111th Congress, 1st Session – – – – – – – – – – – – – – House Document 111–14

FINAL FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT RIO SALADO OESTE

COMMUNICATION

FROM

THE DIRECTOR OF CIVIL WORKS, THE DEPARTMENT OF THE ARMY

TRANSMITTING

A STUDY THAT RECOMMENDS AUTHORIZATION OF AN ECOSYSTEM RESTORATION AND RECREATION PROJECT FOR AN EIGHT-MILE REACH OF THE SALT RIVER BETWEEN 19TH AVENUE AND 83RD AVENUE IN PHOENIX, ARIZONA

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

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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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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- 14

Dear Madam Speaker:

House Resolution 2425, dated March 17, 1994, requested the Secretary of the Army to review reports of the Chief of Engineers on the State of Arizona in the interest of flood damage reduction, environmental restoration, and related purposes. As a result of this review, a study has been completed which recommends authorization of an ecosystem restoration and recreation project for an eight-mile reach of the Salt River, between 19th Avenue and 83rd Avenue in Phoenix, Arizona. The proposal is described in the report of the Chief of Engineers dated December 19, 2006, which includes other pertinent reports and documents. The views of other interested agencies are set forth in the enclosed report. The project for environmental restoration for the Salt River (Rio Salado Oeste), Maricopa County, Arizona, was authorized in Section 1001(5) of the Water Resources Development Act of 2007.

The proposed plan includes grading and terracing eight miles of river channel, regrading material in the vicinity of existing gravel pit lakes, constructing a grade control structure at 35th Avenue, modifying eight storm water outfalls, re-establishment of native plants, and a water distribution system to support vegetation. The plan recommended by the Corps of Engineers would restore and improve approximately 1,466 acres of habitat, including 375 acres of cottonwood/willow, 417 acres mesquite, 190 acres of emergent wetlands, and approximately 296 acres of riparian shrub and 52 acres of scrub shrub, as well as 8 miles of restored river channel. This plan would provide for an approximately 50 percent increase in ecosystem function over the expected without project future condition. The recommended plan would restore a significant ecosystem resource along the Pacific Flyway for neo-tropical birds, reconnect wildlife corridors, restore wildlife habitat for species significant to Maricopa County, provide potential habitat for threatened and endangered species, and restore cottonwood/willow riparian forest and mesquite bosque plant communities. Recreation features include multi-use non-motorized trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs.

Based on October 2008 prices, the total first cost of the project is estimated at $184,000,000 with the ecosystem restoration portion estimated at $171,500,000 and the separable recreation features estimated at $12,500,000. 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 $111,500,000 and the non-Federal share would be about $60,000,000. The Federal and non-Federal shares for the separable recreation features, which have a benefit cost ratio of 2.0, would be about $6,250,000 each. The total first cost of the project would be shared at about $117,750,000 Federal and about $66,250,000 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 $4,100,000 annually. The non-Federal sponsor is the City of Phoenix, Arizona."

Should Congress provide funds for this project, the project would 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." 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 12, 2009 to the House Subcommittees on Energy and Water Development, and Water Resources and Environment.

Very truly yours,

John Paul Woodley, Jr.

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

Enclosures

4 Enclosures

1. Record of Decision, Jan 21, 2009
2. OMB Letter Jan 12, 2009
3. Report of the Chief of Engineers Dec 19, 2006
4. Rio Salado Oeste, Salt River, Phoenix, Arizona - Final Feasibility Report and Environmental Impact Statement, September 2006

RECORD OF DECISION
SALT RIVER (RIO SALADO OESTE) ECOSYSTEM RESTORATION
MARICOPA COUNTY, ARIZONA

The Final Feasibility Report and Final Environmental Impact Statement (FR/EIS) for the Salt River (Rio Salado Oeste) ecosystem restoration project, Arizona, dated September 2006, addresses ecosystem restoration and recreation opportunities for the Rio Salado Oeste reach of the Salt River, Maricopa County, Arizona. Based on this review and views of interested agencies and the concerned public, I find the project authorized by Congress in Section 1001(5) of the Water Resources Development Act of 2007 (Public Law 110-114) to be technically feasible, environmentally sound, economically justified, and in the public interest.

The Rio Salado Oeste project provides ecosystem restoration and recreation along eight miles of the Salt River from 19th Avenue to 83rd Avenue. The authorized project includes the following measures:

- Grading and terracing approximately 8 miles of river channel,
- Constructing a grade control structure at 35th Avenue,
- Planting of native riparian vegetation (about 375 acres of cottonwood/willow, 417 acres of mesquite, 296 acres of riparian shrub, and 52 acres of scrub shrub),
- Modifying eight storm water outfalls to harvest available runoff,
- Installing a water supply and distribution system, including a supply well, pump station, open channel canals, and pressurized distribution piping,
- Constructing maintenance roads and ramps for safety and river access,
- Removing invasive species on about 120 acres and controlling invasive species on about 830 acres,
- Regrading of approximately 3 million cubic yards of material in the vicinity of existing gravel pits lakes to produce emergent wetlands, and,
- Constructing recreation facilities consisting of approximately 16 miles of multi-use non-motorized trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs.

