plant included four ASTs with burner fuel and/or diesel, and a 20,000-gallon asphalt storage tank. All ASTs were within secondary containment structures.

The SRSR-Higley maintenance and fueling area included two diesel ASTs, one gasoline AST, and approximately eight new and used oil and lubricant containers. All of these containers were within secondary containment structures.

Primate Research Center

Liesch visited the primate research center on March 21, 2002 and was accompanied by Ms. Jo Fritz and Mr. Jim Murphy. Ms. Fritz is the originator of this federally funded center. The primate research center is located on the south side of the River between the Granite Reef Dam and the SRSR-Higley operations. The primate research center has been at this location for approximately 25 years and has been constructed using the framework of a former hydro-generating station that predated the construction of the dams upstream on the Salt River. The hydro-generating station dates back to the early 1900's and has historical significance.

The center consists of several modular offices, a building with cages for the primates, a maintenance shed, and several mobile structures for residences. The center conducts behavioral research on chimps and apes.

Very few chemicals are used and/or stored at the site. Chemicals observed include small quantities of cleaning supplies, landscape equipment fuels and lubricants, and several containers of compressed gases.

Ms. Fritz has indicated that all biowaste is cleaned up daily and transported to a landfill for disposal.

Granite Reef Dam, Central Arizona Project (CAP), Arizona and South (formerly recognized as Southern) Canals

The Granite Reef Dam is the northeastern boundary of the Property area. The CAP, Arizona and South canals are within in the Property area near the Granite Reef Dam. The US Government owns the canals and dam. They are operated and maintained by SRP. The Granite Reef Dam is a diversion dam located down stream of the confluence between the Salt and Verde Rivers. Water from the dam is diverted in to the Arizona and South canal for irrigation and municipal purposes. Some of the water from canals, including the CAP canal, is diverted to the GRUSP.

According to Mr. Rick Anduze of the SRP, the dam and canals are all controlled remotely from a central location. Mr. Anduze further indicated that he is not aware of the use of any chemicals associated with the dam, canals and/or GRUSP project. He indicated that there might be small quantities of lubricants or oils associated with the dam.

3.3 Current Ownership

The majority of the portion of the River lies within boundaries of the SRPMIC. Within the Community there is leased land and private allotted land (owned by community members). Other portions of the River and surrounding areas include property that is owned by the State of Arizona, City of Mesa and private individuals and businesses within the City of Mesa and unincorporated portions of Maricopa County.

3.4 Prior Use

The use of the Property has not varied significantly since the time of development. Initially, the River and surrounding portions were undeveloped. Over time, the quarry operations and associated operations have developed. In addition, increased commercial businesses have been established on

the Mesa side of the River primarily near Country Club Drive. Landfill operations appear to have been an ongoing activity along the River since at least the early 1960s. The various locations of the landfills have changed.

3.5 Adjacent Properties

Due to the extensive Property area, the adjacent properties have not been identified. Liesch has attempted to discuss all sites within a ¼ mile of the River that may have some impact on the potential restoration project.

4.0 PROPERTY HISTORY

4.1 Aerial Photograph Review

A 1936 aerial photograph was reviewed at the City of Phoenix Historical Records Department. Aerial photographs were also reviewed at the Landiscor Aerial Photography in Phoenix in approximate three-year increments. Negative N-19 covered the Salt River beginning at Loop 101 ending at Mesa Drive from the years 1966 through 2002. Negative M-20 covered the Salt River beginning at Mesa Drive ending at Val Vista Drive from the years 1964 through 2002. Negative M-21 covered the Salt River beginning at Val Vista Drive ending at Power Road from the years 1962 through 2002. Liesch also reviewed aerial photographs made available by the SRPMIC for the years 1997, 2000, and 2002. Copies of Negative N-19 for the years 1966, 1971, 1981 and 1991; Negative M-20 for the year 1964; and M-21 for the year 1962 are included in **Appendix C**. The information obtained during the review is summarized as follows:

1930's

In the 1936 photograph, no structures or man-made objects were observed in or adjacent to the Salt River.

1960's

The Salt River appeared relatively unchanged from Mesa Drive to Power Road. The United Metro Operations were visible in the early 1960's. There appeared to be some commercial development south of the River near Alma School Road and Country Club Drive. The Cypress golf course is also present. The United Metro facility occupied a much smaller area that it currently does. A quarry is present to the west of the current location of the Highway 101.

1970's

A quarry appeared east of Gilbert Road (RMC location). A structure was present at the approximate location of the Arizona Propane propane facilities in the early 1970's. The primate research center appeared in the mid 1970's. What appears to be landfill activity was observed in the area of the Cypress landfill. McKellips Road appears in the early 1970's.

1980's

The Lehi Cemetery and the SRSR Mesa Operations, appear in the early 1980's. In addition, quarry operations on the south side of the River near Alma School are ongoing. In the mid to late 80's operations at the SRSR-Higley Plant are apparent. The United Metro operations appear to be expanded in the mid 1980's. The Tri-Cities landfill is apparent in the 1980's. There is increased commercial development south of the River near Country Club Drive.

1990's

The Mesa wastewater recharge ponds located south of the south bank of the River appeared in the early 1990's. The GRUSP groundwater recharge ponds appeared in the mid 1990's. Operations appear to be expanded at SRSR-Mesa in the 1990s.

2000-2002

The hard bank along the north and south sides of the River was present in 2000. The SRP Methane Gas Power Plant appeared in 2002.

4.2 Topographic Maps, City Directories, And Sanborn Maps

Liesch reviewed the USGS 7.5-minute series topographic maps "Tempe, Arizona", dated 1952/1982, "Mesa, Arizona", dated 1952/1982, "Buckhorn, Arizona", dated 1956/1982, and "Granite Reef", dated 1964/1974. Topographical maps may identify structures, roads and general use of a Property for the year determined by the date of the map. These maps were used extensively in conjunction with the 2002 aerial photographs to verify locations of the developed portions along the Property area.

4.3 Interviews

The following individuals were interviewed in compiling the information contained within this report. Please refer to the individual site descriptions for interview details.

CONTACT	PROGRAM	NUMBER	INFORMATION
Ms. Dawn Daw	SRPMIC – CES	480-850-8950	General property information
Mr. Morris Paukgana	SRPMIC – CES	480-850-8062	General, UST, and site walk-over information
Mr. Abel Ramirez	SRPMIC – CES	480-850-8500	General, landfills
Mr. John Wharam	SRPMIC – ECS	480-850-7284	GRUSP
Mr. Kimball Siegfried	SRPMIC – ECS	480-850-7228	2002 aerial photographs
Mr. Bill Garrard	SRPMIC-EDO	480-850-8526	Land lease information
Mr. Richard Allen	SRPMIC–Landfill Serv.	480-941-3427	Landfill information
Mr. Bob Ronzo	SRPMIC – Public Works	480-850-8260	Lehi Cemetery
Mr. Eddie Centers	Vulcan – Mesa	480-947-8135	Vulcan-Mesa
Mr. Kevin Derrossett	Vulcan - Mesa	480-947-8135	Vulcan-Mesa
Mr. Wayne Hills	SRSR-Mesa	480-990-1987	General information SRSR
Mr. Vern Wilson	SRSR-Mesa	480-990-1987	General information SRSR
Mr. Bob Mackey	SRSR-Higley	480-981-5895	SRSR-Higley
Mr. Russ Hampton	United Metro	480-990-0847	general information
Mr. Joe Delarosa	United Metro	480-990-0847	operational information
Ms. Jo Fritz	Primate Research Center	480-832-3780	Primate center operations
Mr. Martin Dawson	Arizona Propane	480-990-2245	Arizona Propane
Mr. Gordon Haws	Mesa, Engineering Design	480-644-3380	General Mesa information, Mesa WWTP
Ms. Christine Zielonka	Mesa, Environmental Programs	480-644-3833	Landfill, Firing Range, Storage Yard
Mr. Richard Anduze	Salt River Project	480-236-2804	Dam, GRUSP, Central canals

5.0 ASSESSMENT INFORMATION

5.1 Regulatory File Search

A computerized file search organization, First Search, conducted an evaluation of regulatory databases to determine if identifiable environmental concerns exist on or within the ASTM-defined radii from the Property. For the purposes of this project a linear search was completed. The radii search extended from a line through the approximate center of the River. The FirstSearch report, dated April 26, 2002, is included as **Appendix D**. The database search included the following components:

The EDR response consisted of an examination of the following U.S. Environmental Protection Agency (EPA) and ADEQ databases, as follows:

1)	US EPA	National Priorities List (NPL) – 1 mile;
2)	US EPA	RCRA Corrective Actions and associated TSD (CORRACTS, TSD) – 1 mile;
3)	State	State Equivalent Priority List (SPL, or WQARF) 1 mile;
4)	State	State Equivalent CERCLIS List (SCL, or ACIDS) – 1 mile;
5)	US EPA	Sites currently or formerly under review by US EPA (CERCLIS) - ½ mile;
6)	US EPA	RCRA Permitted Treatment, Storage and Disposal Facilities (TSD) - ½ mile;
7)	State	Leaking Underground Storage Tanks (LUST) – ½ mile;
8)	State	Permitted Solid Waste Landfills, Incinerators or Transfer Stations (SWLF) – ½ mile;
9)	US EPA	RCRA Violations / Enforcement Actions - 1 mile;
10)	US EPA	Toxic Release Inventory Database (TRIS) - 1 mile;
11)	State	Registered Underground or Aboveground Storage Tanks (REG UST/AST) – ¼ mile;
12)	US EPA	Emergency Response Notification System of Spills (ERNS) – ¼ mile;
13)	US EPA	RCRA Registered Small or Large Quantity Generators of Hazardous Waste (RCRA GEN) – ¼ mile;
14)	State	Hazardous Materials Incident Logbook (SPILLS) – ¼ mile;
15)	State	Registered Dry Wells (Permits) – ¼ mile.

A review of the database indicates that the following sites were identified within the Property area. These sites have been determined to be within the Property area, based upon address or general location provided and or based upon observation of the facility during the site-walk over.

FirstSearch Database Information		
Data Base Type	**Site Name & Address** (*unknown if within Property boundaries)	**General Information**
NPL	Indian Bend Wash Area McDowell Road & Hayden, Scottsdale, AZ	The Indian Bend Wash encompasses 12 square miles in parts of Scottsdale, Tempe and Phoenix, AZ. Groundwater is contaminated with TCE and other chlorinated solvents. The EPA is developing a Remedial Action Plan outlining the investigations needed to determine the full extent of cleanup required at the site.
CERCLIS	North Center Street Landfill End of Center Street at River	Status is listed as no further remedial action planned
CERCLIS	Mesa Area Groundwater Contamination T1N, R5E	Status is listed as no further remedial action planned
CERCLIS	Tri-City Landfill Salt River Indian Reservation	Status is listed as no further remedial action planned
SWL	City of Mesa Northeast Corner of Center St Mesa, AZ	Closed
SWL	Salt River/Pima Tribe/Tri-City 1 Mile North of McDowell Gilbert, AZ	Closed
UST/LUST	ADOT Mesa Maintenance 2409 North Country Club Drive Mesa, AZ	Four removed USTs and two current USTs One LUST incident listed as Undefined or unknown soil contamination One LUST incident listed as Free product on Groundwater and/or SW
UST/LUST	Bingo Hall/Ray Station 2435 North Country Club Drive Mesa, AZ	Three removed USTs One LUST incident listed as Closed soil levels meet RBCA Tier 1
UST/LUST	DPS/AZ Dept of Public Safety 2409 North Country Club Drive Mesa, AZ	One removed UST One LUST incident listed as Closed soil levels meet RBCA Tier 1
UST/LUST	Tevizo Hay Co. 1747 North Alma School Mesa, Arizona	Three removed USTs One LUST soil contamination undefined
LUST	Karl Watkins 2116 N. Country Club Mesa, Arizona	One LUST incident listed as Closed soil levels meet RBCA Tier 1
LUST	Contreras Contractors 2110 North Country Club Mesa, Arizona	Seven LUST incidents all listed as Closed soil levels meet RBCA Tier 1
LUST	Sunward Materials/BCW 1564 North Alma School Mesa, Arizona	One LUST incident listed as Closed soil levels meet RBCA Tier 1
LUST	Cashway Concrete & Materials 650 W. McKellips Road Mesa, Arizona	One LUST incident listed as Closed soil levels meet RBCA Tier 1

FirstSearch Database Information		
Data Base Type	**Site Name & Address** (*unknown if within Property boundaries)	**General Information**
LUST	Valley Wide Contracting 620 W. McKellips Mesa, Arizona	One LUST incident listed as Closed soil levels meet RBCA Tier 1
LUST	Chandler Ready Mix 3250 E. Lehi Road Mesa, Arizona	Six LUST incidents all listed as Closed soil levels meet RBCA Tier 1
UST	Sun Valley Crushing Co 2343 North Country Club Drive Mesa, AZ	One removed UST
UST	Superstition Crushing 2343 North Country Club Drive Mesa, AZ	One inactive UST
UST	W R Skousen Contractor Inc 2333 North Country Club Drive Mesa, AZ	One removed UST
RCRACOR	Talley Defense Systems, Inc. 4111 & 4301 N. Higley Road Mesa, Arizona	RCRA Corrective Action ongoing associate with land disposal activities and storage and treatment. No reference to media contaminated. Numerous violations that have been resolved are listed.
RCRAGN	Salt River Indian Community 11134 Beeline Highway Scottsdale, AZ	Generates less than 100 KG/Month of hazardous waste
RCRAGN	Calmat Companies 1900 Longmore Road Mesa, AZ	Generates less than 100 KG/Month of hazardous waste
RCRANLR	Valley Oil Services 1747 N. Alma School Road, Ste. B Mesa, Arizona	No longer regulated
RCRANLR	Salt River Indian Community 11134 Beeline Highway Scottsdale, AZ	No longer regulated
RCRANLR	StatewideEnvironmental Svcs. 1747 N. Alma School Road Mesa, Arizona	No longer regulated
RCRANLR	Calmat Companies 1900 Longmore Road Mesa, Arizona	No longer regulated
SPILLS	City of Mesa Salt River & Alma School Mesa, AZ	Spill date: July 26, 1990. An unknown material was released form trucks
SPILLS	*Moreno Trucking Salt River Indian Reservation Scottsdale, AZ	Spill date: July 10, 1991. 30-gallon of unknown substance was released from bottles
SPILLS	SRPMIC Tribal Golf Course Scottsdale, AZ	Spill date: April 10, 2001. a threat of 60-gallon of unknown substance from drums

FirstSearch Database Information		
Data Base Type	**Site Name & Address** (*unknown if within Property boundaries)	**General Information**
SPILLS	Unknown/SRIC Country Club & McDowell Rd Scottsdale, AZ	Spill date: July 15, 1996. a threat of 50 to 60-drums of unknown substance from drums
SPILLS	Talley Defense 1 mile N of 4111 N Higley Mesa, AZ	Spill date: June 5, 1992. a fire 1000 pounds of unknown substance

Liesch has also obtained a copy of the US EPA database for UST and LUST sites within the Property. Mr. Morris Paukgana provided this database to Liesch. Database print outs received from Mr. Paukgana are included in **Appendix E**. The following is a summary of the information within the database. The database information indicates that there are several open LUST sites. However, according to Mr. Paukgana there are no current open LUST sites within the Property. There are four existing USTs within the Property. These are located at the Vulcan asphalt batch plant.

US EPA UST/LUST DATABASE	
Site Name	**General Information & Notes**
Industrial Asphalt Inc-CalMat (Vulcan-Mesa) [1]	No site closure or remediation date listed
Salt River CalMat – CalMat of Arizona (Vulcan-Mesa) [1]	1993 remediation completed
Salt River Sand & Gravel (SRSR-Mesa)	1992 Site closure letter sent
Union Rock & Materials Corp (United Metro) [2]	There was no site closure or remediation date
JR's Convenience Store	No releases reported at this site
Industrial Asphalt (Vulcan – Mesa) [1]	No releases reported at this site
Tri City Landfill [3]	No releases reported at this site

1-Based upon discussions with Mr. Mark Paukgana, there is some duplication in this database. These three sites are the same site. There were six USTs on site. To have been removed and four remain on-site. Further Mr. Paukgana indicated that the two removed USTs have been granted closure.
2-According to Mr. Morris Paukgana clean up is complete for this site.
3-This UST has been removed and no releases have been reported.

6.0 PHYSICAL SETTING

6.1 Topography

Based on the USGS 7.5-minute series topographic maps "Tempe, Arizona" dated 1952 photorevised 1982, "Mesa, Arizona" dated 1952 photorevised 1982, "Buckhorn, Arizona" dated 1956 photorevised 1982, "Granite Reef, Arizona" dated 1964 photorevised 1974 the Property is approximately between 1,200 and 1,300 feet above mean sea level. Regional topography of the Property is generally slopes gradually to the west to southwest.

1952 & 1956
Unimproved roads were depicted throughout the project area.

1964 &1974
Granite Reef Dam was depicted at the east boundary of the project area. Unimproved roads were depicted throughout the project area. Gauging Stations were depicted east and west of the Granite Reef Dam. The generally northeast/southwest aligned South Canal was depicted beginning at the Granite Reef Dam. The generally east/west aligned Arizona Canal was depicted beginning at the Granite Reef Dam. Talley Defense Systems is present in the 1974 edition.

1982
Generally northeast/southwest aligned high-tension power transmission lines were depicted from the Highway101 (south of McKellips) and continuing northeast just south of the Highway 87. Quarry operations pits were depicted in the River from the approximate alignment of Longmore Road to the approximate alignment of Country Club Drive. An intricate surface area indicates the Tri-Cities landfill. The RMC quarry operations (at Gilbert Road) are depicted by an intricate surface area. Quarry operations were noted at the River between the Greenfield and Higley Road alignments.

6.2 Soils

Based on a soil survey of Eastern Maricopa and Northern Pinal County by the Soil Conservation Service (SCS), soils within the Salt River bed primarily consist of Alluvial Land. Alluvial land is nearly level land that generally has a hummock appearance. Alluvium consists of stratified, recently deposited stream sediment in the channels of the Salt River. Texture of the surface layer ranges from gravelly sand or very gravely sand to fine sandy loam. The material beneath the surface layer is very gravelly sand to very fine sandy loam and loam. Permeability ranges from very rapid to moderate, runoff is slow, and soil blowing is generally a hazard.

6.3 Regional Geology

The Property is located in the central portion of the Phoenix Active Management Area (Laney and Hahn, 1986). The Salt River Valley is a broad alluvial basin within the Basin and Range Physiographic Province in south central Arizona (Wilson, 1962). The basin is almost completely surrounded by mountains composed primarily of granitic, metamorphic and volcanic rocks. The valley floor is underlain by unconsolidated to semi-consolidated basin-fill sediments that are more than 10,000 feet thick in the central part of the basin. Depth to bedrock in the project area varies extensively.

6.4 Surface and Groundwater Hydrology

The principal drainage through the Phoenix Basin is the Salt River, an ephemeral stream that normally flows only in response to reservoir releases or significant precipitation events. The Property is located within the Salt River. Other drainage features in the Property area include the South, Arizona and CAP canals near the eastern end of the Property. There were several irrigation run-off collections ponds as wells as distribution ponds for the mining operations.