A total of nineteen alternatives were screened down to a final array of five alternative plans plus the no-action alternative. Alternative 2, and all the remaining alternatives, provided for channel modifications to maximize stormwater retention for habitat use. Alternative 4 added active restoration of cottonwood and mesquite and emergent habitat, as well as active management to control invasive species. Alternative 5 included all of the above plus the development of two existing gravel pits into lakes. Alternative 5A, the selected and authorized plan, was similar to Alternative 5 except that it included filling the pits to restore them to emergent wetland and riparian areas. Alternative 5B combined Alternatives 5 and 5A to develop one gravel pit into a lake and the other pit into an emergent wetland/riparian area. The alternative plans were evaluated using functional assessment, cost effectiveness, and incremental analysis techniques and Alternative 5A was determined to achieve ecosystem function increases in the most cost effective manner. It is the preferred alternative of the local sponsor, the City of Phoenix, and also the National Ecosystem Restoration plan, the least environmentally damaging practicable alternative, and the environmentally preferable alternative. All of the alternatives are fully discussed in the FR/EIS.

Encl 1

All practicable means to avoid or minimize adverse environmental effects have been incorporated into the authorized 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. The plan includes provision for monitoring and adaptive management for the first 5 years of operation and maintenance so as to assure success of the project.

The recommended and authorized ecosystem restoration plan complies with applicable environmental requirements. Recommendations made by the U.S. Fish and Wildlife Service and the Arizona Game and Fish Department have been incorporated into the plan. Consultation under Section 7 of the Endangered Species Act resulted in determinations that the proposed action may affect, but not likely adversely affect the Bald Eagle, Yuma clapper rail and Southwestern willow flycatcher. The proposed action will have no effect on the Cactus ferruginous pygmy-owl, Lesser long-nosed bat, California brown pelican, Mexican spotted owl, Sonoran pronghorn antelope, Desert pupfish, Razorback sucker, Gila topminnow, Gila chub, Arizona agave, and Arizona cliffrose. Coordination with the Arizona State Historic Preservation Office pursuant to the National Historic Preservation Act has been accomplished and, in accordance with the Act, 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 will be detailed in a Memorandum of Agreement between the Corps of Engineers, Arizona State Historic Preservation Officer, and the City of Phoenix. Compliance of the Clean Air Act will be met through mitigation measures that reduce emissions and limit potential nuisance effects from dust to a less-than-significant levels. Impacts associated with social equity or environmental justice are not anticipated so the project is in compliance with, Executive Order 12898, Environmental Justice. As of the date of this Record of Decision the project has not met the requirements for a Clean Water Act Section 404(r) waiver of State Water Quality certification. Therefore, full compliance with the Clean Water Act will be accomplished prior to execution of a project partnership agreement and initiation of construction.

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 overall benefits gained by this ecosystem restoration project 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

January 12, 2009

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 Corps of Engineers for the ecosystem restoration and recreation project for the Salt River (Rio Salado Oeste), 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

ENCL 2

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET NW
WASHINGTON, D.C. 20314-1000

DEC 1 9 2006

CEMP-SPD (1105-2-10a)

SUBJECT: Salt River (Rio Salado Oeste), Phoenix, Maricopa County, Arizona

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the study of ecosystem restoration, flood damage reduction, and recreation opportunities on the Salt River, Rio Salado Oeste in Phoenix, AZ. It is accompanied by the report of the District and Division Engineers. These reports are in partial response to Public Law 761, 75th Congress (Section 6 of the Flood Control Act of 1938) and a resolution adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives on 17 May 1994 (HR 2425). 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 continue.

2. The reporting officers recommend a plan for ecosystem restoration and recreation for an 8-mile reach of the Salt River in Phoenix, Arizona (Maricopa County), between 19th Avenue and 83rd Avenue. The recommended plan includes the following measures:

- Grading and terracing eight miles of river channel,
- Constructing a grade control structure at 35th Avenue,
- Planting of riparian vegetation (375 acres of cottonwood/willow, 417 acres of mesquite, 296 acres of riparian shrub, and 52 acres of scrub shrub),
- Modifying eight storm water outfalls to harvest available runoff,
- Installing a water supply and distribution system, including a supply well, pump station, open channel canals, and pressurized distribution piping,
- Constructing maintenance roads and ramps for safety and river access,
- Invasive species removal on about 120 acres and invasive species control on about 830 acres,
- Regrading of approximately 3 million cubic yards of material in the vicinity of existing gravel pits lakes to produce emergent wetlands, and
- Constructing a recreation plan consisting of approximately sixteen miles of multi-use non-motorized trails, pedestrian bridges, parking lots, comfort stations, and interpretive signs.

EXCL 3

3. In Arizona, over ninety percent of riparian areas have been lost due to impacts from historical settlement and urbanization. Restoration of these areas is significant because riparian areas in the Southwest represent only one percent of the landscape yet contribute to the survival of seventy-five to ninety percent of wildlife in the arid West. The recommended plan would restore a significant ecosystem resource along the Pacific Flyway for neo-tropical birds, reconnect wildlife corridors, and restore wildlife habitat for species significant to Arizona. To insure recommendation of an efficient plan, the alternative environmental restoration plans were evaluated using functional assessment, cost effectiveness, and incremental analysis techniques. The recommended plan is the National Ecosystem Restoration Plan and is the plan that is locally preferred. The recommended plan would restore and improve approximately 1,466 acres of habitat, including 375 acres of cottonwood/willow, 417 acres mesquite, 190 acres of emergent wetlands, and approximately 296 acres of riparian shrub and 52 acres of scrub shrub, as well as 8 miles of restored river channel. The cost of the recommended environmental restoration features are justified by an increase of about 267 average annual functional capacity units over the no action alternative, and provides for achieving ecosystem function increases in the most cost effective manner. Based on a total ecosystem restoration cost of $153,770,000, the cost per acre of restoration is about $104,900. The annual cost per average annual functional capacity unit is about $45,300.

4. Based on October 2005 price levels the estimated first cost of the recommended plan is $164,950,000. In accordance with the cost sharing provisions of the Water Resources Development Act (WRDA) of 1986, as amended, the estimated Federal share of the total project cost would be approximately $105,540,000 and the estimated non-Federal share would be approximately $59,410,000. The estimated total first cost of the ecosystem restoration portion of the recommended plan is $153,770,000, which is cost shared 65 percent Federal and 35 percent non-Federal, has an estimated Federal cost of $99,950,000 and an estimated non-Federal cost of $53,820,000. The estimated total first cost of the recommended plan includes approximately $3,760,000 for five (5) years of monitoring and adaptive management necessary to ensure success of the project. Additionally, the estimated total first cost of the recommended plan incorporates recreation features, including multipurpose trails, comfort stations, benches, parking, interpretive signage, and trails. These recreation features have an estimated first cost of $11,180,000, which would be shared 50 percent Federal and 50 percent non-Federal, at about $5,590,000 each. The total estimated annual operation and maintenance costs for the project, which are the responsibility of the non-Federal sponsor, are estimated to be $2,880,000. The non-Federal sponsor is also responsible for an associated water cost of $817,000 annually.

5. The reporting officers further recommend that the plan recommended herein be exempt from section 401 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 first five *years of the operation and maintenance phase of the project, as described in the feasibility* report and environmental impact statement.

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SUBJECT: Salt River (Rio Salado Oeste), Phoenix, Maricopa County, Arizona

6. Washington level review indicates that the project is technically sound, environmentally acceptable, and economically justified. The plan conforms with essential elements of the U.S. Water Resources Counsel's Economic and Environmental Principles for Water and Related Land Resources Implementation studies and complies with other administration and legislative policies and guidelines. Also, the views of interested parties, including Federal, State, and local agencies have been considered.

7. I concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the Salt River, Rio Salado Oeste, Maricopa County-Phoenix, Arizona, Project be constructed in accordance with the reporting officers' recommended plan. My recommendation is subject to cost sharing and financing and other applicable requirements of Federal and State laws and policies, including WRDA 1986, as amended by WRDA 1996.

8. Federal implementation of the authorized project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide 35 percent of the total project costs allocated to environmental restoration and 50 percent of the total 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. Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features, without cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and 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 the Flood Control Act of 1970, Public Law 91-611, as amended, 42 U.S.C. 1962d-5b, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, 33 U.S.C. 2213, which provide 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. Agree that, as between the Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, 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 obstructions of, or encroachments on, the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the level of protection it affords, hinder its operation and maintenance, or interfere with its proposed function, such as any new developments on project lands or addition of facilities which would degrade the benefits 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, 42 U.S.C. 4601-4655, 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.

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SUBJECT: Salt River (Rio Salado Oeste), Phoenix, Maricopa County, Arizona

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.

9. 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, nor 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 sponsor, 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, U.S. Army
Chief of Engineers

NOTICE

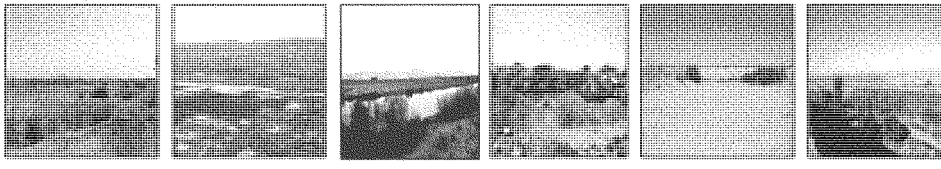
SALT RIVER (OESTE), AZ

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 2

Final Feasibility Report and Environmental Impact Statement

Rio Salado Oeste



Salt River-Phoenix, Arizona

Prepared by:

US Army Corps of Engineers

Los Angeles District

South Pacific Division

City of Phoenix

September 2006

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 Rio Salado Oeste, Salt River study area in Phoenix, 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. Today, the study area consists of a highly disturbed riverbed with minimal extant native vegetation.