According to the Arizona Department of Water Resources (ADWR) well registration database, dated July 2001, depth to groundwater in the project area varies from around 10 to 440 feet below ground surface. Local drainage features that may alter or influence the groundwater depth and flow direction include: wastewater treatment recharge ponds, GRUSP, quarry operation distribution ponds, water well pumping, and canals.

7.0 WALK-OVER SURVEY

On March 20, 2002 two Liesch teams of two individuals conducted a walkover of the Riverbed within the Property. Access to the Riverbed was from roadways along the hard bank, quarry operation haul roads, canals, and public roadways. The purpose of this walkover was to assess conditions within the Riverbed and to obtain a general understanding of the sites located on the banks of the river. During March 22 through March 27, 2002, Liesch representative, Ms. Julianne Hamilton conducted individual site visits of businesses and operations within the SRPMIC. On April 15, 2002, Ms. Hamilton conducted a site visit of the Mesa northwest wastewater treatment plant, firing range and North Center Street Landfill. During April 15 through April 19, 2002, Liesch conducted an inspection of the sites located along the south side of the River from publicly accessible areas. Photographs taken during the walkover are included in **Appendix F.**

7.1 Vegetation and Stained Soil

Vegetation types varied throughout the Property and included natural desert vegetation and landscaped vegetation. Also within the River, Liesch observed wetland vegetation. In many areas of the Property, particularly the quarry operations, there was no vegetation, rather bare soil.

Stained soil was observed throughout the Property. Most stained areas appeared to be associated with automotive chemicals and wastes. Staining and corrosion was observed associated with the cement truck wash down areas. Staining was also observed in the areas where vehicle storage and repair were occurring on bare soil. Section 3.2 provides additional detail with regards to stained areas at individual sites.

7.2 Chemicals and Raw Materials

Numerous chemicals and raw materials were stored throughout the Property. Chemicals included petroleum products for fueling, automotive/equipment chemicals such as oils, lubricants, degreasers, antifreeze, blended fuels and oils for the asphalt batch plants, various varieties of add-mixture chemicals for the cement batch plants, acid and neutralizing solutions for cement truck wash down, release agency for asphalt truck wash down, wastewater treatment chemicals, dynamite, fertilizer, cement color dye, fly ash, and propane. Some of these chemicals were stored within secondary containment structures while others were not. In several areas, leakage and staining was observed. Raw material storage included aggregate rock, asphalt, cement and roto-mill. Additional information regarding chemical and raw material storage for individual sites is included in Section 3.2

7.3 Polychlorinated Biphenyls (PCBs)

Numerous electrical transformers were observed on the Property. In addition, potential PCB-containing equipment was observed on the Property. Liesch was not provided with any information regarding testing of the transformers and equipment for PCBs.

7.4 Asbestos-Containing Materials (ACMs)

Based upon the age of some of the structures on the property it is possible that asbestos-containing materials are present on the Property. Liesch did not conduct an asbestos survey as part of this scope of work.

7.5 Hazardous Wastes and Hazardous Substances

Several sites within the Property area were listed as RCRA generators (some no longer regulated) and Talley Defense Systems site is listed as RCRA Corrective action site which indicates that some degree of corrective action was required for the site with respect to a release of hazardous wastes/substances.

7.6 Landfills, Dumps, Debris Piles

Liesch observed the presence of four landfills within the Property included Cypress Landfill; North Center Street Landfill, and the Tri-Cities Landfills (north and south sides of the River). A discussion of each landfill is provided in Section 3.2.

Liesch observed numerous areas of stockpiles of soils, debris piles, and dumped debris throughout the Property. The majority of the material was along boundaries of the River and canals. However, some debris was observed within the Salt Riverbed. The debris consisted of soils, concrete, old tanks, asphalt, household debris, and vegetative wastes. Of particular concern is the large debris piles located at the southeast portion of the SRSR-Mesa. This debris reportedly contains waste resulting from past washouts of the upstream landfills during periods when the River flowed and prior to construction of the hard banks. In addition, Mr. Paukgana reports that there have also been indications of illegal dumping, including drums, have occurred in this area.

7.7 Pits, Wells, Sumps, Drywells, Catch Basins

Liesch observed water wells throughout the Property including wells used for quarry operations, domestic supplies, and SRP wells. Numerous pits/sumps/catch basins were observed throughout the Property including a wash racks, bay drain sumps, cesspool for cement truck wash down water, and floor drain sumps. No drywells were observed on the Property.

At SRSR-Mesa, SRSR-Higley, United Metro, CEMEX, and RMC on Gilbert Road water distribution ponds were observed. Reportedly the water within these ponds is supplied by well water and/or natural groundwater infiltration. Some water within SRSR's pond is recirculated after removal of fine sediment.

Liesch also observed several areas within the River where irrigation run-off water and storm water is collected.

7.8 On-Site Storage Tanks (Aboveground and Underground)

Based upon information provided by Mr. Morris Paukgana there are four USTs associated with the Vulcan asphalt plant. In addition, there are three USTs listed for JR's Convenience Store. The ADOT storage yard and numerous other business near the River at Country Club Drive, Alma School Road, and McKellips Road are listed on the database has having registered USTs. Numerous USTs have been removed and have been listed a LUST incidents. All LUST incidents within SRPMIC have been resolved and are closed. It also appears that the majority of the LUST incidents on the south side of the River within the City of Mesa have also received a "case closed" status.

Numerous ASTs were observed throughout the site including ASTs for fuel, new and used oil, water storage, asphalt storage, add mixture chemicals, blended fuels for asphalt productions, cement and asphalt release agents, fly ash, propane, digester gas, and waste water treatment chemicals. The majority of the ASTs were within secondary containment structures. In some areas, staining was observed within the containment or on the ground surface.

8.0 PREVIOUS ENVIRONMENTAL REPORTS

In preparation of this report, Liesch reviewed numerous documents that were provided by the SRPMIC. Some of these documents are included in Appendix B. Other documents are referenced in Section 3.2 as they related to specific sites.

9.0 QUALIFICATIONS

Qualifications of this author are attached in **Appendix G**.

10.0 CONCLUSIONS

Liesch has focused on identifying general environmental issues that may be of concern specifically to the design and planning of the proposed Salt River Restoration project, which is focused primarily along the Salt River bed and banks.- Access to private properties within the City of Mesa on the south side of the River and to the Cypress golf course, RV storage facility, JR's Convenience Store, Saddleback Communications, and private allotted land within SRPMIC was not provided at the time of Liesch's site visit. Therefore, only the portions of these areas visible from public right-of-ways were observed. More detailed assessment of individual areas within the Property may be necessary depending upon the specific proposed restoration. This site assessment does not include a comprehensive compliance analysis regarding local, state or federal environmental laws, rules or regulations.

Based on Liesch's assessment, the following environmental issues were identified for the Property.

Salt River Sand and Rock

- Maintenance shop – wash rack, chemical/waste storage
- Lube shop – chemical/waste storage and staining
- Sand blasting/paint area – bare ground
- Vehicle repair and storage area – bare ground
- Large quantities of debris (potential disposal issues)
- Cement dump area
- Former leaking UST (historic)

Chandler Ready Mix at SRSR

- Maintenance shop – storage, staining
- Wash down area – corrosion, staining

Hanson/United Metro/Vulcan Cement Batch Plants at SRSR Mesa and Higley

- Wash down areas – staining, corrosion
- Vehicle maintenance – staining, storage
- Chemical storage – leakage, some without secondary containment

Vulcan Maintenance Yard and Asphalt Batch Plant

- Wash down chemical storage area - staining
- Former USTs – (historic)
- Four existing USTs
- 1999 Explosion (historic)
- Debris/parts storage area

CEMEX Operations (and associated operations)

- Assumed issues same as other quarries

Arizona Propane

- Former site operations (Forest Homes)
- Stockpile of debris/waste
- Maintenance sump

Various Commercial Businesses

- Chemical/waste storage
- References to spills/releases in the database
- USTs/ASTs

United Metro

- Chemical storage area (numerous drums and staining)
- Cement batch plant chemical storage
- Cement/asphalt dump area – extending over hard bank
- Wash down area – corrosion, staining, pond water
- Former USTs (historic)

Enviro-Systems

- Soil contamination clean-up (historic)
- Former site operations (unknown)

Tri-City Landfill (north and south sides)

- Groundwater contamination
- Methane migration

North Center Street Landfill

- No information available

Cypress Landfill

- Known contamination currently requesting brownfield pilot clean-up funding

Mesa Firing Range

- Lead contamination
- Berms constructed of debris/soil mixture

Vulcan Demolition Debris Landfill

- Unknown

Chandler Ready Mix – at Gilbert Road

- Assumed issues same as other quarries

Salt River Sand and Rock – Higley Operations

- Wash down areas/sump/cesspool
- Chemical storage – some staining

Talley Defense Systems

- Existing contamination
- Explosive testing

General Issues – Property Wide

- Irrigation run-off water
- Debris/illegal dump areas
- Wastewater recharge ponds
- Septic systems
- Water wells

11.0 REFERENCES

CH2M Hill, 1994, Final closure Report and Post Closure Maintenance Plan, Tri-Cities Landfill and North Center Street Landfill, September.

Geotechnical and Environmental Consultants, Inc., 2002, Phase I Environmental Site Assessment Proposed TSA Multipurpose Facility, SE of McKellips Road and Dobson Road, Maricopa County, Arizona, March.

Laney, R.L. & Hahn, M.E., 1986, Hydrogeology of the Eastern Part of the Salt River Valley Area, Maricopa and Pinal Counties, Arizona, U.S. Geological Survey Water-Resources Investigations Report 86-4147.

Soil Conservation Service (SCS), 1974, Eastern Maricopa and Northern Pinal Counties Area by the Soil Conservation Service, United States Department of Agriculture, November.

Terrane Engineering Corporation, 2001, Stained Soil Excavation, Former Environ-Systems Facility, Beeline Highway, ¼ Mile North of McDowell Road, SRPMIC, Arizona for Enviro-Systems Corporation, October.

U.S. Geological Survey (USGS), 1952, Tempe, Arizona 7.5-minute Series Topographic Map, photorevised 1982.

U.S. Geological Survey (USGS), 1956, Buckhorn, Arizona 7.5-minute Series Topographic Map, photorevised 1982

U.S. Geological Survey (USGS), 1952, Mesa, Arizona 7.5-minute Series Topographic Map, photorevised 1982

U.S. Geological Survey (USGS), 1964, Granite Reef, Arizona 7.5-minute Series Topographic Map, photorevised 1974

Wilson, E.D., 1962, A Resume of the Geology of Arizona, The Arizona Bureau of Mines, Bulletin 171.

Appendix I

Yuma Clapper Rail Survey Report

Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area Maricopa County, Arizona

Prepared for:

U.S. Army Corps of Engineers, Los Angeles District
Phoenix Field Office
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602/640-2003

Prepared by:

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602/256-6662

August 2004

Jones & Stokes. 2004. *Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area, Maricopa County, Arizona.* August 2004. (J&S 03-048.) Phoenix, AZ.

Yuma Clapper Rail Survey Report for the Va Shly'ay Akimel Project Study Area, Maricopa County, Arizona

Project Location

The U.S. Army Corps of Engineers (Corps) is proposing restoration of the Salt River between Granite Reef Dam and the interchange of the Loop 101 and Loop 202 in Maricopa County, Arizona. The area proposed for restoration has been designated by the Corps the "Va Shly'ay Akimel Project Study Area." Project boundaries encompass both banks of the Salt River channel between dam and Loop 101/202 to a distance of ½-mile to either side of the *thalweg*, or deepest portion of the river channel. Suitable habitat for the Yuma clapper rail is located within the boundaries of the project area in Township 1 North, Range 5 East, Section 18 (Figure 1).

Survey Area

Elevation of the project area is approximately 1,200 feet above mean sea level, and topography in the vicinity is predominantly flat. The project area is located within the Lower Colorado River Subdivision of the Sonoran Desertscrub biotic community (Brown et al. 1994). However, the project area is within an urban setting and the river bottom exhibits signs of long-term disturbance, including roads, landfills, mining operations, and illegal trash dumping.

During the planning process for the restoration project, it was determined that suitable habitat for the Yuma clapper rail is present in wetlands located adjacent to the interchange of the Loop 101 and Loop 202. The wetland has year-round water present and vegetation in the survey area is dominated by cattail (*Typha domingensis*). Table 1 details plant species occurring in and around the surveyed wetland during field activities.

Table 1. Plants Documented in the Salt River During Surveys

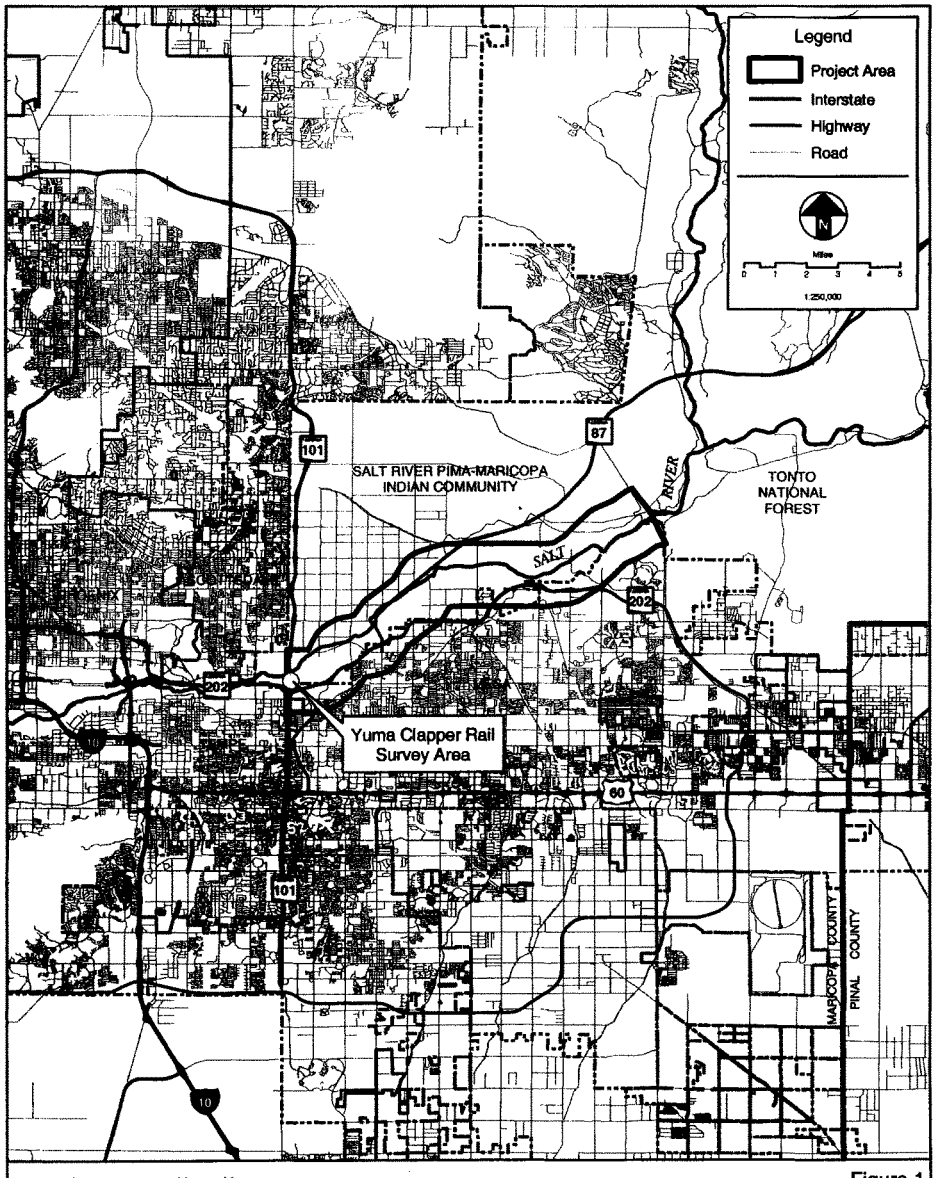
Species Name (Common Name)	Scientific Name
Bermuda-grass	*Cynodon dactylon*
Rabbits-foot	*Polypogon monspeliensis*
Fountain-grass	*Pennisetum ciliare*
Mexican sprangletop	*Leptochloa dubia*
Curly-dock	*Rumex crispus*
Cattail	*Typha domingensis*
Yellow nut-sedge	*Cyperus esculentus*
Bulrush	*Scirpus validus*
Bulrush	*Scirpus paludosus*
Knotweed	*Polygonum argyrocoleon*
Water speedwell	*Veronica anagallis-aquatica*
Salt heliotrop	*Heloptropium curassavicum*
Euphorbia	*Euphorbia albomarginatus*
Desert bedstraw	*Stephanomeris pauciflora*
Sweetbush	*Bebbia juncea*
Sowthistle	*Sonchus asper*
London rocket	*Sisymbrium irio*
Brittle-bush	*Encelia farinosa*
Cockle-bur	*Xanthium strumarium*
Turpentine-bush	*Apolopappus* sp.
Arrowweed	*Pluchea sericea*
Goodding's willow	*Salix gooddingii*
Fremont cottonwood	*Populus fremontii*
Salt-cedar	*Tamarix ramosissima*
California fan palm	*Washingtonia filifera*

Survey Information

Yuma Clapper Rail (*Rallus longirostris yumanensis*)

Life History

The Yuma clapper rail is a grayish-brown marsh bird with long legs and a short tail; adults of the species are typically 35–41 centimeters (14–16 inches) tall. During the breeding season, adult Yuma clapper rail males display a tawny-orange or burnt-orange breast and orangish beak while females display a brick-orange breast. (Arizona Game and Fish Department 2001)



Mapped for: U.S. Army Corps of Engineers

Mapped by: Jones & Stokes

Figure 1
Vicinity Map
Va Shly'ay Akimel Project Study Area

The current range for the Yuma clapper rail includes the Lower Colorado River drainage from the Gulf of California in Mexico north to Topock Marsh in the Havasu National Wildlife Refuge (NWR), Arizona. In Arizona, this subspecies also occurs in several major river drainages in the central and southwestern portions of the state, including the Bill Williams River drainage, the Lower Gila River drainage, and the lower Salt and Verde River drainages (Arizona Game and Fish Department 2001).

Breeding occurs after territories are established in March or April. Breeding activities are known to occur at Mittry Lake, Bill Williams River drainage, Topock Gorge and Topock Marsh in the Havasu NWR, and Cibola NWR (Arizona Game and Fish Department 2001). Average clutch size is 8 to 10 eggs with incubation lasting about 21–23 days. Hatching success is usually high, but mortality among young is usually high as well. Family groups of clapper rails stay together for approximately 24–30 days post-hatching. Chicks become independent from their parents at 35–42 days, and first flight usually takes place 63–70 days post-hatching (Terres 1980).

This subspecies is the only clapper rail to breed in freshwater marshes. They also inhabit brackish water marshes and river sidewaters. They prefer tall, dense cattail and bulrush marshes found in the Lower Colorado River Subdivision of the Sonoran Desert Biome at an elevation between below sea level to approximately 400 meters (1,300 feet) above mean sea level. Clapper rails prefer to feed on crustaceans, including amphipods, but will also feed on fish, frogs, clams, spiders, large insects, and aquatic plant seeds. On the Colorado River, introduced crayfish are the most common food consumed in bulk (Arizona Game and Fish Department 2001).