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. It 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 implement able solution that best meets the planning objectives of a comprehensive ecosystem restoration through the study area.

This study effort is a joint partnership of the City of Phoenix and the Corps of Engineers, Los Angeles District. A wide variety of management measures were identified for use in developing full-scale alternatives.

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 5A is the plan that reasonably maximizes net ecosystem restoration benefits by having the maximum amount of restoration benefits compared to costs. Therefore, Alternative 5A 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 $164,950,295 ($153,776,850 for ecosystem restoration and $11,173,445 for recreation). Based on the requirements of WRDA 1986, cost-sharing for ecosystem restoration features including all lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) would be 65 percent Federal and 35 percent non-Federal. Cost sharing for the recreation plan 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. Thus, the Federal share is currently estimated at $105,541,675 ($ 99,954,952.50 for ecosystem restoration and $5,586,722.50 for recreation). The cost for all operations and maintenance would be the responsibility of the non-Federal sponsor. Annual operation and maintenance for the ecosystem restoration project and recreation is currently estimated at $2,083,000 and $800,000 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 $817,000 annually.

The recommended plan provides a habitat value of 847 AAFCU's, or an increase in 267 AAFCU's over without-project conditions. This is a 46 percent increase with project 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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LIST OF ACRONYMS

AAFCU	Average Annual Functional Capacity Units
ac-ft	acre-feet
ADMP	Area Drainage Master Plan
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game & Fish Department
AGR	Annual Growth Rate
AMA	Active Management Area
APE	Area of Potential Effects
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CERCLIS	Comprehensive Environmental Response, Compensation, and Information System
CE	Cost Effectiveness
City	City of Phoenix
c.y.	cubic yards
DDT	dichlorodiphenyltrichloroethane
DRCC	Durango Regional Conveyance Channel
EAD	Equivalent Annual Damages
EDC	Engineering During Construction
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQ	Environmental Quality
ER	Engineering Regulation

ERDC	Engineering Research and Development Center
ERNS	Emergency Response and Notification System
ESA	Environmental Site Assessment
FAA	Federal Aviation Administration
FCD	Flood Control District
FCI	Functional Capacity Index
FCSA	Feasibility Cost Sharing Agreement
FCU	Functional Capacity Unit
FCDMC	Flood Control District of Maricopa County
FEMA	Federal Emergency Management Agency
ft	Feet
ft/ft	Feet vertical drop per lineal feet
HGM	Hydrogeomorphic Modeling
HR	House Resolution
HTRW	Hazardous, Toxic, and Radioactive Wastes
IDC	Interest During Construction
ICA	Incremental Cost Analysis
LERRD	Lands, Easements, Rights-of-way, Relocations, and Disposal Areas
LPP	Locally Preferred Plan
LUST	Leaking Underground Storage Tank
MAG	Maricopa County Association of Governments
mgd	million gallons per day
MNA	Museum of Northern Arizona
NED	National Economic Development
NER	National Ecosystem Restoration

NPDES	National Pollution Discharge Elimination System
NPL	
NRPA	National Recreation & Parks Association
O&M	Operations and Maintenance
OMRR&R	Operation, Maintenance, Repair, Replacement, and Rehabilitation
OHV	off-road vehicle
OSE	Other Social Effects
P&G	Planning and Guidance
PCA	Project Cooperation Agreement
PED	Pre-Construction Engineering and Design
PWAA	Partial Wetland Assessment Area
RBA	Risk-based Analysis
RCRA	Resource Conservation and Recovery Act
RED	Regional Economic Development
RM	River Mile
S&A	Supervision and Administration
SHPO	State Historic Preservation Office
SR101	State Route 101, Pima Freeway
SROG	Multi-City Sub-regional Operating Group
SRP	Salt River Project
SWPPP	Storm water Pollution Prevention Plan
TDS	total dissolved solids
TIN	Triangular Irregular Network
UAU	Upper Alluvial Unit
URS	URS Corporation

USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WRDA	Water Resources Development Act
WWTP	Wastewater Treatment Plant
yr	Year

CHAPTER I
STUDY AUTHORITY

This report was prepared as an interim response to the following authorities provided by Congress. It presents the findings of a feasibility study of the Rio Salado Oeste, Salt River, Arizona. The Salt River is a significant tributary to the Gila River in the State of Arizona (Figure I-1).

- The first authority is given by Section 6 of Public Law 761, dated June 28, 1938, known as the Flood Control Act of 1938, which reads in part as follows:

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

- The second and most recent authority is provided by a Resolution of the Committee on Public Works and Transportation, U.S. House of Representatives, adopted May 17, 1994 (Docket 2425) (Figure I-2) which states:

  "*...the Secretary of the Army is requested to review the 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 Energy and Water Appropriations Act, 2000, Public Law 106-60 appropriated funds for investigations of civil works project prior to construction. A reconnaissance level review of the Salt River (Rio Salado Oeste) was conducted under that authorization. The results and conclusions of the reconnaissance phase were presented in the *Rio Salado Oeste, Salt River, Phoenix Arizona Section 905(b) Report September 2000.* The recommendation of this report was that there was a Federal interest in proceeding to a second, feasibility phase of the General Investigation. The Corps of Engineers Headquarters certified the reconnaissance report on November 8, 2000, giving the Los Angeles District authority to move into the feasibility phase.