The decline in numbers of this species has been attributed to river channelization, dredging, drying and flooding of marshes, wildfires, and toxic levels of heavy metals.

Survey Methodology and Results

Yuma clapper rail surveys were conducted May 21, May 23, May 28, and May 30, 2003. Biologists Ron Van Ommeren and Amy Gibbons, Jones & Stokes, conducted all surveys under U.S. Fish and Wildlife Service (USFWS) permit number TE013086-0.

Observation Methodology

Topographic maps and a site visit were used to determine the boundaries of the survey area. A total of 30 call points were established, approximately 100 feet apart, and GPS coordinates of these points were logged for quality control purposes (Table 2). These points are shown in Figures 2 and 3.

Table 2. GPS Coordinates for Survey Call Points (UTM)

Call Point	Easting	Northing
1	0417270	3700084
2	0417257	3700111
3	0417255	3700141
4	0417258	3700170
5	0417255	3700200
6	0417258	3700232
7	0417287	3700239
8	0417293	3700221
9	0417288	3700197
10	0417289	3700160
11	0417284	3700126
12	0417289	3700099
13	0417319	3700104
14	0417315	3700136
15	0417315	3700168
16	0417311	3700198
17	0417314	3700231
18	0417316	3700266
19	0417349	3700131
20	0417347	3700159
21	0417346	3700193
22	0417377	3700187
23	0417407	3700174
24	0417408	3700206
25	0417377	3700214
26	0417351	3700229
27	0417376	3700248
28	0417413	3700238
29	0417441	3700252
30	0417381	3700145

All surveys were conducted in compliance with the USFWS *Yuma Clapper Rail Survey Protocol* (U.S. Fish and Wildlife Service 2000). Call playback tapes were used at the 30 call points in an effort to elicit a response from resident Yuma clapper rails. In addition to recording responses, a log was kept of other species of birds that were seen or heard at the call sites (Table 3).

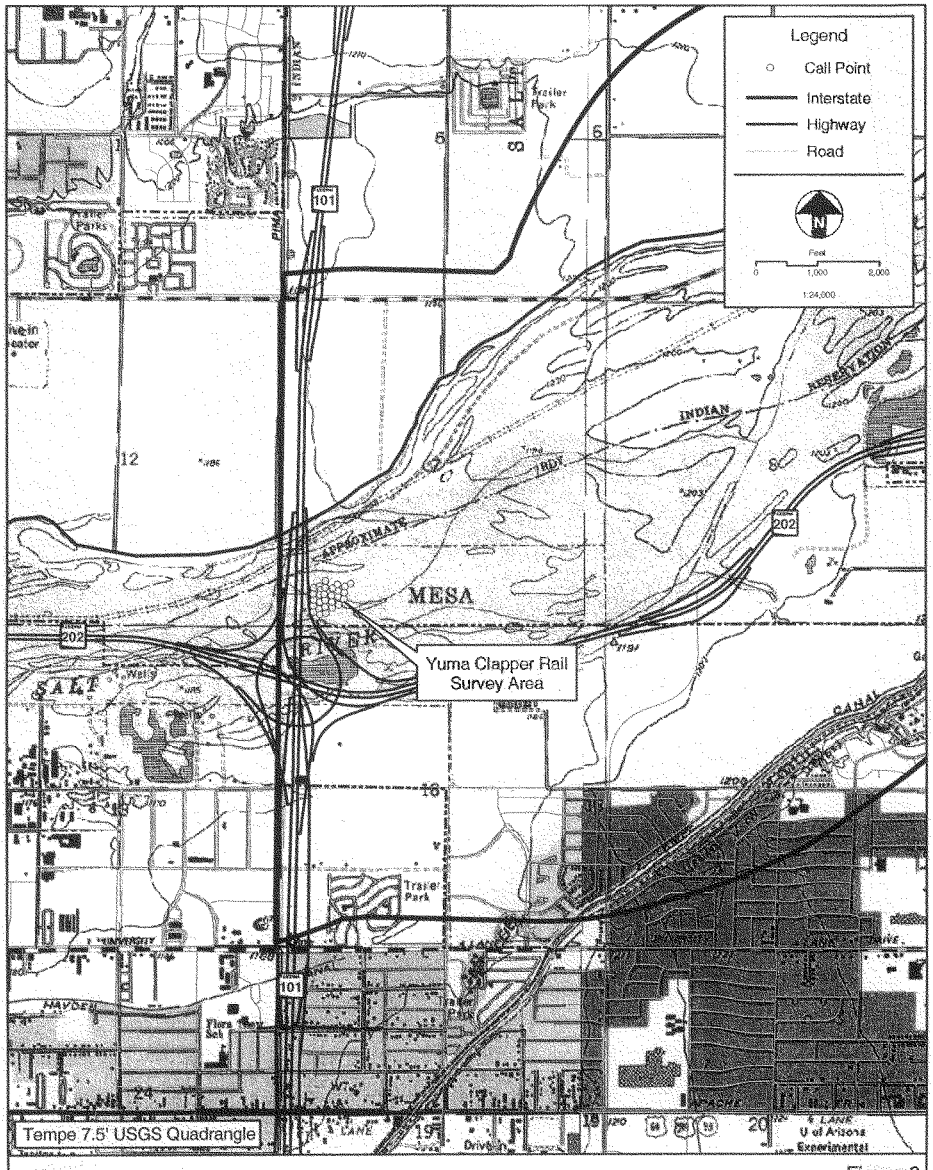


Figure 2
Call Point Location Map
Va Shly'ay Akimel Project Study Area

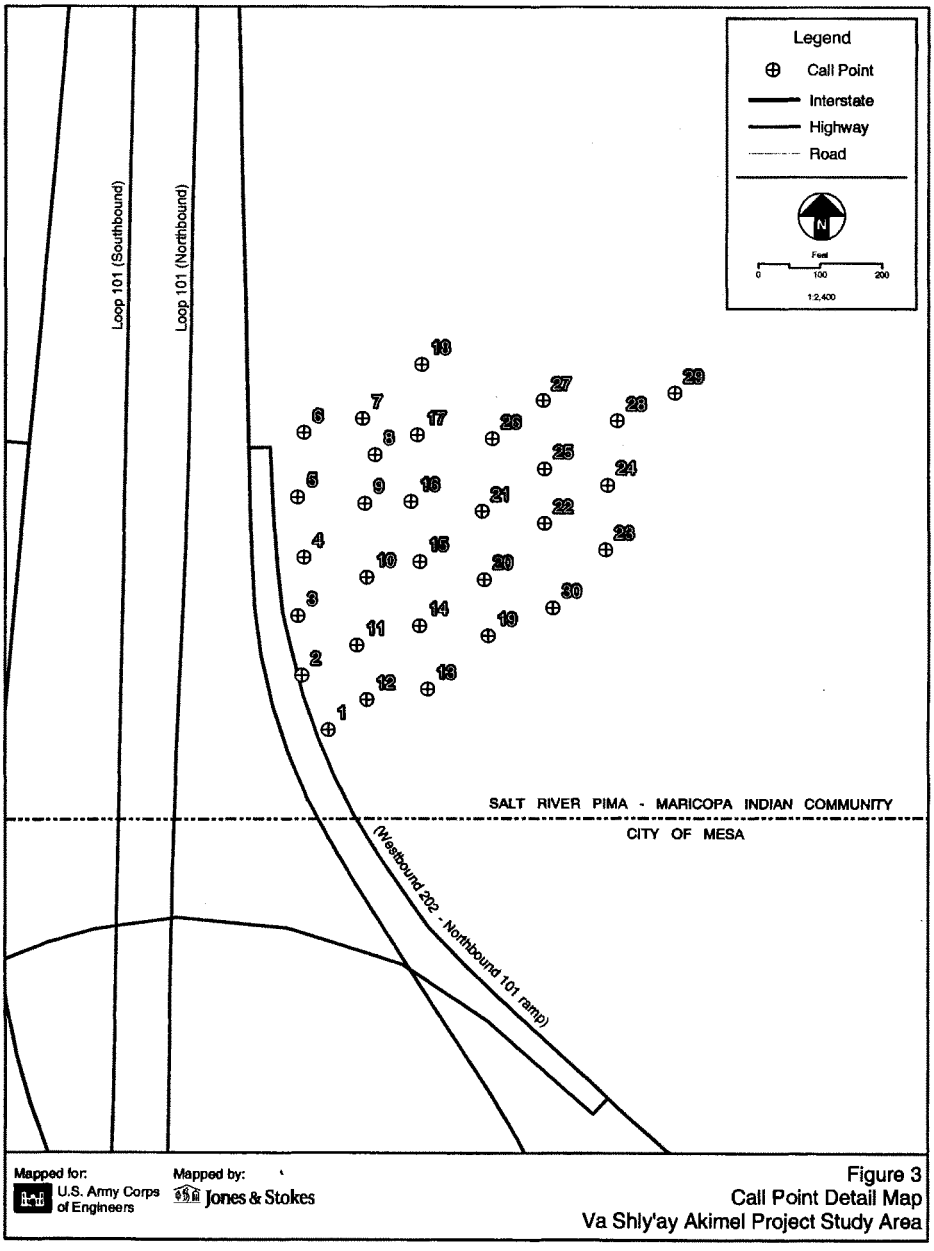


Figure 3
Call Point Detail Map
Va Shly'ay Akimel Project Study Area

Table 3. Bird Species Documented in the Salt River During Surveys

Species Name (Common Name)	Scientific Name
Abert's towhee	*Pipilo aberti*
American avocet	*Recurvirostra americana*
American coot	*Fulica americana*
Black phoebe	*Sayornis nigricans*
Black-crowned night-heron	*Nycticorax nycticorax*
Brown pelican	*Pelecanus occidentalis*
Brown-headed cowbird	*Molothrus ater*
Cliff swallow	*Petrochelidon pyrrhonota*
Common moorhen	*Gallinula chloropus*
Common yellowthroat	*Geothlypis trichas*
Costa's hummingbird	*Calypte costae*
Double-crested cormorant	*Phalacrocorax auritus*
Gambel's quail	*Callipela gambelii*
Great blue heron	*Ardea herodias*
Great egret	*Adrea alba*
Great Horned owl	*Bubo virginianus*
Great-tailed grackle	*Quiscalus mexicanus*
Green heron	*Butorides virescens*
House finch	*Carpodacus mexicanus*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Mourning dove	*Zenaida macroura*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Red-winged blackbird	*Agelaius phoeniceus*
Rock dove	*Columba livia*
Snowy egret	*Egretta thula*
Song sparrow	*Melospiza melodia*
Turkey vulture	*Cathartes aura*

Survey Results

The survey did not result in a response from a Yuma clapper rail. However, two brown pelicans, a species federally listed as endangered, were observed in flight in the project area.

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Appendix J

Response to Comments Received on the Public Draft EIS

David Montiel testimony

"I'm not used to speaking in front of people. I have a real problem with this. Our people have been here for many, many years, and they own the mountain ranges throughout the Valley. And what happened was, we had settlers come in. And what happened, what -- the result is where we're at now. I'm speaking for my grandchildren. I'm speaking for my great grandfather. Encroachment has come on to us to the degree it is now. They are talking about putting Via de Ventura all the way to Gilbert Road. They are talking about extending or widening Gilbert. And we're talking about this now. How much more land does our -- do my grandchildren have to give up, my great-great-grandchildren? Sure, it's just a road here. But how many miles does that road take up on our reservation? How many miles will this take up from our people? You know, it sounds real good and, you know, I like it. I'd like to have it the way it was again. But how much do we have to give up for that? How much do we have to give up for all the land? It's just -- I don't understand. It sounds good. I'd like to have the river the way it was, but are we giving up our sovereignty? Are we giving up our policing? We don't have enough police to police these areas. Are we going to put fences up to limit people from going off of these areas and onto the reservation? You know what, I could probably talk here for a long time but I know I have so many minutes. Am I up?
(Moderator: No. You're still green.)
MR. MONTIEL: So I really think that it's a good thing that you guys are talking about this. But when I was talking to some of the elders I was sitting by, they were telling me that

RESPONSE:

Thank you for your comment. The U.S. Army Corps of Engineers (USACE) would at no time take possession of the land as part of the Va Shly'ay Akimel Ecosystem Restoration project. The USACE would only be on the project site during construction, and with written permission from the Salt River Pima-Maricopa Indian Community and the City of Mesa for Mesa lands. The Community would retain sole rights to the land, but would commit to maintaining the restored area, as outlined in the Operations and Maintenance manual.

The primary reason for the project is ecosystem restoration. The recreation component is only an ancillary benefit to the non-Federal sponsor(s), and the non-Federal sponsor(s) do not have to elect to have a recreation component.

saltcedar is one of the main things that we use because we don't have any large mesquites any more. We use that for our ceremonies, ceremonies that only our people know of. And they are really sacred ceremonies. When we go up to the river and we do our ceremonies up at Red Mountain, you know, that's something that we know about but we don't share with people. And that's what I have to say. But also the reason they closed the river to the outsiders is because the eagles were being affected, the eaglets. They weren't surviving because there was too many hikers up there. There was too many people that were from Mexico going over there and living back there and partying back there and killing back there, raping back there. Jurisdiction. We don't have the police power. I don't know how much was discussed before because this is my first meeting. And I just question this, you know. I see a military guy here. And, you know, everybody respects that. But at this point I can't really understand it.

PARTICIPANT: Are you for it?

MR. MONTIEL: Am I for it?

PARTICIPANT: Yes.

MR. MONTIEL: Not at this point.

PARTICIPANT: Tell them "yes" or "no."

MR. MONTIEL: Well, I just said it. And there's -- you know, like I said, encroachment is a big thing. A road that runs throughout the reservation is going to take lot of land, and it's going to open up the reservation to all kinds of people. And this could happen, you know, like, if you run from this river, there is no telling what it's going to bring in my eyes. It's a good thing. Don't get me wrong. It's a really good thing. But I don't think it is for myself and my mother and everybody I know."

Gary Owens testimony

"I'd like to speak too. I'm not afraid to say anything to people. I'd like to talk to them and tell them what I think. And as Mr. Montiel said, I'm not from this reservation but my grandchildren and my children are members here. And I want to make sure that they have land to live on, places to go on the reservation where they are not stepping over outsiders that are sleeping in the woods and doing things. This project that somebody thought up, you never did find out -- I never did find out who did it. Who thought it up? It says sponsors. Well, you named the mayor of Mesa but who in the Salt River Pima-Maricopa Indian Community was with him?
PARTICIPANT: Bobby Ramirez.
MR. OWENS: Was it a member of the Tribal Council?
COLONEL THOMPSON: It was the president.
MR. OWENS: The president. Who else? He decided for the Community; right? There you go. You've got a council that decides what's going to be good for the Community whether the Community wants it or not. You'll have a problem if you get this going through. And one of the things they mentioned was, if the Federal Government funds it, then it's open to the public. Once federal money is used for any project, no matter what it is, then the whole United States can come in on the land, not just in Arizona but from out of state, from all over. So think about it. Is that what you want? Non-Indians on the land? The fact is, they're already on it. You see them out there with their ATVs. They come out here and they dump their dogs and their cats. I don't know how many dogs and cats have come to my place because they come out and they dump them. They come out and they dump garbage. They come out and

RESPONSE:

Thank you for your comment. The implementation of the Va Shly'ay Akimel Ecosystem Restoration project would not require access to Community land by the general public unless there were recreational features funded by the Federal government. If there are no recreational features funded by the government, then access to the restoration project site may be restricted according to Community rules and regulations.

they steal the wood. They chop the trees down. So if you put up this project you have here, you're just opening it up. You're going to lose almost everything that you have. Another thing. What happened to the water 100 years ago or 80 years ago? Why didn't they just let the water keep running? No. They had to dam up the dams to get water to people who don't live along the river so that they could plant crops. But did they think of the Indian people that were living on the river? No. The State Legislature, all the non-Indians didn't care one hoot about the Indian people, and so they dammed up the river and it's dry as a bone. I have been here 40 years, and that river, the only time it flooded is when they let the water out of the dam because they were getting full. So how come all of a sudden you have to have a river running -- a river runs through it, so to speak? What's the big deal? What does it do for the Community? Ask that question. You know, Indians, think about that. What value is it to the Indian Community? The only -- it's -- the value is to the outside. Who supplies the water? The Community supplies the water. What does Mesa supply? An effluent plant further west. How many acres does the Community -- I mean, does Mesa give? 73 acres. And the Tribe has to give 4,023 acres. So who is it benefiting? It doesn't benefit the Tribe. It doesn't benefit the Community. It benefits those that live along the south side of the river so they can look down and see a pretty landscape down there. Right now there is no landscape. I'll be through in just a second. Okay. I see your time out. But I think it's something else other than beautifying, restoring. Just leave it alone. That's my opinion."

Virginia Loring testimony

"Good evening. I'm grateful to be here. First of all, I think that I would like all the Community members to stand. That includes our councilman Grinelda Gates. Look at the number that are here. And you want us to make a choice or you want to make a decision compared to the people that are here? I think that any time it involves Tribal land, I think that the whole Community needs to say. I think that a vote needs to be taken, councilman, councilwoman, because it does involve Tribal land. It's not just Lehi land. It's Tribal land. Another thing that I really -- I was concerned about is in the handout that was given, it says that in 25 years from now, Leon, Bob, 25 years from now if we decide that we no longer want this, do you know what's going to happen? It's going to take an act of Congress. Do you know how long an act of Congress takes? I'll be lucky to be alive to see that. And what if, along further down the way, we decide that we no longer have our casinos, we no longer have our enterprises, everything is passing us by, where is that money going to come from that we are supposed to foot for this? Also, Corps of Engineers, I commend you for your presentation that you have, everything that you've done, Bobby Ramirez. Really, it's excellent. But what concerns me is, why can't the Community do this? We have Salt River Sand and Rock. Why can't we do this? It's our Community. We have people that are very intelligent and can do that. Do you know that I'm going to contracting school to be a contractor simply because I don't want to be just a member sitting there? I want to do something in this Community. And we have people out there like that as well. Maybe they may be nonCommunity members but so is the Corps of Engineers.

RESPONSE:

Thank you for your comment.

But we already have people that are employed. I only have one statement left, and that comes from the council-approved mission statement. And I got this from the Au-Authm News. It's our local newspaper. And it says, "The Salt River Pima-Maricopa Indian Community projects sovereignty and promotes individual self-sufficiency. How much prouder should we be because we can do that? And those are my comments. Before I leave, I have one thing, and that is for all of you outside members from the outside community, Rusty Bowers, thank you for coming and being here, but I wish we would have had more of our Community members here. Thank you."

SRMG **Phoenix Cement Company.Salt River Sand & Rock**

Salt River Materials Group Aggregates .Construction .Fly Ash .Phoenix Cement

June 3, 2004

District Engineer
u.S. Army Corps of Engineers Los Angeles District
ATTN: CESPL-PD-RN
P.O. Box 532711
Los Angeles, Ca., 90053-2325

My name is Roger Smith Jr. and I am the President and Chief Executive Officer of the Salt River Materials Group, a business enterprise that is wholly owned by the Salt River Pima Maricopa Indian Community. The Materials Group consists of two divisional entities, Phoenix Cement Company and Salt River Sand and Rock Company. I am also a member of the Community.

In this letter, I have attempted to quantify some potential impacts that need to be addressed in considering whether or not the Salt River Materials Group can be totally supportive of the development of the Va Shly'ay Project in its current proposed form. We have concerns in the following areas: Financial impact on the Community's Enterprise, loss of control of the timing of the project's development, the mitigation of flood control issues as they relate to relieving flood issues and cultural landmarks, and the degree of revegetation and proposed park land development.

In terms of financial impact, (1) If we were to agree that all mining within the project boundary were to cease, with the exception of the area presently being performed at our Higley Plant Location, our operational costs would skyrocket. The

RESPONSE:

Thank you for your comment.

trucking costs that we would incur to supply the existing ready mixed concrete plants at Dobson and Beeline locations would be an additional $2.50 per ton. At a rate of approximately 3.5 million tons per year, the additional cost to keep our customers supplied would increase by $8.75 million dollars per year. This would, of course deplete the Higley site an increased rate and diminish our long-term presence as a factor in our synergistic sales efforts to also sell our cement and fly ash products.

(2) If we do not mine the channel between Gilbert Road and the GRUSP, we would be abandoning (assuming a 25 foot deep and 1100 foot wide channel) approximately 22.5 million tons. of aggregates. At a profit of approximately $2.00 per ton, the negative economic impact to the Community would approach $45 million.

A Salt River Pima-Maricopa Indian Community Company
Tel: 480.850.5757 . Fax: 480.850.5758 . 8800 E. Chaparral Rd, Suite 155 . Scottsdale Al 85250-2606

(3) Our cement plant reserves are in excess of a 70-year supply, so it is necessary for us to maintain a strong aggregates position in the East Valley to complement our cement sales. The Community has just finished a $140 million modernization of the facility and the payback projections were rationalized by an increase in cement sales from 650,000 tons per year to 1.1 million tons. Cement sales have been the traditional "bread and butter" for the Community creating tens of millions of dollars to the Community annually. Fly ash, as a concrete additive has been a moneymaker as well, and long-term contracts that the company has with the power plants are also a consideration in these matters.

(4) Also, it should be noted that our industry employs between 75 and 100 Community Members on the sites located within the project boundary.

In terms of timing, the Army Corps plan to date has left little input from the Community in terms of the Project's build out. There seem to be little flexibility in each phase of the proposal as it relates to funding and construction. Conversely, the Materials Group has proposed a Mining and Reclamation Plan draft that accommodates the business unit for many years, while allowing a timeline as dictated by Tribal Leadership for riverbed restoration.

We have also addressed in our Plan the need for flood control measures including hard banking along stretches of the river to remove flood prone areas from the floodplain and protecting the cultural river island and the Lehi cemetery.

Finally, we feel that the development, or lack thereof, of lands for public use should be an exclusive decision for the Community Council.

We continue to try to be supportive of the project, and have met with the Corps on numerous occasions. Our discussions have included a mining plan that would include assuming the Rinker lease liabilities, addressing the design issues in the Mckellips road area, and cleaning up the Beeline pit issues west of Gilbert Road, over a twelve to fifteen year time frame.

We have proposed a channel to be mined between the Groundwater Recharge Underground Storage Project (GRUSP) and Gilbert Road (approximately 1100 feet wide and 25 feet deep as mentioned above). We further have proposed a time frame to refurbish and surrender these easterly properties to the project annually in *1'2* mile increments. Since this concession would include removing the aggregates and storing them for use at a much later date, we have proposed that we be compensated for the removal as part of the overall project contract. Our internal plans are to extract the materials as a business enterprise to create profits for the Community, while creating an environment that provides employment for the Community members, as well as minimizing potential flood damages. We certainly believe that we can also participate, through our plan, in the beautification of the river bottom by replanting natural type vegetation.

1855

It is our goal to continue to work toward addressing and achieving desirable positive results for the Salt River Pima-Maricopa Indian Community.

Sincerely Yours,

Roger Smith, Jr.
President and Chief Executive Officer Salt River Materials Group

Carol Harris testimony

"Well, I'm a resident of Mesa right above the Lehi City, and I just wanted to say I support the project. I know I don't belong to the Indian Community and I respect their wishes and I have a high opinion of them. But I am a registered nurse and I believe that we need to have more places for recreation. We need to have more places for people to walk and ride their bikes and enjoy nature. Not only does it give our bodies what we need, but it also gives our minds and our spirits what we need to commune with nature. And I believe in the holistic approach to living, that we need to really work, each of us need to work to be healthy individuals. And I just think this would be another place where we could exercise and commune with nature. And I believe it will be a real positive impact on our whole community. Thank you."

RESPONSE:

Thank you for your comment.

Addie Garcia testimony

"My name is Addie Garcia. I just wanted to know, which of my presidents agreed to this project?
COLONEL THOMPSON: Okay. I have got that as a question. We're going to address that right at the end; all right?
MS. GARCIA: Okay. Out of this 98 percent of the Community members or the land, how much of it is allotted land? And if the people with the allotted land said it was okay for this project to go through, why aren't they here to support you, you know? I'm very disappointed that I don't see them. And, you know, it's -- for us, they said that we cannot even get a road through there. And I'm so surprised that they are going to let you do that. You know, it looks real nice, but, you know, we have a hard time. Our police have a hard time getting to this area. And I'll be very disappointed. I'm not for this because all we're asking for is a road and you're asking more, you know. And I'm just not for the project. Thank you."

RESPONSE:

Thank you for your comment. The real estate gross appraisal conducted by the Salt River Pima Maricopa Indian Community identified that the proposed alternative does not include allotted lands.

Carolyn Stacey testimony

"Good evening. My name is Carolyn Stacey. I'm not for this project. We have gone to some tours on how they improved it, how it's been improved in certain areas. I just want to say that I'm like David Montiel. My father has always said that when people dammed up the water, all our natural resources went down the drain and dried up, all the things that we lived off the land and used to survive all these many years, thousands of years. Now here comes this new project that you're thinking about that -- it is true that it's encroachment and I don't agree with it. It's just like me going into your backyard and making a shed or doing some -- pulling out your roses or something like that. That's what you're doing to us. You're invading our privacy. I'm sorry to say that, sir. But anyway, that's the way I feel. I have my great-great-grandchildren. I'm 63 years old. And if they just let that water flow freely, we'll have all these things replaced. Thank you."

RESPONSE:

Thank you for your comment. The U.S. Army Corps of Engineers (USACE) would at no time take possession of the land as part of the Va Shly'ay Akimel Ecosystem Restoration project. The USACE would only be on the project site during construction, and with written permission from the Salt River Pima-Maricopa Indian Community and the City of Mesa for Mesa lands. The Community would retain sole rights to the land, but would commit to maintaining the restored area, as outlined in the Operations and Maintenance manual.

June 03, 2004

District Engineer
U.S. Army Corps of Engineers
Los Angeles District
ATTN: CESPL-PD-RN
P.O. Box 532711
Los Angeles, CA 90053-2325

Comments of Mr. Hollis M. Chough
(Regarding Va Shly' Ay Akimel River Restoration project)
Recorded by Mr. Roger Smith
May 22, 2004

Good evening. My name is Hollis M. Chough, a full blood Maricopa Indian of Salt River Pima-Maricopa Indian Community. In my lifetime, I have, and my family and the Tribe, have been confronted with many issues that would better our land, better our community, that would better our lifetime stay on the Salt River Indian Reservation. It's been a long time since we had issues that come up before us that are very important. And usually, the issues are presented to us in a way that we either have to move with it or sit with it. I think we the Pimas and Maricopas of this community are mature enough to think some things out and take this issue and vote on it. I feel that it's an issue that has to be voted upon and the issues are the river restoration of the Salt River. The main purpose is to restore the river to its original condition with the wildlife, the vegetation, and so forth. It's a long ways to come yet, but these were the discussions that the group was involved in in discussions. We will present the discussions; the people that were involved in the discussions were Robert Aguilar, Herbert Chiago and Garnet Gates.

There was only the three of us and four of us, sometimes five of us that were involved in the discussions. The discussions were very hard because the Corps of Engineers were very adamant about getting this thing approved and moving with it as soon as possible. And we, the Indians, we say, "Wait a minute. What is in store for us? What do we profit from the whole project?" Now the profitability of the whole project centers around big money making kind of issue that comes forward before us, and that is our extraction of sand and rock at Salt River. That is our bread and butter. I think no tribe in the United States has a unique situation such as ours. We have our sand and rock located in the bed of Salt River. Salt River is used by many companies extracting land either in a regular contract form or stealing from us. We know that there's a lot of contractors who stole from us when we were talking about this some months back. It seems that the uncontrollable truckers were stealing from us, were stealing sand and rock, which we don't know, which we have no records of, and

RESPONSE:

Thank you for your comment. The U.S. Army Corps of Engineers (USACE) would at no time take possession of the land as part of the Va Shly'ay Akimel Ecosystem Restoration project. The USACE would only be on the project site during construction, and with written permission from the Salt River Pima-Maricopa Indian Community and the City of Mesa for Mesa lands. The Community would retain sole rights to the land, but would commit to maintaining the restored area, as outlined in the Operations and Maintenance manual.

eventually, when we get down to brass tacks of studying this thing and putting into written form, we would ask the questions: how many tons of sand and rock were not accounted for during the early discussions of this topic?

And as you notice, once the Tribe got into a situation where they had to tighten their belt to get things done the right way, they began to do profit and loss analysis of each company on our Reservation, and once that started, the truckers that were stealing from us, they quit hauling, you will notice. They quit hauling. I don't know how many tons or how much money or dollars and cents was stolen from us, but we stuck with it, and we raised the issue time and again, but not to the point where it was a real official comment.

We, the people of the committee are not experienced in any situation like this. Initially, it was the Tribal Council that wanted to approve the plan earlier in the year. They approved the plan, but the Tribe had no plans for how to implement this whole project. There was some talks about it but we were not a part of these discussions, we the committee, were not very well versed on it because Council or people that were assigned to do the study never contacted us or never met with us. It was always the Advisory Committee that was the aggressor to set up meetings and invite various department heads to discuss some things with the Tribe. When I talk about the Tribe, we're talking about 7200 community members, the committee members that were active in these discussions. We were active in discussions, certain things that you probably would like and probably won't like that is the general citizen, this committee, or the Reservation population.

Once you approve of this plan, the restoration plan, there are certain things that we need to know about. First thing, it has been our experience and understanding that other tribes in the mid-West have used the Corp of Engineers for their flood plain plan, their reservation dam reservoir plan, and the giving up of tribal land around the big lakes that they have. In the mid-West, those people they have a lot of plain lands that they wanted to develop and when the reservoir was built in the area there, some of you may know some of the dams that I'm talking about. Those dams were built with the tribal approval, but there are conditions to it that have never been fulfilled yet. And one of the things that have never been fulfilled is the payment of certain amount to the Tribe to rebuild and restore their community with whatever they need to do. It is a good thing to do that, restore the community. And it takes money, and Uncle Sam has that money. We need to take a look at it.

At first, when I understood the project, it was... as I understand it; the project was a $3 million project. We don't care how it's divided up, or who takes a share of that, that means the City and Corp and the Tribe, but we do know that the Tribe has to give quite a bit up, of tribal land, and that's the river, and we, as a whole, will also give up our own water to the outside communities, such as the growing City of Mesa, City of Tempe, and the various cities and towns that are going up

all over the Valley. They need water, once they are set up, once they are completed, they will need water for fifteen, twenty, thirty years or maybe for one hundred years, and who has it? We have it. Salt River has it. It has a reservoir underground under the river, it is known as the Aquifer, and the water in those areas are saved for future use for our Reservation. We don't know this. As we really get into this matter, this issue will come up again. The question will be did the Tribe sell Aquifer water to outside cities? If they did, what are we getting in return? We need to know that. The other point is, how much did we get in terms of dollars and cents? We have never heard that expressed publicly by tribal planners or administrators of the Tribe.

On this Reservation, we talk about many projects, and this restoration project is one of them. As I said, this project is one of the projects that the Tribe has ongoing. What I can see as a layperson not involved in Tribal affairs is that some of the things I predicted to Mr. LaLonde, the Community Treasurer, are actually coming into play. And one of the things that I had fears about was that if the Tribe ever put a plan like the Tribal reorganization, it is entirely new to them, the people, that is, and they'll have a hard time understanding what the purpose is for. It has never been explained why we're doing it, why it has to be done. Instead, people are just told this is Tribal plan, and it scares them, and that throws them off. And when it's actually implemented, people don't want to get involved in it.

I guess a clear case is where we have various committees organized for specific purposes and those organizations or those committees have not actually done their job because members of the committee have not shown up for work, or committee discussions, so that's one problem we have. The other problem we have is, when it's actually implemented, it will cause quite a confusion because, as I see it, there has never been any training, nor workshops, nothing was ever done for the tribal members. That is for the committee; it was just thrown to them. "Here, do this." And they don't know how to do it. At least I know how to do it because I was involved in the state; City of Phoenix and City of Flagstaff general plan similar to what we're going through. And I know what we're going to go through eventually, and that is the lack of participation by the tribal employees. I knew that that would come about when tribal employees failed to show up for committee meetings, or show up for conferences, or even show up for work, because they are afraid to attend because they don't understand the general plan.

The general plan has never been discussed with the people, so therefore, we are in doubts about a lot of things, and so with that kind of background, the same thing holds true with the river restoration project. Our people may come through and they may not because they are not acquainted with it. And I mentioned this at one meeting one time that we need to be educated on this particular subject. It's a very, very deep subject, and it has to be explained by experienced people. Those experienced people also must know what they are talking about because

it is a project that they have to have approved, and we've never had that. The Corp of Engineers has never said, "We have an experienced person who can explain this step-by-step if the committee wants it or if the people want it." Those things have never been offered to us.

My idea was, initially, I could see a flowering kind of riverbed, clean and so nice, like the City of Scottsdale river drainage, and that's what I wanted to see. Actually, when we got into it, we found out that was not so. It was something else that the Corps wanted. The Corps wanted quite a bit of land for the Reservation to give up. And it is quite a bit of land, in terms of dollars and cents; it goes into the thousands and millions of dollars that we will lose in years to come. And who will benefit from it?

Our neighboring towns, our neighboring cities, our neighboring communities, I am sure that once the labor or the Corps has authority over the riverbed, they will allow a lot of excavation by truckers and land developers, and they're going to allow that, and they will get the money, and where do we stand? The tribe is just giving the land away. I'm talking about sand and rock. That is our lifeblood of our Reservation. If we ever get rid of that, we won't have any dollars and cents. I'm looking at it from the standpoint of what the tribe has planned already, and that is the plans to build buildings here and there, and they have no land, and once they do that, they will need some dollars and cents. How are we going to get our money? The sand and rock business is one of the only things that is keeping the tribe alive by bringing income.

In closing, I wish to see the Salt River Restoration project become a reality or not depending on a community-wide vote. On the other hand we have approximately 7200 community members, if we don't get 15% of voter turnout from that to vote on this project that would be detrimental for the Tribe. Thank you for the opportunity to address my concerns in this public forum.

Sincerely,

Hollis M. Clough
10516 East Montecito Avenue
Scottsdale, Arizona 85256

Chris Higgins (email)

"I attended the public meeting on 6/3/2004 and have the following comments. I live in Tempe and have been interested for many years in the Salt River as it runs through the Phoenix Metro area, and have been excited by the various river improvement projects such as Tres Rios, Rio Salado, and Tempe Town Lake. While the restoration and beautification of the river is important to me, just as important are the future recreational opportunities that the above-mentioned project can offer to me and my family. When I heard about the Va Shly'ay Akimel project, I again was excited by the possible recreational opportunities the project would present. I had visions of being able to ride my bicycle along the river from Granite Reef Dam to Tres Rios! I did not realize that the river, for most of the Va Shly'ay Akimel project, is owned by SRPMIC, and was disappointed by comments made by members of the SRPMIC in the meeting, saying that they did not want the project, and certainly did not want 'outsiders' entering and enjoying 'their land'. As a non-Native American, and a non-member of the SRPMIC, I very much felt like an 'outsider' by the end of the meeting, and was glad to get out of there. As a result of the meeting, my hopes for recreational opportunities through the Va Shly'ay Akimel project are now very low, and I can't honestly say I support the project. My compliments to you, however, and your staff, on a professionally run and informative meeting. Please keep me on your mailing list."

RESPONSE:

Thank you for your comment. Your name will be added to the Final Environmental Impact Statement mailing list.

Tim Barnard Comments (email)

"Staff comments for the Va Shly'ay Akimel EIS are as follows:
Figure 3-10 – Consider including the updated Multiuse Path Master Plan Map in this document instead of the one originally included in the Parks & Recreation Master Plan. Staff can provide copy in Word format.
Figure 3-11 – It would be helpful if the trail connections into the Museum and Cultural Center were highlighted or labeled on the conceptual drawing.
P. 3-42 – Section 3.4.2.3 references the operation and maintenance costs for the trails. If this function falls to Mesa's Parks Maintenance staff, we would appreciate inclusion in the discussion of expectations and costs, in particular, the surface braided irrigation network seems to be a difficult and time consuming system to maintain.
P. 3-36 – Section 3.4.4.1 references a connection to Mesa's existing trail system along the Tempe Canal. Although the canal exists and can be used by the public, Mesa has not yet improved the pathway. It might be more accurate to say there will be a connection to Mesa's planned trail system along the Tempe Canal.
p. 3-46 – Regarding the recreation trail options, the City of Mesa's Community Services Department prefers the implementation of Option C as outline in Section 3.4.4.3.
We appreciate the opportunity to comment.

Tim Barnard, CPRP
Administrator, Community Services Department
City of Mesa

RESPONSE:

Thank you for your comment. Updated Multiuse Path Master Plan Map will be included in Final Environmental Impact Statement. Mesa's preferences have been noted.

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Phoenix, AZ 85072-2025
(602) 236-5812
Fax (602) 236-5444
E-mail: jfsully@srpnet.com

JOHN F. SULLIVAN
Associate General Manager
Water Group

June 21, 2004

VIA FACSCIMLE
And US MAIL

Colonel Alex Dornstauder
District Engineer
Los Angeles District
U.S. Army Corp of Engineers
ATTN: CESPL-PD-RN
P.O. Box 532711
Los Angeles, CA 90053-2325

RE: **Salt River Project Comments on Draft Environmental Impact Statement (April 2004) Va Shly'ay Akimel Salt River Ecosystem Restoration Feasibility Study**

Dear Colonel Alex Dornstander:

On April 28, 2004, the United States Army Corps of Engineers (Corps) published a notice in the Federal Registry requesting public review of the Draft Environmental Impact Statement (EIS) for the Va Shly'ay Akimel Ecosystem Feasibility Study. The proposed action in the EIS includes the establishment of riparian habitat and restoration of river channel functions through a 14-mile reach of the Salt River located in Maricopa County Arizona.

The Salt River Project (SRP) operates dams upstream of the proposed project, operates water delivery structures to divert and distribute water from those dams in the vicinity of the proposed project, and operates the Granite Reef Underground Storage Facility (GRUSP) located within the study area. Additionally, SRP owns land parcels adjacent and near the project. SRP therefore has a keen interest in the construction and operation of the proposed project.