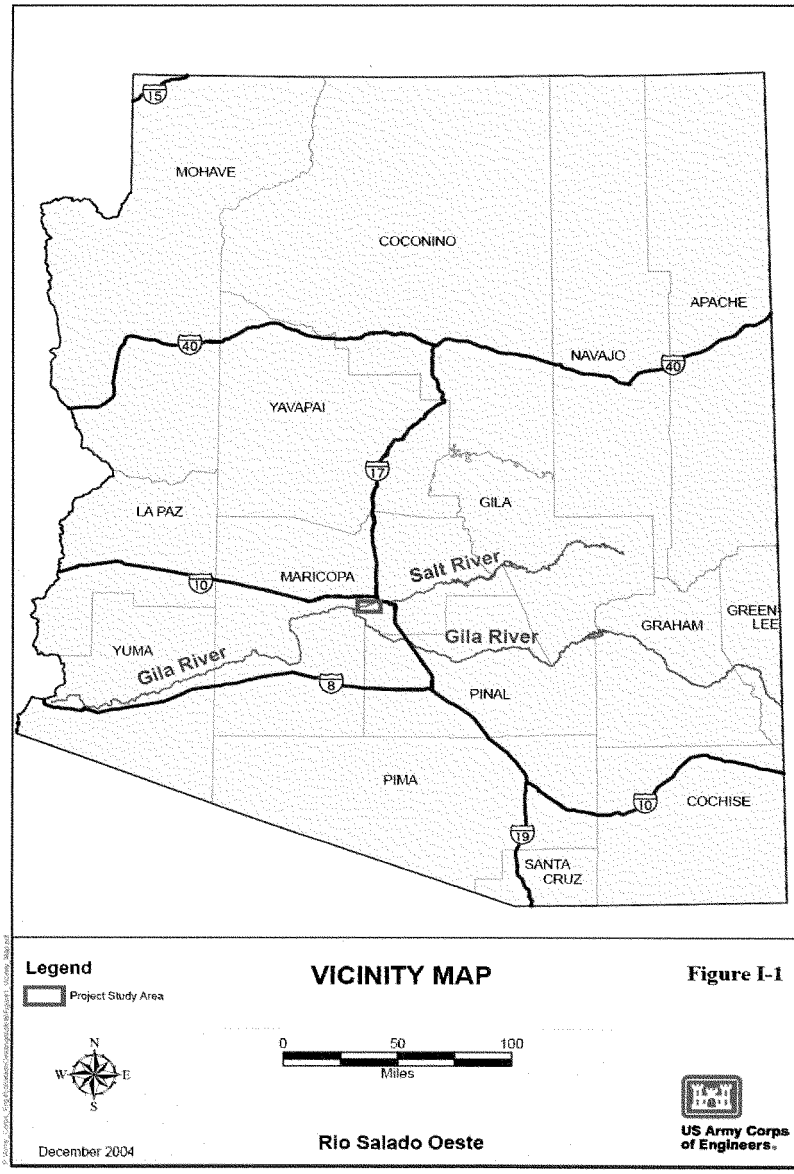

MOHAVE
COCONINO
APACHE
NAVAJO
YAVAPAI
LA PAZ
GILA
MARICOPA
Salt River
Gila River
YUMA
Gila River
GRAHAM
GREEN-LEE
PINAL
PIMA
COCHISE
SANTA CRUZ
15
40
40
17
10
8
10
19
Legend
Project Study Area
VICINITY MAP
Figure I-1
N
W
E
S
0
50
100
Miles
December 2004
Rio Salado Oeste
US Army Corps of Engineers

Figure I-2: HR 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 Rio Salado Oeste Study is being conducted by the U.S. Army Corps of Engineers (USACE), Los Angeles District and the City of Phoenix, with the cooperation of the Flood Control District of Maricopa County (FCDMC). The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix. This study is to identify feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as the non-Federal sponsor, supports the proposed project purpose to provide flood damage reduction, 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, for each alternative, what is expected to happen if that 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 between alternatives.

Alternative plans are being developed and evaluated to meet the objectives stated above. 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

- 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 City of Phoenix 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 groundwater 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 and effluent discharge.

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. The Nature Conservancy lists desert riparian woodland as a very rare although significantly important cover type and describes restoration of riparian systems in the Sonoran Desert as critical. (Marshall et al 2000).

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 populations 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 is land available for restoration. As long as these conditions remain unchanged, there is 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 region. In addition to restoration there are opportunities to reduce future flood damages and improve recreation opportunities associated with the restored floodplain.