SRP is supportive of the proposed project goals and believes that the restoration of this portion of the Salt River will not only benefit the project participants but the Phoenix Metropolitan area as a whole. However, SRP does have concerns with some components c the proposed project. The purpose of this letter is to offer comments on these components And to request that the Corps meet with SRP and coordinate the proposed activities before completing the final EIS.

RESPONSE:

Thank you for your comment. The USACE will continue to coordinate with Salt River Project, should the project move into the design stage.

Project features currently require that irrigation water be diverted on the north bank of the Salt River. The SRPMIC and USACE assumed that SRPMIC waters may be redirected through the Hennessey Drain. If, after discussions with SRP, the Hennessey Drain does not have the capacity to convey irrigation waters to the vegetated areas along the north bank of the Salt River, Alternative O can be modified to no longer be dependent on Hennessey Drain. Evergreen, Tempe and Country Club drains are only used in the sense that the USACE anticipates diverting, or harvesting storm water runoff when available. There will be no additional water added to these drains.

Due to the groundwater hydrology, it is uncertain what, if any, contribution the recharge waters at the GRUSP site will have toward the newly planted vegetation survival. In addition, the project is designed such that vegetation around the GRUSP site will not be dependent on GRUSP waters.

A number of the project alternatives (F, N, E, and O), including the preferred alternative O, state that the Hennessy Drain would be used to deliver water to irrigate newly established vegetation and possibly wetlands. The proposed use of the Hennessy Drain raises some concerns. The Hennessy Drain is an integral part of a federal reclamation project and performs a critical operational need for the SRP's canal operations. The drain was designed solely for the purpose of discharging or removing excess waters from the South Canal.

The South Canal periodically and unpredictably experiences excess waters because of storm inflows or "upset conditions" in canal operations such as when water is returned to the canal from adjacent facilities such as Val Vista water treatment, RWCD pumping plant and South Con Hydrogenerating Plant. Delivering water through the Hennessy Drain to irrigate vegetation in the river bottom would diminish the drain's designed capacity to remove excess canal waters and could create potential flooding hazards further down the South Canal. It was for this reason that a new and separate delivery structure was constructed immediately adjacent to the Hennessy Drain and used for deliveries to GRUSP.

Additionally, the wasteway into which the Hennessy Drain discharges is currently blocked by an erodible earthen "fuse plug" for the purpose of diverting water from the wasteway into the GRUSP delivery channel. At this time there is no additional capacity in the GRUSP delivery channel to accommodate irrigation deliveries to new cottonwood or mesquite plantings on the north side of the river.

A number of the proposed alternatives also discuss the use of the Evergreen, Tempe, and Country Club Drains to deliver water. SRP has concerns, which are similar to those listed above in reference to the Hennessy Drain, regarding the use of these drains to deliver water. In addition, SRP is concerned that these drains discharge without notice and may pose a public hazard particularly if there is an increase in recreational use of the river channel associated with the proposed project. The Corps should meet with SRP to, among other things, coordinate the proposed use of these structures to determine if it is possible to schedule and deliver the volume of water necessary to meet the project requirements.

In association with using the Hennessy Drain for deliveries, the preferred alternative, and others, calls for constructing wetlands at the Hennessy Drain outlet and protecting the wetlands with a berm of rock upstream to force flood flow releases away from the south bank of the river. Forcing flood flows to the north at this location might negatively impact the GRUSP delivery channel and basins. Impacts of these berms and any others on local facilities such as GRUSP should be explored an identified before moving forward with the project.

It is uncertain how vegetation outside of the GRUSP site would cause more GRUSP maintenance, but continued coordination with SRP would alleviate future problems.

No vegetation was planned near the Granite Reef Dam, only invasive plant eradication. Granite Reef leakage water is not a considered a reliable source and will not be used as a potential water source in the scope of this project.

Salt and Verde Rivers are considered sources only when the waters overtops Granite Reef Dam and flows into SRPMIC lands, during high flow conditions similar to the 1993 flood.

The Corps has been in direct coordination with the U.S. Fish and Wildlife Service throughout the Plan Formulation process, and will continue to coordinate through the design phase. Issues such as Safe Harbor Agreements and the inability to use Salt and Verde River waters will be resolved during that time. The data corrections provided will be included in the final document, and the Salt River Project will be added to the Final Environmental Impact Statement distribution list.

1866

Many of these same alternatives, including the preferred alternative O, propose to establish vegetation near the GRUSP site and identify water being stored at the site as a potential water supply for the project. This proposal seems to imply that some of the water being recharged at GRUSP will be used to support mesquite and cottonwood restoration efforts. This is not consistent with the ADWR-permitted intent of GRUSP or with the understanding of the GRUSP participants (see list below) who provide the water being recharged at GRUSP.

If vegetation is planted near the GRUSP site and it utilizes the infiltrated water, the effectiveness of GRUSP as a storage site will be reduced and the volume of water and cost needed to store the intended amount of water will be increased. Additionally, the proposed irrigation of some of this vegetation and other newly established vegetation and wetlands might increase groundwater levels resulting in a reduction in GRUSP's storage capacity. It should be noted that while SRP operates the GRUSP facility, there are a number of other entities that participated in its construction and who have a vested interest in its operation. These participating entities include the City of Chandler, the Town of Gilbert, the City of Mesa, the City of Phoenix, the City of Scottsdale, and the City of Tempe.

Another concern that SRP has with establishing vegetation near GRUSP is that it may result in an increase in the need for maintenance activities, including the operation of monitoring wells, due to an increase in the rate of volunteer vegetative growth. The proposed establishment of vegetation near the GRUSP site will likely increase the number of visitors to the area and could result in an increase in operational expenses and pose a safety issue. Concerns regarding the impact of vegetation on maintenance activities and the effect of increased visitation also apply to the establishment of habitat near Granite Reef Dam. The Corps should also investigate whether the growth of vegetation immediately downstream of Granite Reef Dam could potentially increase flooding problems, due to reduction in channel flow velocities, or result in a reduction in the ability to pass flood flows over Granite Reef, due to pooling of water behind the downstream vegetation.

An additional concern associated with proposing to develop habitat near Granite Reef Dam is the reference to SRP water leaking from Granite Reef Dam (see Chapter 10). This should not be considered a potential water supply because SRP water supplies can only be used on SRP member lands. Moreover, this cannot be considered a reliable supply source because future modifications to Granite Reef Dam should be removed from the list of water sources proposed for the project.

Chapter 4 discusses the possibility that federally listed threatened or endangered species could potentially occur in the new habitat that is established by the project. Given that the Draft EIS recognizes the flooding potential on the Salt River, SRP recommends that the Corps pursue an incidental take statement to cover any threatened or endangered species that may occur in the habitat created by the project and which may be destroyed by future

flooding. Additionally, SRP recommends that the Corps consider pursuing an incidental take statement to cover any threatened or endangered species that may occur on habitat that would be created through the use of the potential water supplies identified in the Draft EIS that are not owned or controlled by the project participants. Drain flows, water associated with the delivery and storage of water at GRUSP, and leakage water from Granite Reef Dam are examples of such supplies. Finally, the Corps should consider whether there is a need for incidental take protection in the event that habitat created by the project is eventually destroyed because water used to irrigate the habitat is reduced or eliminated entirely.

Appendix E, titled "Fish and Wildlife Coordination Act Documentation of the Draft EIS" contains a letter from Steven L. Spangle, Field Supervisor for the U.S. Fish and Wildlife Service. Contained within the letter is the following recommendation "Consider and evaluate opportunities to provide additional surface water to the project area directly from the Salt and Verde Rivers by coordinating with water users, managers, agencies, communities, Tribes, and/or other parties interested in riparian habitat improvement (for listed and non-listed animal species) on the lower Verde River below Bartlett Dam from flows more consistent with the natural hydrologic regime."

For a variety of reasons we do not believe the Corps should consider this as a source of supply for the project. These reasons include, but are not limited to: 1) significant impact on water rights and complex contracts with SRP shareholders, irrigation districts, Indian tribes, a mining company, and the City of Phoenix; 2) any operation to provide this water source would be contrary to the purpose of the Salt River Federal Reclamation Project; 3) limited frequency and duration of available flows caused by high variability of runoff; 4) high costs; and 5) limited benefit to riparian vegetation. For more detailed explanations of these reasons see the Final Environmental Impact Statement for the Roosevelt Habitat Conservation Plan Gila and Maricopa Counties, Arizona, December 2002.

Attached are a series of additional comments and observations regarding information contained in the Draft EIS.

Lastly, it should be noted that SRP was not initially provided a copy of the Draft EIS for review and is not listed in Chapter 11 as an entity that was provided a copy of the document. Please include SRP on any further correspondence regarding this project and address all correspondence on the matter to:

Mr.. David Roberts
Salt River Project
Mail Station PAB 11
P. O. Box 52025

We also recommend that before pursing a Final EIS, the Corps contact all potentially impacted parties such at the GRUSP participants previously mentioned. This would provide them with the opportunity to comment on the project and will help to ensure the project's success.

Given the potential impacts to SRP facilities, SRP recommends that the Corps coordinate their efforts with SRP before proceeding forward with a Final EIS. We appreciate the opportunity to comment on the Draft EIS. If you have any questions about these comments, please feel free to contact David Roberts at (602)-236-2343 or John Hetrick at (602)-236-5649.

Sincerely,

John F. Sullivan

JFS/JH
Attachment

c: Marilyn Ethelbah, Salt River Pima Maricopa Indian Community
Gordon Haws, City of Mesa
Steven Spangle, U.S. Fish and Wildlife Service

6981

LIST OF ADDITIONAL SRP COMMENTS REGARDING TECHNICAL ISSUES.

1. Page 4-8. It is stated that SRP operates seven dams and storage reservoirs within the Salt River watershed. SRP does operate seven dams but only six have storage capacity. Granite Reef is a diversion dam and does not have storage capacity.

2. Page 4-8. Table 4.2-1 has a number of errors. The construction date listed for Mormon Flat Dam in Table 4.2-1 should be 1925, not 1938. Granite Reef Dam, which was completed in 1908, should be included with a storage volume of zero. The table should be modified to include these correct storage volumes; Bartlett 178,000 af, Horseshoe 109,000 af, Stewart Mountain 70,000 af, Mormon Flat 58,000 af, and Horse Mesa 245,000 af.

3. Page 4-8 and 4-9. It is stated that SRP releases water only for flood-control purposes to lower reservoir levels, either prior to winter rains or when the reservoirs are unexpectedly full. This is incorrect. SRP primarily releases water from reservoirs to meet shareholders water demands, but does release water for other purposes including minimum flow requirements and power generation.

4. Page 4-9. It is stated that dams upstream of the study area effectively delay flows by one month. This statement should be clarified. This is the case in normal years or years with minimal downstream releases. However, this is not the case in years with big flow events (1993) or very wet years (1983).

5. Figure 4.2-2. The data used to construct the graph appear to be incorrect, or they at least do not match SRP's data. SRP's data show a peak discharge in March with less in April. Additionally, a y-axis scale would be beneficial to help understand the information portrayed in the graph.

6. Page 4-12. The Buckhorn Mesa Project discharges storm water upstream of Granite Reef Diversion Dam, not downstream as stated.

7. Page 4-21. It is stated that minor flows are the results of controlled releases, while the major floods are caused by uncontrolled releases. All flood flows associated with dam releases are made via spillway gates and as such are controlled releases.

8. Page 4-70. Section 4.5.3.5 is titled the Southern Canal and the text below refers to the Southern Canal. The proper name for this canal is the South Canal.

USDA

United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Wildlife Services

6929 N 23rd Ave., Suite 2
Phoenix, AZ 85021
(602) 870-6734
Fax (602) 870-2951

June 15, 2004

U.S. Army Corps of Engineers
Los Angeles District
Attn: Mr. Steve Dibble (CESPL-PD-RN)
P.O. Box 532711
Los Angeles, CA 90053-2325

Dear Mr. Dibble:

Thank you for the opportunity to review the Va Sily'ay Akimel (VSA) plans with regards to ensure that wildlife hazards for Falcon Field (FFZ). Wildlife Services appreciates your concern and continued commitment to aviation safety near FFZ.

The United States Department of Agriculture (USDA)--Animal and Plant Health Inspection Service (APHIS)--Wildlife Services (WS) program is authorized and directed to protect American agriculture and other resources from damage associated with wildlife. WS provides assistance to the aviation community to assess and manage wildlife hazards at airports. The primary statutory authority by which WS operates is the Animal Damage Control Act of March 2, 1931, as amended (7 United States Code (U.S.C.) 426-426c; 46 Stat. 1468). WS has the authority to manage migratory bird damage as specified in the U.S.C. In addition, the Rural Development, Agriculture, and Related Agencies Appropriations Act of 1988 (Public Law 100202) authorizes and directs the Secretary of Agriculture to cooperate with states, individuals, public and private agencies, organizations and institutions in the control of nuisance mammals and birds deemed injurious to the public. WS activities are conducted in cooperation with other federal, state and local agencies, and private organizations and individuals. Authority to conduct these activities on airports is typically granted to WS through contracts and agreements with airports and transportation authorities.

A Memorandum of Understanding (MOU) was established in April of 1989 between the United Stated Department of Transportation, Federal Aviation Administration (FAA) and WS. This MOU establishes a cooperative relationship between the FAA and WS for resolving animal hazards to aviation hazards that benefits public safety. Wildlife recommendations and information provided is in accordance with the safety guidelines set forth by the FAA pertaining to air traffic safety in relation to FFZ and its users. An MOU was also established between the United States Department of Defense and WS. This MOU is to establish procedures for planning, scheduling and conducting animal damage control activities, on United States military installations within the United States and its territories. These MOU's established that WS has the wildlife damage management expertise and may provide technical and operational assistance (when funded by an airport or other entity) to alleviate wildlife hazards at airports.

APHIS United States Department of Agriculture
Animal and Plant Health Inspection Service

Safeguarding American Agriculture

RESPONSE:

Thank you for your comment. The preferred alternative, Alternative O, was modified to remove vegetation within the Critical Zone. This modification is reflected in the alternative description found in Chapter 3, of the Final Environmental Impact Statement. That description will show there are no wetlands within the Critical Zone, and that the constructed low flow channel is well outside of the Critical Zone.

The U.S. Army Corps of Engineers will take the enclosed plant list into consideration during the design phase and will continue to coordinate with your staff to alleviate the risk of wildlife hazards.

A Memorandum of Agreement (MOA) was established in July of 2003 between the FAA, US Air Force, US Army, US Environmental Protection Agency, US Fish and Wildlife Service and USDA. These federal agencies recognize the expertise of WS in addressing wildlife damage issues through a cooperative approach in assessing and managing wildlife hazards. This MOA establishes a cooperative agreement to coordinate missions to more effectively address existing and future environmental concerns that contribute to aircraft-wildlife strikes throughout the United States.

The threat to public safety from aircraft collisions with wildlife is increasing. Wildlife hazards at airports can result in loss of life, injury to passengers, crew, and people on the ground, and costly destruction and damage to aircraft, aircraft components, navigational aids, and airport facilities. Environmental losses from wildlife hazards include fuel dumping and loss of threatened and endangered wildlife species. Indirect impacts of wildlife hazards at airports are economic losses associated with modified flight schedules, closed runways, loss of flying time, passenger delays, and costs associated with emergency and repair procedures. Based on analysis of 13 years of wildlife strike data (1990-2002), the FAA estimates that the costs of wildlife strikes to the U.S. civil aviation industry is in excess of 364,626 hours/year of aircraft down time and $170.89 million/year in direct monetary losses and in associated costs. The risk, frequency, and potential severity of wildlife-aircraft collisions has increased, and will likely continue to increase due to three factors: 1) The trend toward more efficient and quieter 2-engined jet aircraft, and away from 3- and 4-engined aircraft, 2) Increasing population size and distribution of wildlife species that are especially hazardous to aircraft, and 3) Continued increase in air traffic.

Falcon Field Airport receives turbine-powered engine aircraft thereby qualifying within the 10,000 foot (3,048 meters) siting criteria described under the FAA Advisory Circular 150/5200-33, section 1-3b. The FAA Advisory Circular 150/5200-33 recommends separations when siting any wildlife attractant near aircraft movement areas. The distance between the wildlife attractant and the airport's aircraft movement areas, loading ramps, or aircraft parking areas should be 10,000 feet for airports serving turbine-powered aircraft. This area is referred to by WS as the Critical Zone.

A distance of five (5) statute miles (8,047 meters) is recommended for the approach or departure airspace if the wildlife attractant may cause hazardous wildlife movement into or across that airspace. This area, referred to by WS as the Expanded Critical Zone, contains the area five (5) statute miles off of each runway end. The Expanded Critical Zone reflects the boundaries defined by the FAA Advisory Circular 150/5200-33. Wildlife recommendations and information provided will be in accordance with the safety guidelines set forth by the FAA pertaining to air traffic safety.

Both the Critical Zone the Expanded Critical Zone should be designed and managed in a manner that will not support wildlife deemed hazardous to aviation. There is no distinction between the 10,000 foot area and the 5 mile approach and departure area in the AC 150/5200-33, Sections 1-3. A portion of the proposed VSA is in the Critical Zone. The boundaries of this survey were from the northwest area of the 4L runway and Taxiway E.

There are several characteristics which make birds more of a hazard for an airport environment. First is the overall population present in the environment. A flock of 500 blackbirds is more hazardous than a single individual of the same species. However, larger, dense birds present significant hazards even when found singly in the airport environment. Other characteristics such as flying behavior (i.e., soaring) or young and inexperienced birds also present a significant concern in the airport environment.

The purpose of the VSA plan is "to increase the diversity of native plants and animals as well as to sustain larger populations of key indicator species or more biologically desirable species". WS recommends USACE actively monitor the new habitat for wildlife hazards close to FFZ. If hazards do occur, the agencies will make every effort to undertake actions that will alleviate these hazards.

Flood irrigation should not be implemented within VSA. Standing water attracts waterfowl and large wading birds such as egrets, herons and cas be a vector problem. Drip irrigation is recommended for this area. USACE should also ensure that wetlands are placed outside of the siting criteria.

Outside the Critical Zone, any ponds will be small, deep, steep sided, and irregular shaped which should help reduce the number and diversity of wildlife. No part of the will contain islands that provide excellent nesting areas for waterfowl. A Western grebe, an aquatic bird, was struck at FFZ in April, 1998 and caused substantial damage to a Bell 407, a large helicopter.

Page 4-36 states that low-flow channels "do not represent a significant value to wildlife, and are rare in the project." Low flow channels can be attractants for blackbirds such as red-winged blackbirds and yellow-headed blackbirds as well as wading birds and waterfowl. Low flow channels will need to be constructed with the greatest depth and steepest banks feasible to discourage the gathering of wading birds. The channel will need to be constructed with stabilized banks to minimize vegetative growth that could support birds considered hazardous to aviation. Vegetative growth that attracts hazardous wildlife should be cleared out on a regular basis.