2.3 STUDY AREA

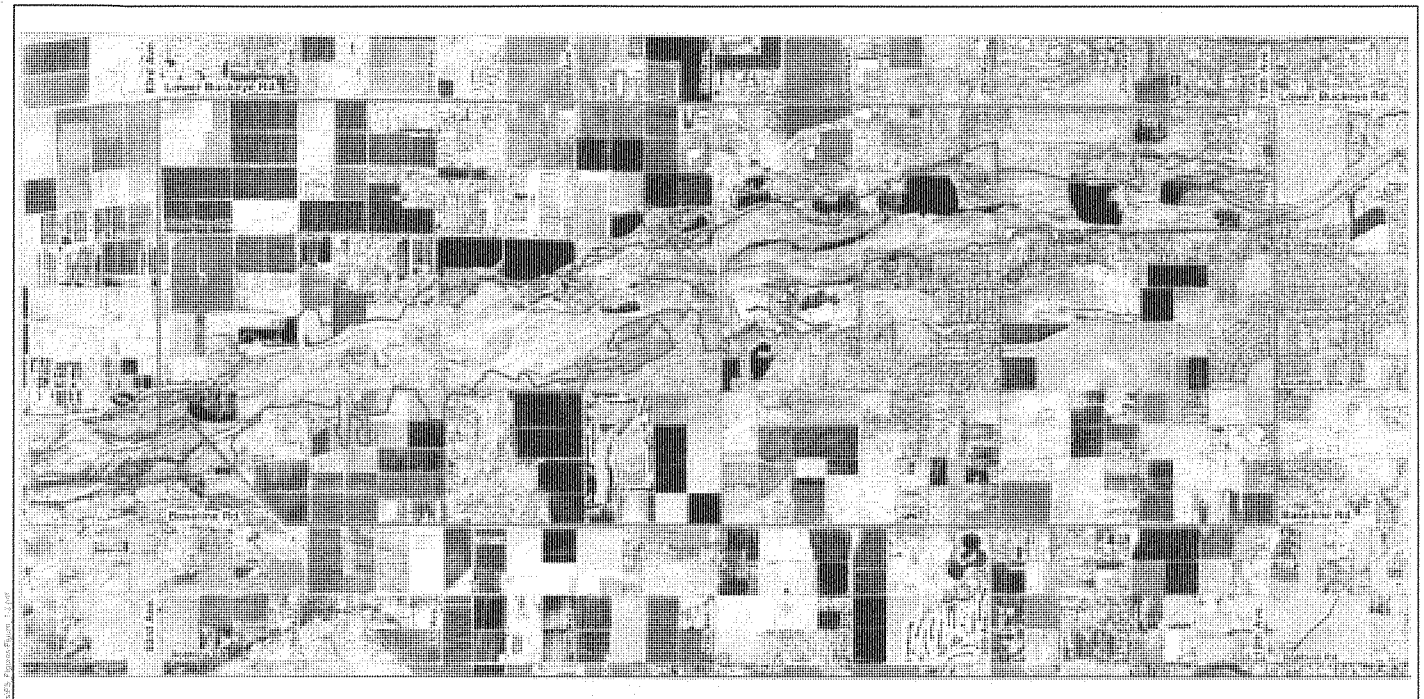
The study area is geographically located in Maricopa County, Arizona, and is entirely within the City of Phoenix (see Figure I-1). The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west, and from Lower Buckeye Road on the north to approximately Baseline Road on the south. While this is a large study area extending beyond the riverbanks, any implementation of project features would be associated with the river floodplain. Alternatives considered within the study are all within that implementation area. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west, and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4 miles wide and consists of approximately 20,480 acres. The project implementation area is, on average, approximately 1 mile wide and consists of approximately 3,315 acres. Figure II-1 displays the study area and project implementation areas.

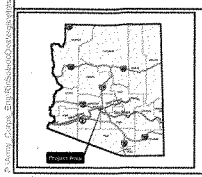
The Rio Salado Oeste Project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction. The projects are being conducted by the Corps and various local sponsors along the Salt River, downstream of Granite Reef Dam. Figure III-1 depicts the locations of these projects with respect to the Rio Salado Oeste Project. Additional description of those projects will follow in Chapter III.

2.4 HISTORY OF THE INVESTIGATION

In response to the study authority, the reconnaissance phase of the study was completed in 2000. This reconnaissance phase resulted in the finding that there was a Federal interest in continuing

to a feasibility phase. The Feasibility Cost Share Agreement (FCSA) with the City of Phoenix was signed in June 2001 and the feasibility phase was initiated.





Legend

Project Study Area

Project Implementation Area

March 2006

PROJECT STUDY AREA AND PROJECT IMPLEMENTATION AREA

Rio Salado Oeste

0 5,000 10,000

Feet

US Army Corps of Engineers.

Figure I1-1

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. 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. 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 VI)

The final product of this feasibility study is a Feasibility Report and 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 Corps 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.