Per an agreement dated March 29, 2001 between USACE and the FAA, within the Critical Zone of Phoenix International Airport, xeriscape landscaping will be utilized. WS expects that USACE would implement the same type of restrictions for FFZ. Other restrictions for that area should include no aquatic strand habitat within the

Critical Zone. Plants should not exceed 15 feet in height and active monitoring will be conducted for removal of any large trees. Wildlife Services recommends incorporating plants from the WS Recommended Plant List which offers landscaping options within the siting area of FFZ. Recommended trees within the aforementioned zone should be species native to southwestern deserts and must be maintained at a maximum of 15 feet (4.5 meters) in height to reduce the attractiveness to wildlife that conflict with airport safety. VSA should adopt a policy of complete eradication of non-native plant species, such as salt cedar and palm. The policy will also include active monitoring and removal of any large trees, such as cottonwoods, that start to grow as "volunteers".

Development of the VSA will change the land use around FFZ. Because major changes are expected through the creation of additional wildlife habitat, increased water availability, changes in wildlife patterns and movements, as well as species diversity and abundance, are likely to occur. Monitoring by a wildlife hazard biologist of wildlife in the area is recommended, since changing habitat may decrease habitat preference for one species but may increase its attractiveness to another. Monitoring will also be beneficial to determine if unforeseen wildlife attractants such as irrigation systems or structure design arise.

VSA representatives should continue to consult and or contract with a wildlife hazard biologist to ensure wildlife hazards do not occur. All plans and drafts should be presented to the FAA and the wildlife hazard biologist for review to make certain they are within the guidelines of the AC 150/5200-33. A wildlife hazard management plan should be compiled in order to manage wildlife hazards if or when they arise. Once the U.S. Army Corps of Engineers completes the project, the new project managers will have the wildlife hazard biologist and the management plan to help follow the guidelines established during the construction.

Thank you for the opportunity to comment on the VSA. WS looks forward to working with the U.S. Army Corps of Engineers in the spirit of the MOA. If you have any questions or wish to discuss any of these items further, please contact Mr. David Bergman, State Director, at (602)870-2081.

Sincerely,

Diane Winterboer

Diane Winterboer
Wildlife Biologist

Cc: David Bergman, WS, State Director
William Long, FAA Western Pacific Region
Ed Cleary, FAA Safety and Compliance
Gordon Haws, City of Mesa, Engineer Design
Mark Meyers, Falcon Field Airport Director

Attachments

USDA-Wildlife Services Recommended Plant List

The USDA-Wildlife Services recommends incorporating desert xeriscape within the critical zone (10,000 foot radius) of the airports in southern Arizona. Desert xeriscape should include plant species native to southwestern deserts and comprise a simple, uncluttered appearance (i.e., cacti, yuccas, dwarf varieties of desert trees, shrubs, ground cover and rocks). Trees should be open, fairly transparent and maintained at less than 15 ft in height to minimize roosting potential for doves, pigeons and blackbirds. Conversion of the airport environment to desert xeriscape should help reduce the potential for attracting wildlife considered hazardous to aviation operations. Although desert xeriscaping is the best option for airports located in arid environments, it should be noted that many of these desert plant species produce seed or bean pods which may attract birds or mammals for feeding opportunities. Seed and bean pods should be removed after they have dropped from the plant. Proper maintenance of the landscaped area should reduce the wildlife foraging potential.

TREES

Acacia berlandieri (Berlandier's acacia)
Acacia coulteri (Coulter's acacia)
Acacia crassifolia (Butterfly-leaf acacia)
Acacia cultiformis (Knife acacia)
Acacia farnesiana (Southwestern sweet acacia)
Acacia greggii (Catclaw acacia)
Acacia pennatula (Sierra Madre acacia, Feather acacia)
Acacia rigidula (Black-brush acacia)
Acacia smallii (Sweet acacia)
Acacia willardiana (Palo blanco)
Brongniartia alamosana (Alamos pea tree)
Bursera fagaroides (White bark tree)
Bursera hindsiana (Red elephant tree)
Bursera laxiflora (Torote prieto)
Bursera microphylla (Little-leaf bursera)
Caesalpinia platyloba (Palo Colorado)
Cercidium microphyllum (Foothills palo verde)
Cercidium sonorae (Hybrid Sonoran palo verde)
- Desert Museum Palo Verde (hybrid of *Parkinsonia aculeata, Cercidium floridum, and C. microphyllum)*

Cercis occidentalis (Western redbud)
Chilopsis linearis arcuata (Western desert willow)
Fraxinus greggii (Gregg ash)
Fraxinus gooddingii (Goodding ash)
Lysiloma watsonii divericatum (Rincon Mountains feather tree)
Olneya tesota (Ironwood tree) – keep trimmed to 15ft.
Pithecellobium leucospermum (Palo pinto)
Prosopis glandulosa torreyana (Western honey mesquite) – keep trimmed to 15ft, clean up pods
Prosopis pubescens (Screwbean mesquite) – keep trimmed to 15ft., clean up pods
Prosopis velutina (Velvet mesquite) – keep trimmed to 15ft, clean up pods

Robinia neomexicana (New Mexico locust)
Tabebuia impetiginosa (Lavender trumpet tree) -- keep trimmed to 15ft.
Thevetia thevetioides (Giant thevetia)
Ungnadia speciosa (Mexican buckeye)

SHRUBS

Abutilon palmeri (Sonoran flowering maple)
Acacia angustissima (Fern acacia, Hirta)
Acacia cochliacantha (Boat-spine acacia)
Acacia constricta (White-thorn acacia, Mescat acacia)
Aloysia wrightii (Wright's bee bush)
Ambrosia deltoidea (Bursage, Rabbit bush)
Ambrosia dumosa (White bursage, Burro weed)
Anisacanthus thurberi (Desert honeysuckle)
Asclepias linaria (Pineleaf milkweed)
Atriplex canescens (Four-wing saltbush)
Atriplex lentiformis breweri (Brewer's saltbush)
Atriplex polycarpa (Desert saltbush)
Baccharis sarothroides (Desert broom)
Berberis harrisoniana (Harrison barberry)
Caesalpinia gilliesii (Yellow bird of paradise)
Caesalpinia mexicana (Mexican bird of paradise)
Caesalpinia pulcherrima (Red bird of paradise)
Calliandra californica (Baja fairy duster)
Calliandra eriophylla (Fairy duster)
Chrysactinia mexicana (Damianita daisy)
Coccoloba goldmanni (Sonoran sea grape)
Condalia correllii (Mexican blue wood)
Cordia parvifolia (Little-leaf cordia)
Dalea bicolor argyrea (Silver dalea)
Dalea frutescens (Black dalea)
Dalea pulchra (Bush dalea)
Dalea wislizenii (Wislizenii's dalea)
Encelia farinosa (Brittle bush)
Ephedra viridis (Mormon tea)
Ericameria laricifolia (Turpentine bush)
Eysenhardtia orthocarpa (Kidneywood)
Jatropha cardiophylla (Limberbrush)
Justicia californica (Chuparosa)
Justicia candicans (Red Mexican honeysuckle)
Justicia spicigera (Mexican honeysuckle)
Lantana species (Trailing lavender, Desert lantana, Texas orange-flowered lantana)
Lantana velutina (White lantana)

Larrea divaricata tridentata (Creosote bush)
Leucophyllum candidum (Cenizo, Thunder cloud sage)
Leucophyllum frutescens (Texas sage)
Leucophyllum laevigatum (Chihuahuan sage)
Leucophyllum langmaniae (Cinnamon sage)
Palisiphonia brachysiphon (Rock trumpet)
Penstemon barbatus (Scarlet penstemon)
Penstemon eatonii (Eaton's penstemon)
Penstemon parryi (Parry's penstemon)
Penstemon pseudospectabilis (Canyon penstemon)
Penstemon superbus (Superb penstemon)
Psilostrophe cooperi (Paper flower)
Rhus choriophylla (Chihuahuan leather-leaf sumac)
Rhus virens (Huachuca sumac)
Ruellia brittoniana 'Katie' (Mexican barrio ruellia
Ruellia californica (Sonoran desert ruellia)
Ruellia peninsularis (Baja ruellia)
Salvia chamaedryoides (Blue Chihuahuan sage)
Salvia clevelandii (Cleveland sage)
Salvia coccinea (Cherry red sage)
Salvia farinacea (Mealy cup sage)
Salvia greggii (Red Chihuahuan sage)
Senecio salignus (Willow groundsell)
Senna lindheimeriana (Lindheimer senna)
Simmondsia chinensis (Jojoba)
Sophora arizonica (Arizona mescal bean)
Sphaeralcea ambigua (Globe mallow)
Tagetes palmeri or *Tagetes lemmonii* (Mount Lemmon marigold)
Tecoma stans angustata (Narrow-leaf yellow bells)
Vallesia bathyana (Vallesia)
Viguiera deltoidea (Golden eye)

SUCCULENTS/CACTI

Agave americana (Century plant)
Agave colorata (Mescal ceniza)
Agave deserti (Desert agave)
Agave geminiflora (Twin-flowered agave)
Agave lechuguilla (Lechuguilla)
Agave lophantha (Holly avage)
Agave murpheyi (Murphy's agave)
Agave ocahui (Ocahui agave)
Agave palmeri (Palmer's agave)
Agave parryi huachucensis (Huachuca agave)
Agave parryi truncate (Gentry's agave)

Agave vilmoriniana (Octopus agave)
Aquilegia chrysantha (Golden columbine)
Asclepias subulata (Desert milkweed)
Carnegia gigantea (Saguaro cactus)
Dasylirion wheeleri (Desert spoon)
Echinocactus grusonii (Golden barrel cactus)
Echinocereus engelmannii (Hedgehog cactus)
Ferocactus cylindraceus (Compass barrel cactus)
Ferocactus wislizenii (Fishhook barrel cactus)
Fouquieria splendens (Ocotillo)
Gaura lindheimeri (Pink gaura)
Hesperaloe funifera (Giant hesperaloe)
Hesperaloe nocturna (Night-blooming hesperaloe)
Hesperaloe parviflora (Red yucca)
Opuntia acanthocarpa (Buckhorn cholla)
Opuntia basilaris (Beaver tail prickly pear)
Opuntia ficus-indica (India fig)
Opuntia engelmannii (Engelmann's prickly pear)
Opuntia microdasys (Bunny ears)
Opuntia phaeacantha (Sprawling Engelmann prickly pear)
Opuntia violacea v. santa-rita (Purple prickly pear)
Stenocereus thurberi (Organ pipe cactus)
Yucca baccata (Banana yucca)
Yucca glauca (Narrow-leaf yucca)
Yucca schidigera (Mojave yucca)
Yucca rigida (Blue yucca)

ACCENTS

Argemone platyceras (Prickly poppy)
Asclepias subulata (Desert milkweed)
Baileya multiradiata (Desert marigold)
Calliandra californica (Baja fairy duster)
Calliandra eriophylla (Fairy duster)
Dyssodia pentachaeta (Golden dyssodia)
Gaura lindheimeri (Pink gaura)
Hymenoxys acaulis (Angelita daisy)
Mascagnia lilacina (Lilac orchid vine)
Melampodium leucanthum (Blackfoot daisy)
Muhlenbergia capillaries (Pink muhly)
Oenothera berlandieri (Mexican evening primrose)
Zexmenia hispida (Orange zexmenia)

GROUND COVER

USDA-Wildlife Services Recommended Plant List

Baccharis hybrid 'centennial' (Desert broom hybrid)
Dalea greggii (Trailing indigo bush)
Dyssodia pentachaeta (Golden dyssodia)
Lantana species (Trailing lavender, Desert lantana, Texas orange-flowered lantana)
Melampodium leucanthum (Blackfoot daisy)
Oenothera berlandieri (Mexican evening primrose)
Oenothera caespitosa (White primrose)
Oenothera stubbei (Saltillo primrose)
Stachys coccinea (Texas betony)
Verbena goodingii (Goodding verbena)
Verbena rigida (Sandpaper verbena)
Zauschneria californica (Hummingbird trumpet bush)
Zinnia acerosa (Desert zinnia)
Zinnia grandiflora (Rocky Mountain zinnia)

Note: This plant list was designed to serve as a template for future landscaping projects within the 10,000 foot radius airports in southern Arizona. This is not a complete list of all plant species that may be acceptable within the critical zones. If other species are to be used within the 10,000 foot radius, they should first be approved by a Wildlife Services wildlife biologist. In addition, this plant list should be considered as continually evolving. As the scientific community continues to gain a better understanding of wildlife relationships with various habitats, individual plant species may be removed from or added to this list.

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS

Date: 9/1/97
Initiated by: AAS-310 and AFP-600

AC No: 150/5200-33
Change:

1. **PURPOSE.** This advisory circular (AC) provides guidance on keeping certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. It also provides guidance concerning the placement of new airport development projects (including airport construction, expansion, and renovation) pertaining to aircraft movement in the vicinity of hazardous wildlife attractants. Appendix 1 provides definitions of terms used in this AC.

2. **APPLICATION.** The standards, practices, and suggestions contained in this AC are recommended by the Federal Aviation Administration (FAA) for use by the operators and sponsors of all public-use airports. In addition, the standards, practices, and suggestions contained in this AC are recommended by the FAA as guidance for land use planners, operators, and developers of projects, facilities, and activities on or near airports.

3. **BACKGROUND.** Populations of many species of wildlife have increased markedly in the last few years. Some of these species are able to adapt to human-made environments, such as urban and around airports. The increase in wildlife populations, the use of larger turbine engines, the increased use of twin-engine aircraft, and the increase in air traffic, all combine to increase the risk, frequency, and potential severity of wildlife-aircraft collisions.

Most public-use airports have large tracts of open, undeveloped land that are desirable for added margins of safety and noise mitigation. These areas also present potential hazards to aviation because they often attract hazardous wildlife. During the past century, wildlife-aircraft strikes have resulted in the loss of hundreds of lives world-wide, as well as billions of dollars worth of aircraft damage. Therefore wildlife attractants near airports could jeopardize future airport expansion because of safety considerations.

DAVID L. BENNETT
Director, Office of Airport Safety and Standards

SECTION 1. HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS.

1-1. TYPES OF HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS. Human-made or natural areas, such as poorly-designed retention ponds, roosting habitats on buildings, landscaping, putrescible-waste disposal operations, wastewater treatment plants, agricultural or aquacultural activities, surface mining, or wetlands, may be used by wildlife for escape, feeding, loafing, or reproduction. Wildlife use of areas within an airport's approach or departure airspace, aircraft movement areas, loading ramps, or aircraft parking areas may cause conditions hazardous to aircraft safety.

All species of wildlife can pose a threat to aircraft safety. However, some species are more commonly involved in aircraft strikes than others. Table 1 lists the wildlife groups commonly reported as being involved in damaging strikes to U.S. aircraft from 1995 to 1995.

Table 1. Wildlife Groups Involved in Damaging Strikes to Civilian Aircraft, USA, 1993-1995.

Wildlife Groups	Percent involvement in reported damaging strikes
Gulls	28
Waterfowl	28
Raptors	11
Doves	6
Vultures	5
Blackbirds-Starlings	5
Corvids	3
Wading birds	3
Deer	11
Canids	1

1-2. LAND USE PRACTICES. Land use practices that attract or sustain hazardous wildlife populations on or near airports can significantly increase the potential for wildlife-aircraft collisions. FAA recommends against land use practices, within the siting criteria stated in 1-3, that attract or sustain populations of hazardous wildlife within the vicinity of airports or cause movement of hazardous wildlife onto, into, or across the approach or departure airspace, aircraft movement area, loading ramps, or aircraft parking area of airports.

Airport operators, sponsors, planners, and land use developers should consider whether proposed land uses, including new airport development projects, would increase the wildlife hazard. Caution should be exercised to ensure that land use practices on or near airports do not enhance the attractiveness of the area to hazardous wildlife.

1-3. SITING CRITERIA. FAA recommends operations when siting any of the wildlife attractants mentioned in Section 2 or when planning new airport development projects to accommodate aircraft movement. The distance between an airport's aircraft movement areas, loading ramps, or aircraft parking areas and the wildlife attractant should be as follows:

a. **Airports serving piston-powered aircraft.** A distance of 5,000 feet is recommended.

b. **Airports serving turbine-powered aircraft.** A distance of 10,000 feet is recommended.

c. **Approach or Departure airspace.** A distance of 5 statute miles is recommended, if the wildlife attractant may cause hazardous wildlife movement into or across the approach or departure airspace.

1881

SECTION 2. LAND USES THAT ARE INCOMPATIBLE WITH SAFE AIRPORT OPERATIONS.

2-1. GENERAL. The wildlife species and the size of the populations attracted to the airport environment are highly variable and may depend on several factors, including land-use practices on or near the airport. It is important to identify those land use practices in the airport area that attract hazardous wildlife. This section discusses land use practices known to threaten aviation safety.

2-2. PUTRESCIBLE-WASTE DISPOSAL OPERATIONS. Putrescible-waste disposal operations are known to attract large numbers of wildlife that are hazardous to aircraft. Because of this, these operations, when located within the separations identified in the siting criteria in 1-3 are considered incompatible with safe airport operations.

FAA recommends against locating putrescible-waste disposal operations inside the separations identified in the siting criteria mentioned above. FAA also recommends against new airport development projects that would increase the number of aircraft operations or that would accommodate larger or faster aircraft, near putrescible-waste disposal operations located within the separations identified in the siting criteria in 1-3.

2-3. WASTEWATER TREATMENT FACILITIES. Wastewater treatment facilities and associated settling ponds often attract large numbers of wildlife that can pose a threat to aircraft safety when they are located on or near an airport.

a. New wastewater treatment facilities. FAA recommends against the construction of new wastewater treatment facilities or unprotected settling ponds within the separations identified in the siting criteria in 1-3. During the siting analysis for wastewater treatment facilities, the potential to attract hazardous wildlife should be considered. If an airport is in the vicinity of a proposed site, Airport operators should voice their opposition to such things. In addition, they should consider the existence of wastewater treatment facilities when evaluating proposed sites for new airport development projects and avoid such sites when practicable.

b. Existing wastewater treatment facilities. FAA recommends correcting any wildlife hazards arising from existing wastewater treatment facilities located on or near airports without delay, using appropriate wildlife hazard mitigation techniques. Accordingly, measures to minimize hazardous wildlife attraction should be developed in consultation with a wildlife damage management biologist. FAA recommends that wastewater treatment facility operators incorporate appropriate wildlife hazard mitigation techniques into their operating practices. Airport operators also should encourage these operators to incorporate these mitigation techniques in their operating practices.

c. Artificial marshes. Waste-water treatment facilities may create artificial marshes and use submerged and emergent aquatic vegetation as natural filters. These artificial marshes may be used by some species of flocking birds, such as blackbirds and waterfowl, for breeding or roosting activities. FAA recommends against establishing artificial marshes within the separations identified in the siting criteria stated in 1-3.

d. Wastewater discharges and sludge disposal. FAA recommends against the discharge of wastewater or sludge on airport property. Regular spraying of wastewater or sludge disposal on improved areas may improve soil moisture and quality. The resultant turf growth requires more frequent mowing, which in turn may mutilate or flush insects or small animals and produce straw. The moisture or flushed organisms and the straw can attract hazardous wildlife and jeopardize aviation safety. In addition, the improved turf may attract grazing wildlife such as deer and geese.

Problems may also occur when discharges saturate unpaved airport areas. The resultant soft, muddy conditions can severely restrict or prevent emergency vehicles from reaching accident sites in a timely manner.

e. Underwater waste discharges. The underwater discharge of any food waste, e.g., fish processing offal, that could attract scavenging wildlife is not recommended within the separations identified in the siting criteria in 1-3.