2.5.1 Environmental Operating Principles

The Corps of Engineers has reaffirmed its commitment to the environment by formalizing a set of "Environmental Operating Principles" applicable to all its decision-making and programs. These principles foster unity of purpose on environmental issues, reflect a new tone and direction for dialogue on environmental matters, and ensure that employees consider conservation, environmental preservation, and restoration in all Corps activities. By implementing these principles, the Corps will continue its efforts to develop the scientific, economic, and sociological measures to judge the effects of its projects on the environment and to seek better ways of achieving environmentally sustainable solutions. The principles are described in Engineering Circular 1105-2-404, "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003.

- Achieve Environmental Sustainability. An environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.
- Consider Environmental Consequences. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
- Seek Balance and Synergy. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- Accept Responsibility. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that affect human health and welfare and the continued viability of natural systems.

- Mitigate Effects. Seek ways and means to assess and mitigate cumulative effects to the environment; bring systems approaches to the full life cycle of our processes and work.
- Understand the Environment. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and effects of our work.
- Respect Other Views. Respect views of individuals and groups interested in Corps activities; actively listen, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems, solutions that also protect and enhance the environment.

CHAPTER III
PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

The Resolution of the Committee on Public Works and Transportation adopted May 17, 1994 (Figure I-2) requested review of 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." Although six specific reports are listed none are relevant to this study area, those include:

- House Document 331, 81st Congress. Gila River and Tributaries Below Gillespie Dam, Ariz.
- Senate Document 116, 87th Congress. Gila River and Tributaries in the Vicinity of Tucson, Arizona.
- Senate Document 127, 87th Congress. Gila River, Arizona, Camelback Reservoir
- House Document 625, 78th Congress. Bill Williams River and Tributaries, Arizona
- House Document 648, 78th Congress. Little Colorado River, Arizona and New Mexico.
- Senate Document 63, 88th Congress. Little Colorado River, Winslow, Arizona.

Other pertinent reports, however, are described below. 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, and identifies existing projects and structures located within the area.

3.1 PRIOR STUDIES AND REPORTS

The Salt River has been extensively utilized for irrigation since prehistoric times. In the 1800s, settlers reestablished many historical irrigation canals. Since then, the Phoenix metropolitan area has established itself around the river. The Salt River has presented many opportunities and challenges, and has been studied extensively.

Various agencies and engineering consulting firms have conducted or published over 50 studies and reports on the Salt River since 1980. The topics of the reports or studies include water resources, flood control, recreation and urban development, and environmental assessment. A sample of the prior studies and reports is presented by topic below, and in effect provide a history of water resources studies in the area. The findings in these reports and the chronology of change within the Salt River corridor are important and essential in describing the changes over time and in outlining the importance of this project.

3.1.1 Water Resources Studies or Reports

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

In 1978, the Corps of Engineers 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 related to flood control, wastewater, floodwater conservation, and fish and wildlife recreation. The study focused especially on the 16-mile reach between 27th Avenue in Phoenix and Country Club Drive in Mesa.

In 1981, the Corps of Engineers investigated water and related land resources issues in the Phoenix Metropolitan area, including issues of water quality, flood control, water conservation, and fish and wildlife enhancement. At that time, none of the projects proposed by local agencies were found to warrant Federal interest, with the exception of flood control along the Salt and Gila Rivers.

The 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 tax authority for the District. However, the District did conduct several studies. A published memorandum in 1982 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 control options for a regional redevelopment of the Salt River. Sources for domestic water include obtaining Central Arizona Project (CAP) allotment, and obtaining water rights from surface and groundwater from lands within the district. The source identified for aesthetic and recreational water was poor-quality groundwater. Flood management plans were based on an existing condition scenario and on an upstream flood control design condition.

Carr, Lynch Associates, a private engineering consulting firm, also conducted a study in 1982, which evaluated the potential water sources and flood control 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, and water supply and flood control.

In 1992, the Corps of Engineers completed the *Central Maricopa County Reconnaissance Study*. This study describes and analyzes 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, these problems. Twenty-three flooding problems were identified within Central Maricopa County. Two areas determined to be of Federal interest were a flood control project on the Dysart Drain near Luke Air Force Base, and a water quality and environmental restoration project on the Salt River near 91st Avenue. That project (Tres Rios) was not recommended to proceed 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, Maricopa County Parks and Recreation, FCDMC, and the U.S. Environmental Protection Agency (EPA). The study evaluates methods for reclaiming water from sewage effluent from the 91st Avenue Regional Wastewater Treatment Plant (WWTP) and develops plans for using the reclaimed water directly or through exchange mechanisms. The 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 completed a geomorphic assessment of the Salt River for the Corps. The assessment supports a reconnaissance-level geomorphologic evaluation of the Lower Salt River and a portion of the Gila River. The study discusses environmental history, hydrologic system, geomorphic system, and engineering features of the Salt River.

The City of Phoenix completed a report in 1994 that summarizes resulting problems and issues that are part of the setting of the present river as it passes through the city. The report includes resources and activities that will be the basis of the area's restoration.