1882

2-4. WETLANDS.

a. Wetlands on or near Airports.

(1) Existing Airports. Normally, wetlands are attractive to many wildlife species. Airport operators with wetlands located on or nearby airport property should be alert to any wildlife use or habitat changes in these areas that could affect safe aircraft operations.

(2) Airport Development. When practicable, the FAA recommends siting new airports using the separations identified in the siting criteria in 1-3. Where alternative sites are not practicable or when expanding existing airports in or near wetlands, the wildlife hazards should be evaluated and minimized through a wildlife management plan prepared by a wildlife damage management biologist, in coordination with the U.S. Fish and Wildlife Service (USFWS) and the U.S. Army Corps of Engineers (COE).

NOTE: If questions exist as to whether or not an area would qualify as a wetland, contact the U.S. Army COE, the Natural Resource Conservation Service, or a wetland consultant certified to delineate wetlands.

b. Wetland mitigation. Mitigation may be necessary when unavoidable wetland disturbance results from new airport development projects. Wetland mitigation should be designed so it does not create a wildlife hazard.

(1) FAA recommends that wetland mitigation projects that may attract hazardous wildlife be sited outside of the separations identified in the siting criteria in 1-3. Wetland mitigation banks meeting these siting criteria offer an ecologically sound approach to mitigation in these situations.

(2) Exceptions to locating mitigation activities outside the separations identified in the siting criteria in 1-3 may be considered if the affected wetlands provide unique ecological functions, such as critical habitat for threatened or endangered species or ground water recharge. Such mitigation must be compatible with safe airport operations. Enhancing such mitigation areas to attract hazardous wildlife should be avoided. On-site mitigation plans may be reviewed by the FAA to determine compatibility with safe airport operations.

(3) Wetland mitigation projects that are needed to protect unique wetland functions (see 2-4.b.(2)), and that must be located in the siting criteria in 1-3 should be identified and evaluated by a wildlife damage management biologist before implementing the mitigation. A wildlife damage management plan should be developed to reduce the wildlife hazards.

NOTE: AC 150/5000-5, *Address List for Regional Airports Division and Airports District/Field Offices*, provides information on the location of these offices.

2-5. DREDGE SPOIL CONTAINMENT AREAS. FAA recommends against locating dredge spoil containment areas within the separations identified in the siting criteria in 1-3, if the spoil contains material that would attract hazardous wildlife.

1883

SECTION 3. LAND USES THAT MAY BE COMPATIBLE WITH SAFE AIRPORT OPERATIONS.

3-1. GENERAL. Even though they may, under certain circumstances, attract hazardous wildlife, the land use practices discussed in this section have flexibility regarding their location or operation and may even be under the airport operator's or sponsor's control. In general, the FAA does not consider the activities discussed below as hazardous to aviation if there is no apparent attraction to hazardous wildlife, or wildlife hazard mitigation techniques are implemented to deal effectively with any wildlife hazard that may arise.

3-2. ENCLOSED WASTE FACILITIES. Enclosed trash transfer stations or enclosed waste handling facilities that receive garbage indoors; process it via composting, incineration, or similar manner; and remove all residue by enclosed vehicles, generally would be compatible, from a wildlife perspective, with safe airport operations, provided they are not located on airport property or within the runway protection zone (RPZ). No putrescible waste should be handled or stored outside at any time, for any reason, or in a partially enclosed structure accessible to hazardous wildlife.

Partially enclosed operations that accept putrescible waste are considered to be incompatible with safe airport operations. FAA recommends these operations occur outside the separations identified in the siting criteria in 1-3.

3-3. RECYCLING CENTERS. Recycling centers that accept previously owned, non-food items such as glass, newspaper, cardboard, or aluminum can, in most cases, not attractive to hazardous wildlife.

3-4. COMPOSTING OPERATIONS ON AIRPORTS. FAA *recommends* against locating composting operations on airports. However, when they are located on an airport, composting operations should not be located closer than the greater of the following distances: 1,200 feet from any aircraft movement area, loading ramp, or aircraft parking space; or the distance called for by airport design requirements. This spacing is intended to prevent animals, personnel, or equipment from penetrating any Obstacle Free Area (OFA), Obstacle Free Zone (OFZ), Threshold Siting Surface (TSS), or Clearway (see AC 150/5300-13, *Airport Design*). On-airport disposal of compost by-products is not recommended for the reasons stated in 2-3.d.

a. Composition of material handled. Components of the compost should never include any municipal solid waste. Non-food waste such as leaves, lawn clippings, branches, and twigs generally are not considered a wildlife attractant. Sewage sludge, wood-chips, and similar material are not municipal solid wastes and may be used as compost bulking agents.

b. Monitoring on-airport composting operations. If composting operations are to be located on airport property, FAA recommends that the airport operator monitor composting operations to ensure that storm or thermal rise does not affect air traffic in any way. Discarded leaf disposal bags or other debris must not be allowed to blow onto any active airport area. Also, the airport operator should reserve the right to stop any operations that create unsafe, undesirable, or incompatible conditions at the airport.

3-5. ASH DISPOSAL. Fly ash from resource recovery facilities that are fired by municipal solid waste, coal, or wood, is generally considered not to be a wildlife attractant because it contains no putrescible matter. FAA generally does not consider landfills accepting only fly ash to be wildlife attractants. If these landfills are maintained in an orderly manner, admit no putrescible waste of any kind, and are not co-located with other disposal operations.

Since varying degrees of waste consumption are associated with general incinerators, FAA classifies the ash from general incinerators as a regular waste disposal by-product and, therefore, a hazardous wildlife attractant.

3-6. CONSTRUCTION AND DEMOLITION (C&D) DEBRIS LANDFILLS. C&D debris (Class IV) landfills have visual and operational characteristics similar to putrescible-waste disposal sites. When co-located with putrescible-waste disposal operations, the probability of hazardous wildlife attraction to C&D landfills increases because of the similarities between these disposal activities.

FAA generally does not consider C&D landfills to be hazardous wildlife attractants, if these landfills are maintained in an orderly manner, admit no putrescible waste of any kind, and are not co-located with other disposal operations.

1884

3-7. WATER DETENTION OR RETENTION PONDS. The movement of storm water away from runways, taxiways, and aprons is a normal function on most airports and is necessary for safe aircraft operations. Detention ponds hold storm water for short periods, while retention ponds hold water indefinitely. Both types of ponds control runoff, protect water quality, and can attract hazardous wildlife. Retention ponds are more attractive to hazardous wildlife than detention ponds because they provide a more reliable water source.

To facilitate hazardous wildlife control, FAA recommends using steep-sided, uneven, linearly-shaped, rip-rap lined, water detention basins rather than retention basins. When possible, these ponds should be placed away from aircraft movement areas to minimize aircraft-wildlife interactions. All vegetation in or around detention or retention basins that provide food or cover for hazardous wildlife should be eliminated.

If soil conditions and other requirements allow, FAA encourages the use of underground storm water infiltration systems, such as French drains or buried rock fields, because they are less attractive to wildlife.

3-8. LANDSCAPING. Wildlife attractions in landscaping may vary by geographic location. FAA recommends that airport operators approach landscaping with caution and confine it to airport areas not associated with aircraft movements. All landscaping plans should be reviewed by a wildlife damage management biologist. Landscaped areas should be monitored on a continuing basis for the presence of hazardous wildlife. If hazardous wildlife is detected, corrective actions should be implemented immediately.

3-9. GOLF COURSES. Golf courses may be beneficial to airports because they provide open space that can be used for noise mitigation or by aircraft during an emergency. On-airport golf courses may also be a convenient way that provides income to the airport.

Because of operational and monetary benefits, golf courses are often deemed compatible land uses on or near airports. However, waterfowl (especially Canada geese) and some species of gulls are attracted to the large, grassy areas and open water found on most golf courses. Because waterfowl and gulls occur throughout the U.S., FAA recommends that airport operators exercise caution and consult with a wildlife damage management biologist when considering proposals for golf course construction or expansion on or near airports. Golf courses should be monitored on a continuing basis for the presence of hazardous wildlife. If hazardous wildlife is detected, corrective actions should be implemented immediately.

3-10. AGRICULTURAL CROPS. As noted above, airport operators often promote revenue-generating activities to supplement an airport's financial viability. A common assessment use is agricultural crop production. Such use may create potential hazards to aircraft by attracting wildlife. Any proposed on-airport agricultural operations should be reviewed by a wildlife damage management biologist. FAA generally does not object to agricultural crop production on airports where wildlife hazards are not predicted, the guidelines for the airport areas specified in 3-10.a-f. are observed, and the agricultural operation is closely monitored by the airport operator or sponsor to ensure that hazardous wildlife are not attracted.

NOTE: If wildlife becomes a problem due to on-airport agricultural operations, FAA recommends undertaking the remedial actions described in 3-10.f.

a. **Agricultural activities adjacent to runways.** To ensure safe, efficient aircraft operations, FAA recommends that no agricultural activities be conducted in the Runway Safety Area (RSA), OFA, and the OFZ (see AC 150/5300-13).

b. **Agricultural activities in areas requiring unobstructed object clearances.** Restricting agricultural operations to areas outside the RSA, OFA, OFZ, and Runway Visibility Zone (RVZ) (see AC 150/5300-13) will normally provide the minimum object clearances required by FAA's airport design standards. FAA recommends that farming operations not be permitted within areas critical to the proper operation of localizers, glide slope indicators, or other visual or electronic navigational aids. Determinations of minimal areas that must be kept free of farming operations should be made on a case-by-case basis. If navigational aids are present, then leases for on-airport agricultural activities should be coordinated with FAA's Airway Facilities Division, in accordance with FAA Order 6750.16, *Siting Criteria for Instrument Landing Systems*.

NOTE: Crop restrictions limit conforming to the dimensions set forth in Table 3 will normally provide the minimum object clearance required by

FAA airport design standards. The presence of navigational aids may require expansion of the restricted area.

c. Agricultural activities within an airport's approach areas. The RSA, OFA, and OFZ all extend beyond the runway shoulder and into the approach area by varying distances. The OFA normally extends the farthest and is usually the controlling surface. However, for some runways, the TSS (see AC 150/5300-13, Appendix 2) may be more controlling than the OFA. The TSS may not be penetrated by any object. The minimum distances shown in Table 2 are intended to prevent penetration of the OFA, OFZ, or TSS by crops or farm machinery.

NOTE: Threshold siting standards should not be confused with the approach areas described in Title 14, Code of Federal Regulations, Part 77, (14 CFR 77), *Objects Affecting Navigable Airspace*.

d. Agricultural activities between intersecting runways. FAA recommends that no agricultural activities be permitted within the RVZ. If the terrain is sufficiently below the runway elevation, some types of crops and equipment may be acceptable. Specific determinations of what is permissible in this area requires topographical data. For example, if the terrain within the RVZ is level with the runway ends, farm machinery or crops may interfere with a pilot's line-of-sight in the RVZ.

e. Agricultural activities in areas adjacent to taxiways and aprons. Farming activities should not be permitted within a taxiway's OFA. The outer portions of aprons are frequently used as a turnaround and farming operations should not be permitted within the OFA. Farming operations should not be permitted between runways and parallel taxiways.

f. Remedial actions for problematic agricultural activities. If a problem with hazardous wildlife develops, FAA recommends that a professional wildlife damage management biologist be contacted and an on-site inspection be conducted. The biologist should be requested to determine the source of the hazardous wildlife attraction and suggest remedial action. Regardless of the source of the attraction, prompt remedial actions to protect aviation safety are recommended. The remedial actions may range from directing another crop or farming technique to complete termination of the agricultural operation.

Whenever on-airport agricultural operations are stopped due to wildlife hazards or annual harvest, FAA recommends plowing under all crop residue and harvesting the surface area smooth. This will reduce or eliminate the area's attractiveness to foraging wildlife. FAA recommends that this requirement be written into all on-airport farm use contracts and clearly understood by the lessee.

1886

Table 2. Minimum Distance Between Certain Airport Features And Any On-Airport Agriculture Crops

Aircraft Approach Category And Design Group[1]	Distance In Feet From Runway Centerline To Crop		Distance In Feet From Runway End To Crop		Distance In Feet From Centerline Of Taxiway To Crop		Distance In Feet From Edge Of Apron To Crop
	Visual & ≥¾ mile	< ¾ mile	Visual & ≥¾ mile	< ¾ mile			
Category A & B Aircraft							
Group I	250[2]	400	250[2]	400	45		40
Group II	250	400	400[2]	400	66		58
Group III	400	400	400	800	93		81
Group IV	400	400	1,000	1,000	129		113
Category C, D & E Aircraft							
Group I	250	575[2]	1,000	1,000	79		69
Group II	250[2]	575[2]	1,000	1,000	94		81
Group III	550[2]	575[2]	1,000	1,000	93		81
Group IV	550	575[2]	1,000	1,000	129		113
Group V	550	575[2]	1,000	1,000	160		138
Group VI	550	575[2]	1,000	1,000	193		167

1. Design Groups are based on wing span, and Category depends on approach speed of the aircraft.
Group I: Wing spans up to 49 ft. Category A: Speed less than 91 knots
Group II: Wing spans 49 ft. up to 79 ft. Category B: Speed 91 knots up to 120 knots
Group III: Wing spans 79 ft. up to 118 ft. Category C: Speed 121 knots up to 140 knots
Group IV: Wing spans 118 ft. up to 170 ft. Category D: Speed 141 knots up to 165 knots
Group V: Wing spans 171 ft. up to 213 ft. Category E: Speed 166 knots or more
Group VI: Wing spans 214 ft. up to 261 ft.

2. If the runway will only serve small airplanes (12,500 lb. And under) in Design Group I, the distance may be reduced to 125 feet; however, this distance should be increased when runway is intended for use by aircraft in Design Group II or larger. For example, farming operations should not be allowed within 25 feet of a Precision Approach Path Indicator (PAPI) light box.

3. These dimensions refer to TSS as defined in AC 150/5300-13, Appendix 2. The TSS must be protected by any object. Under some conditions, the TSS may be more restrictive than the OFA, and the dimensions shown here are to prevent penetration of the TSS by crops and farm machinery.

APPENDIX 1. DEFINITIONS OF TERMS USED IN THIS ADVISORY CIRCULAR.

1. GENERAL. This appendix provides definitions of terms used throughout this AC.

a. Aircraft movement area. The runways, taxiways, and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas.

b. Airport operator. The operator (private or public) or sponsor of a public use airport.

c. Approach or departure airspace. The airspace, within 5 statute miles of an airport, through which aircraft move during landing or takeoff.

d. Concurrent use. Aeronautical property used for compatible non-aviation purposes while at the same time serving the primary purpose for which it was acquired; and the use is clearly beneficial to the airport. The concurrent use should generate revenue to be used for airport purposes (see Order 5190.6A, *Airport Compliance Requirements*, para. 5b).

e. Fly ash. The fine, sand-like residue resulting from the complete incineration of an organic fuel source. Fly ash typically results from the combustion of coal or waste used to operate a power generating plant.

f. Hazardous wildlife. Wildlife species that are commonly associated with wildlife-aircraft strike problems, are capable of causing substantial damage to airport facilities, or act as attractants to other wildlife that pose a wildlife-aircraft strike hazard.

g. Piston-use airport. Any airport that would primarily serve FIXED-WING, piston-powered aircraft. Incidental use of the airport by turbine-powered, FIXED-WING aircraft would not affect this designation. However, such aircraft should not be based at the airport.

h. Public-use airport. Any publicly owned airport or a privately-owned airport used or intended to be used for public purposes.

i. Putrescible material. Rotting organic material.

j. Putrescible-waste disposal operation. Landfills, garbage dumps, wastewater waste discharges, or similar facilities where activities include processing, burying, storing, or otherwise disposing of putrescible material, trash, and refuse.

k. Runway protection zone (RPZ). An area off the runway end to enhance the protection of people and property on the ground (see AC 150/5300-13). The dimensions of this zone vary with the design aircraft, type of operation, and visibility minimums.

l. Sewage sludge. The de-watered effluent resulting from secondary or tertiary treatment of municipal sewage and/or industrial wastes, including sewage sludge as referenced in U.S. EPA's *Effluent Guidelines and Standards*, 40 C.F.R. Part 401.

m. Shoulder. An area adjacent to the edge of paved runways, taxiways, or aprons providing a transition between the pavement and the adjacent surface, support for aircraft running off the pavement, enhanced drainage, and blast protection (see AC 150/5300-13).

n. Turbine-powered aircraft. Aircraft powered by turbine engines including turbojets and turboprops but excluding turbo-shaft rotary-wing aircraft.

o. Turbine-use airport. Any airport that ROUTINELY serves FIXED-WING turbine-powered aircraft.

p. Wastewater treatment facility. Any devices and/or systems used to store, treat, recycle, or reclaim municipal sewage or liquid industrial wastes, including Publicly Owned Treatment Works (POTW), as defined by Section 212 of the Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-576) and the Water Quality Act of 1987 (P.L. 100-4). This definition includes any pretreatment involving the reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a POTW. (See 40 C.F. R. Section 403.3 (o), (p), & (q)).

1888

q. **Wildlife.** Any wild animal, including without limitation any wild mammal, bird, reptile, fish, amphibian, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, including any part, product, egg, or offspring there of (50 CFR 10.12, *Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants*). As used in this AC, WILDLIFE includes feral animals and domestic animals while out of the control of their owners (14 CFR 139.3, *Certification and Operations: Land Airports Serving CAB-Certificated Scheduled Air Carriers Operating Large Aircraft (Other Than Helicopters)*).

r. **Wildlife attractants.** Any human-made structure, land use practice, or human-made or natural geographic feature, that can attract or sustain hazardous wildlife within the landing or departure airspace, aircraft movement area, loading ramps, or aircraft parking areas of an airport. These attractants can include but are not limited to architectural features, landscaping, waste disposal sites, wastewater treatment facilities, agricultural or aquacultural activities, surface mining, or wetlands.

s. **Wildlife hazard.** A potential for a damaging aircraft collision with wildlife on or near an airport (14 CFR 139.3).

2. **RESERVED.**

United States Department of the Interior
OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
1111 Jackson Street, Suite 520
Oakland, CA 94607

June 17, 2004

ER 04/357

Ms. Sarah Laughlin, Environmental Coordinator
c/o District Engineer
U. S. Army Corps of Engineers
Los Angeles District
Attension: CESPL-PD-RN
P. O. Box 532711
Los Angeles, CA 90053-2325

Subject: Draft Environmental Impact Statement (DEIS) for the
Va Shly'ay Akimel Ecosystem Restoration Feasibility Study, Maricopa County, AZ

Dear Ms. Laughlin,

The U. S. Department of the Interior has reviewed the Draft Environmental Impact Statement (DEIS) for the Va Shly'ay Akimel Ecosystem Restoration Feasibility Study in Maricopa County, Arizona. The DEIS addresses foreseeable environmental impacts from measures being investigated to include habitat restoration, channel realignment, and sand and gravel mining quarry pit reshaping within and around the Salt River, Maricopa County, Arizona.

The U. S. Army Corps of Engineers (Corps), Salt River Pima-Maricopa Indian Community (SRPMIC), and the City of Mesa have cooperated in conducting this feasibility study. The Corps is the lead Federal agency for this study.

The purpose of the Va Shly'ay Akimel Ecosystem Restoration Study (Study) is to produce an available riparian ecosystem that will support native wildlife and vegetation, which will improve the overall ecological health of the river and return the project area to a less degraded, more natural condition. The Study resulted in a report recommending that Congress authorize a project for implementation by the Corps to address the problems and needs of the study area.

Six alternatives, including the "no action" alternative, are evaluated in the DEIS. In general, the primary difference among alternatives is the acreage of each vegetation type and the resulting water necessary to maintain the vegetation. Other differences are the inclusion or exclusion of structural features, such as river channelization and bank stabilization.

RESPONSE:

Thank you for your comment.

The USACE researched the concern regarding the withdrawn lands. A Department of Interior, Bureau of Reclamation memo dated January 20, 1956, revokes the withdrawn lands identified in the memo. Therefore, there are no Bureau of Reclamation withdrawn lands in Reach 6, 7, 8 or 9.

The environmental commitments section details the additional studies that may be required to address historical features found within the project site. These studies will not be undertaken until a future phase. The USACE is in the early stages of complying with Section 106 of the National Historic Preservation Act (36 CFR 800). As we go through this process, any required studies will completed and fully coordinated with the State Historic Preservation Officer, the SRPMIC, City of Mesa, interested public, Native American tribes, and Federal, state and local agencies. If a memorandum of agreement is required to address impacts to National register sites, the USACE would welcome the Bureau of Reclamation to be a concurring party to the document.

This study area includes a 14-mile reach of the Salt River within the SRPMIC and City of Mesa, and its upper banks. The SRPMIC and the City of Mesa identified the need for restoration of the riparian ecosystem and of the river channel functions.

General Comments

The U. S. Fish and Wildlife Service (Service) has participated in the planning process for this study with the Corps. The Service has participated in an alternative formulation and incremental benefits analysis, prepared a Draft Fish and Wildlife Coordination Act Report, and completed section 7 consultation under the Endangered Species Act. Any potential concerns pertaining to fish and wildlife resources were resolved thanks to early coordination on this project. As a result, the DEIS accurately reflects the Service planning assistance and recommendations. Accordingly, the Service has no comments on the DEIS.

There are Bureau of Reclamation (Reclamation) withdrawn lands for the Salt River Project (SRP) in Reaches 6, 7, 8, and 9 of the project area. These lands need to be identified, and impacts to them described, in the EIS.

There are some historic canals on the south side of the river within the project area that are or were part of the SRP system. These are not identified and described in the DEIS. There are also some historical features linked to the canals, some of which are mentioned in the DEIS. A discussion of the historic archaeology needs to be included in the final EIS. Some of the historic sites may be property of the Federal Government. More research needs to be documented in the Final EIS in this area to ascertain what is present in the project area and its ownership, its significance, and the need for mitigation.

Reclamation should be a concurring party to any cultural resource mitigation agreements. However, if impacts to the withdrawn lands prove to be a significant issue, then Reclamation should be a signatory to any future agreements rather than a concurring party.

For questions or further information concerning these Reclamation comments, please contact Mr. Jon Czaplicki at 602-216-3862 or jczaplicki@lc.usbr.gov.

Thank you for the opportunity to review and comment on this DEIS.

Sincerely,

Patricia Sanderson Port
Regional Environmental Officer

cc: Director, OEPC, D.C.
FWS, Albuquerque, NM
BOR, Boulder City, NV

1891

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

June 24, 2004

Mr. Steve Dibble
U.S. Army Corps of Engineers
P.O. Box 532711
Los Angeles, CA 90053-2325

Subject: Draft Environmental Impact Statement (DEIS) for the Va Shly'ay Akimel Salt River Ecosystem Restoration Study, Maricopa County, Arizona (CEQ#040215)

Dear Mr. Dibble:

The Environmental Protection Agency (EPA) has reviewed the above referenced document pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508), and Section 309 of the Clean Air Act. Our detailed comments are enclosed.

The Corps of Engineers proposes to restore riparian habitat and provide passive recreation opportunities along the Salt River in Maricopa County. EPA supports the Corps, City of Mesa, and Salt River Pima Maricopa Indian Community in their efforts to increase native vegetation, and improve wildlife habitat and aquatic ecosystem function in this section of the Salt River.

Although we support the restoration effort, we have several concerns about impacts of the proposed actions due to a lack of information in the DEIS. As such, we have rated this DEIS as Environmental Concerns - Insufficient Information (EC-2). Please refer to the attached "Summary of Rating Definitions" for further details on EPA's rating system. In particular, EPA is concerned about the potential impacts from the construction and operation of the project's recreational facilities, impacts to water quality from the use of stormwater for irrigation, the effects of increased recreation on local traffic, and the potential cumulative impacts of the project.

We appreciate the opportunity to review this DEIS. When the Final EIS is released for public review, please send two copies to the address above (mail code: CMD-2). If you have any questions, please contact me or Shanna Draheim, the lead reviewer for this project. Shanna can be reached at (415) 972-3851 or draheim.shanna@epa.gov.

Sincerely,

Tanio Fujii for

Lisa B. Hanf, Manager
Federal Activities Office

Enclosures: EPA Summary Rating Sheet

RESPONSE:

Thank you for your comment. A final recreation plan had not yet been determined at the release of the draft Environmental Impact Statement. However, Recreation Option B has since been identified in the FEIS as the preferred recreation option. The FEIS contains a thorough discussion of the direct, indirect, and cumulative impacts associated with the alternatives analyzed in the document, including the 3 recreation options. Descriptions of any potential impacts and mitigation measures (if required) associated with construction and operation of the proposed recreational facilities are provided in the appropriate resource sections (e.g., Section 5.9 Transportation).

The FEIS (HWR-5) has been revised to state that the local sponsor will be responsible for implementing water quality improvement measures. Examples of additional measures that could be implemented to improve stormwater quality were also added to the FEIS discussion. As it is unknown what measures will be implemented, if any, it is speculative to analyze potential adverse affects or effectiveness of these measures.

Both the SRPMIC and the City of Mesa have existing stormwater monitoring plans in place as part of their permit requirements. Those same monitoring requirements will exist throughout the project construction. A reference to existing stormwater pollution permits currently held by the local sponsors have been added to the FEIS. This section also discusses the need to develop a stormwater monitoring plan if pollutant levels exceed allowable standards.

EPA DETAILED COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS) FOR THE
VA SHLY'AY AKIMEL SALT RIVER RESTORATION PROJECT, JUNE 24, 2004

Environmental Impacts Associated with Construction of Recreation Facilities

The DEIS evaluates five action alternatives, and no-action for the Salt River restoration component of the project. In addition, the document identifies three alternatives for recreational improvements associated with the restoration; all of which include construction of trails and a cultural center. The DEIS indicates that the local sponsors will decide the final recreation components, and that only a portion of the costs of these facilities can be attributed to the federal project.

The Environmental Consequences chapter of the DEIS focuses on the impacts associated with construction and maintenance of the Salt River restoration. Except for a brief discussion of operational impacts on traffic and recreation, the DEIS does not assess the impacts associated with the proposed recreation facilities. Construction and operation of the recreational facilities could have significant short- and long-term environmental impacts, particularly on water, biological, and cultural resources. While the recreational components are primarily locally-sponsored, they are part of the overall Va Shly'ay Akimel project, and as such should be incorporated into the analysis of environmental impacts.

Recommendation: The Final EIS (FEIS) should include an analysis of the direct, indirect, and cumulative environmental impacts from all components of the proposed Va Shly'ay project, including the recreational facilities. If there are significant environmental impacts associated with construction and operation of the recreation facilities, appropriate mitigation should be identified.

Water Quality

Stormwater:

The DEIS states that irrigation for the proposed restoration will come from several sources including treated wastewater, agriculture return flows, and stormwater runoff. According to the document, stormwater runoff may contain high concentrations of pollutants during "first flush" events, which could adversely impact water quality and aquatic organisms. The DEIS states that the Corps will mitigate this potential impact by developing a stormwater quality sampling program to measure contaminant levels in stormwater used for irrigation. If concentrations exceed water quality standards, the Corps will identify other water sources or implement improvement measures such as stormwater detention basins. The document does not describe the components of the stormwater quality sampling plan (i.e., what parameters will be measured, when and where will sampling occur, how will results be reported). In addition, the DEIS does not discuss the potential environmental impacts associated with construction of water quality improvement measures such as detention basins.

Section 4.9 Transportation of the FEIS contains a thorough discussion of existing traffic levels and provides Average Daily Traffic (ADT) Volumes and Level of Service (LOS) designations for local roadways and arterial intersections. A discussion of estimated traffic associated with construction and recreational use is provided in Section 5.9 Transportation. Expected vehicle trips associated with recreational use were calculated based on the revised study prepared by the Va Shly' ay Akimel recreation technical committee. Because the majority of recreational use is expected to occur during off-peak commute hours (prime recreation time is defined as weekends and holidays) the project is not expected to adversely affect LOS (peak hour capacity) of any of the surrounding intersections.

The FEIS will include a discussion of potential cumulative impacts related to past and planned community growth as it relates to biological resources and habitat value.

Two copies of the FEIS will be sent to: US EPA, Region IX, 75 Hawthore Street (Mail code CDM-2), San Francisco, CA 94105-3901.

Recommendation: The FEIS should include additional details regarding the stormwater monitoring plan (e.g., water quality parameters, sampling intervals, potential sampling locations). A copy of the proposed stormwater quality sampling plan, if completed, should be included as an appendix. In addition, the FEIS should include a discussion regarding the potential environmental impacts associated with construction of detention basins or treatment swales, and the effectiveness of these measures in removing pollutants of concern.

Agriculture Irrigation Return Flow Water:

The DEIS states that agriculture return flows are of "relatively high quality and are suitable for use as irrigation for restoration plantings." However, the document does not identify or discuss what types of agriculture (e.g., crops, grazing) will be supplying the return flows, and what particular contaminants might be of concern. The quality of the return water is not quantified. Agriculture irrigation return flows, especially in arid regions, often contain high levels of contaminants such as selenium, salts, pesticides, nutrients and sediments. Return flows which have high levels of any of these contaminants might not be suitable for restoration of aquatic ecosystems.

Recommendation: The FEIS should identify the types of agricultural land use from which the project will receive return flows. The document should discuss the types and concentrations of contaminants found in the proposed sources of return flow, and evaluate the impacts on water quality and aquatic resources in the project area. If there are significant concentrations of pollutants in the agriculture return flows, the Corps should develop a water quality monitoring and mitigation plan similar to, or integrated with, the stormwater plan.

1894

Traffic

Section 5.9 of the DEIS addresses the short- and long-term impacts of the project on regional traffic. The DEIS provides estimated recreationist trips (round trips) for winter and summer, and states that no impacts to traffic or circulation are anticipated. However, the document does not put the estimated number of vehicle trips into the context of local and regional traffic. Numerous intersections in the project area operate at level of service "E" and "F" (at or over capacity), and could be further impacted by an increase in recreational users.

Recommendation: The FEIS should discuss how projected vehicle trips compare to current traffic levels (e.g., what percentage of overall projected local traffic is attributed to the proposed project), and whether the project will cause a worsening in the level of service of any surrounding intersections.

Cumulative Impacts

While the DEIS provides a discussion of the cumulative impacts of the proposed project, it appears to limit the scope of that analysis to the four other restoration projects adjacent to Va Shly'ay on the Salt River. The document does not evaluate or discuss the cumulative impacts of other past, present or reasonably foreseeable projects in the study area. There is considerable ongoing and planned community growth (i.e., residential, commercial, and recreational developments) to the north and south of the Va Shly'ay project. The DEIS does not evaluate how the proposed project, in conjunction with these developments, might cumulatively impact resources of concern in the study area. In particular, there could potentially be cumulative impacts (beneficial and adverse) to air and water quality, wildlife, habitat, cultural resources, and traffic.

Recommendation: The FEIS should expand the discussion of cumulative impacts to include other past, present, and reasonably foreseeable projects in the area which might impact the same resources as the Va Shly'ay project. This should include an analysis of cumulative impacts from past and planned community growth surrounding the project area.

1895

SUMMARY OF EPA RATING DEFINITIONS

This rating system was developed as a means to summarize EPA's level of concern with a proposed action. The ratings are a combination of alphabetical categories for evaluation of the environmental impacts of the proposal and numerical categories for evaluation of the adequacy of the EIS.

ENVIRONMENTAL IMPACT OF THE ACTION

"LO" (Lack of Objections)

The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

"EC" (Environmental Concerns)

The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

"EO" (Environmental Objections)

The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

"EU" (Environmentally Unsatisfactory)

The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potentially unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the CEQ.

ADEQUACY OF THE IMPACT STATEMENT

Category 1" (Adequate)

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

"Category 2" (Insufficient Information)

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

"Category 3" (Inadequate)

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

*From EPA Manual 1640, "Policy and Procedures for the Review of Federal Actions Impacting the Environment."

U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

FEMA

May 20, 2004

Ms. Ruth B. Villalobos
Office of the Chief, Planning Division
Environmental Resources Branch
U.S. Army Corps of Engineers
P.O. Box 532711
Los Angeles, CA 90053-2325

Re: Va Shly'ay Akimel Ecosystem Restoration Feasibility Study DEIS

Dear Ms. Villalobos:

This letter addresses impacts to the National Flood Insurance Program in response to your recent request for Agency input with respect to the Draft Environmental Impact Statement (DEIS) for the Va Shly'ay Akimel Ecosystem Restoration Feasibility Study and Salt River restoration project prepared by the Army Corps of Engineers and planned for development within the City of Mesa and Maricopa County, Arizona, as well as on lands of the Salt River Pima-Maricopa Indian Community (SRPMIC).

The City of Mesa and Maricopa County participate in the National Flood Insurance Program (NFIP), and have current Flood Insurance Rate Maps (FIRM) on file and available for review within their respective Engineering and Flood Control Departments. Any development within Mesa and Maricopa County must comply with the requirements of their respective floodplain management ordinances, which regulate development within the high risk Special Flood Hazard Area (SFHA) shown on the current FIRM, and must meet the minimum Federal requirements established in Volume 44 of the Code of Federal Regulations (44CFR). The NFIP floodplain management building requirements are described in Parts 59 through 65 of the Code.

As noted by the mitigation measures identified in Section Eight and in Table ES-1 of your report, there could be significant impacts (if unmitigated) which would change the 100-year water surface elevations for most of the alternatives presented, and a preliminary review of the current FIRM does indicate the likelihood of project encroachment within the SFHA.

Per Section 60.3 (b) of the Code of Federal Regulations, Local and County permits shall be required for all proposed construction and other development located within the SFHA (Zone A on the FIRM); and the final proposal should include base flood elevation data. The Section also describes flood-resistant design criteria and requirements for construction occurring within flood-prone areas.

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MAY 24 2004
PLANNING DIVISION

RESPONSE:

Thank you for your comment. Any development within Mesa and Maricopa County will follow compliance with the requirements of their respective floodplain management ordinances.

Selected NFIP definitions and floodplain management building requirements are summarized as follows:

- A determination of the Base Flood Elevation (BFE) must be performed prior to the start of development and indicated in the Proposal, which should demonstrate what impact the development would have on base flood levels.

- If implementation of the proposed project would result in any change of the existing BFE or floodplain delineation, the requirements for revising the FIRM must be implemented (44CFR § 65.12). These regulations include obtaining a Conditional Letter of Map Revision (CLOMR) from FEMA prior to the start of any development that will cause any rise within a floodway or that will alter or relocate a watercourse. If implementation of the project results in physical changes that increase or decrease the BFE, a request for a final Letter of Map Revision (LOMR) must be submitted within six months of the project's completion. To obtain copies of FEMA's Flood Map Revision Application Packages, please refer to the FEMA website at: http://www.fema.gov/mit/tsd/dl_mt-2.htm.

- The NFIP-participating communities (City of Mesa and Maricopa County) shall notify, in riverine situations, adjacent communities and the Arizona National Flood Insurance Program Coordinating Officer prior to any alteration or relocation of a watercourse, and submit copies of such notifications to the FEMA Administrator; and,

- Assure that the flood-carrying capacity within the altered or relocated portion of any watercourse is maintained.

The full text of Volume 44, Code of Federal Regulations (44CFR) may be found on the Internet at: http://www.fema.gov/nfip/laws1.shtm

Please Note:

Many communities participating in the NFIP have adopted building requirements and regulations that are more restrictive or comprehensive than the minimum federal criteria set forth in CFR No.44 for purposes of floodplain management and regulation of development in the floodplain. Please contact the Maricopa County Principle Floodplain Coordinator at (602) 506-4874 for further information on local permitting requirements.

If you have any questions, or if you need further assistance, you may contact me by telephone at: (510) 627-7036, or by email at: clare.polansky@dhs.gov.

Sincerely,

Clare C. Polansky

Clare C. Polansky
Natural Hazards Program Specialist
National Flood Insurance Program

Cc: Sandra Amaglio, Environmental Officer, FEMA Region IX

Ted Collins
Principle Floodplain Coordinator
Maricopa County Flood Control District
2801 W. Durango
Phoenix, AZ 85009
(602) 506-4874

Gordon Haws
Senior Civil Engineer
City of Mesa
P.O. Box 1466
Mesa, CA 85211-1466

Brian Cosson
Program Specialist, Flood Mitigation, Flood Warning
Arizona Dept. of Water Resources
500 N. Third Street
Phoenix, AZ 85004

Marilyn Ethelbah
Cultural & Environmental Services Office
Salt River Pima-Maricopa Indian Community
10005 E. Osborne Road
Scottsdale, CA 85256

1899

MARTIN H. YOUNG
2601 E Mckellips Rd #2022
Mesa, AZ 85213
(480) 835-7505
[redacted]

April 8, 2004

RE: Salt River Restoration Project

I would like to thank you in advance for listening to my concerns.

I am speaking as a community member and an employee of Salt River Materials Group. After a long absence I have come back to make my home and become apart of this Community.

I gained employment at Salt River Sand & Rock, and felt secure in my future as an employee of a Tribal enterprise, contributing to the prosperity of our Tribe. All of a sudden I'm going thru a merger of Salt River Sand & Rock and Phoenix Cement. Which cast doubt for my future, because of changes that were under way. As I weathered through that storm and was seeing daylight at the end of the tunnel, I was blind-sided by news of the possibility of the Dobson plant as well as others might be shut down due to the restoration project. I have no problems with the project as far as the idea, my mother, aunts and uncles used to tell me stories of the trees, water and fishing along the Salt River when they were young.

I'm worried for my future and that of my family. I have worked at SRMG for seven years and I'm now forty years old. I now have benefits I've never had, such as health insurance, vacation, retirement not to mention a future. I not only enjoy what I'm doing, I also get a sense of contributing not only to the Community but also to society.

It was my understanding that Tribal enterprises were not only to create income for the Tribe but also to create jobs for our Community members as well as native peoples.

Please address what provisions will be made to keep Salt River Community members gainfully employed, without having to start over at entry level jobs with none of the benefits we have worked so many years for.

Sincerely,

Martin H. Young

LEHI PUBLIC MTG 8 APR 04

RESPONSE:

Thank you for your comment. Any loss or gains in employment as a result of the project is the local responsibility.