In 1995, the Corps completed the reconnaissance phase of the Rio Salado, Salt River, Arizona Project. The report included an assessment of the problems and opportunities and an evaluation of alternatives for a 33-mile portion of the Salt River. A preliminary environmental assessment and a detailed habitat evaluation of the study reach were included.

In April 1998, the Corps completed the feasibility report and EIS for the Rio Salado, Salt River, Arizona Project. The report identified plans that would provide environmental restoration benefits and serve the public interest. The project is currently in the final phase of construction with anticipated completion in 2006/2007.

In April 2000, the Corps completed a feasibility report and EIS for the Tres Rios, Arizona Project. The study examined a portion of the Salt River and Gila River from 83rd Avenue downstream to the Agua Fria River, and selected a plan that includes environmental restoration and flood control components. The project is currently in the design phase.

3.1.2 Flood Control Studies or Reports

In 1981, the Corps prepared a document as a result of severe flooding along the Salt and Gila Rivers. The flood damage reduction measures presented include discussion on flood proofing, relocation, floodplain regulations, preparedness planning, channel excavation, and evaluation of hydraulic structures.

In 1989, Simons, Li & Associates, Inc., a private engineering consulting firm, prepared a report on the channelization of the Salt River through Tempe, Arizona. The study addresses issues related to channel design, determines appropriate hydraulic design criteria, and presents several alternative design concepts. The engineering analysis includes the evaluation of alternative river

sections, alignments, and profiles. In addition, the study identifies potential impacts due to the proposed changes.

The Corps of Engineers completed the Salt-Gila Reconnaissance Report in 1989. The study focuses on the flooding problems and associated solutions downstream from the confluence of the Verde and Salt Rivers to Gillispie Dam. It was determined that no analyzed solution was economically justified; therefore, the study did not proceed to the feasibility phase.

In 1994, the Corps 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 and 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 there was no Federal interest in participating in installation of bank stabilization at this location. With Federal Emergency Management Agency (FEMA) funding, the Salt River Pima-Maricopa Indian Community initiated construction of bank stabilization of two of the landfill sites, which were studied.

The FCDMC completed a land use and structures inventory in 1994. The inventory was published in a report that listed the various structures, utilities, and land use conditions along the Salt and Gila Rivers from Granite Reef Dam to Gillespie Dam.

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

The 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. The plan addresses much of the land to the north of the project area and the potential for flooding problems due to interior drainage (http://www.fcd.maricopa.gov/Projects/DurangoADMP/).

The FCDMC has also completed the Laveen ADMP. The study area is in the southwestern portion of the metropolitan Phoenix area within Maricopa County, Arizona, and comprises 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 Community 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. (http://www.laveenadmp.com/)

3.1.3 Recreation and Urban Development Studies or Reports

In 1983, the Rio Salado Development District completed an economic analysis of the impacts that a redeveloped Salt River would have on the economy of metropolitan Phoenix. The study quantifies, on an annual basis, new public dollar revenues derived from increased property and sales tax revenues and income generated by a redevelopment project from the sale and/or lease of publicly owned land in the project area. Conclusions from this study indicated that over a fifty-year period, redevelopment of the Salt River corridor would provide $7.6 billion in public revenues and $2.4 billion in private benefits to the metropolitan region and the State of Arizona.

In 1985, Carr, Lynch Associates 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, development of its banks, and cultural and educational uses. This master plan was never implemented.

In 1989, the City of Phoenix completed the South Village Redevelopment Plan. The plan established that redevelopment activities in this area of Phoenix must begin with rehabilitation and redevelopment of the Salt River as it passes through Phoenix.

In 1991, the City of Phoenix Planning Department completed an estimate of what the City would be like in the year 2015. The estimate included discussion of the future role of the Salt River.

In 1994, the City of Phoenix conducted an economic analysis that included a listing of development activities necessary to initiate and sustain economic development within the Salt River area of Phoenix. The analysis determined that the key to redevelopment outside of the river corridor was redevelopment of the river itself.

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.

The Rio Salado Beyond the Banks Area Plan was completed by the City of Phoenix and became effective December 17, 2003. The plan is a policy document for future investment in and revitalization of the area. The plan boundaries are Interstate 17/Interstate 10 (I-17/I-10) freeways on the north, Broadway Road on the south, 19th Avenue on the west, and 32nd Street on the east. The area is being revitalized to realize its full potential from its proximity to Rio Salado, Downtown Phoenix, Sky Harbor International Airport, other job centers, and regional transportation linkages. It connects to the restored Rio Salado as an attractive recreational and environmental amenity; provides an attractive mix of land uses abutting the Rio Salado; builds on existing neighborhoods, area history, and cultural identity; provides infill housing to support seven city employment centers; employs a growing and increasingly skilled workforce; and creates a vibrant place that attracts area residents and visitors to a wide variety of recreational, environmental, and commercial activities

The Estrella Planning Area land use plan (Maricopa County, 1992a) regulates planning and development activities within its jurisdiction of unincorporated Maricopa County. Within the study area, this includes the land uses extending north from and including the Salt River. There are also islands of land incorporated within the city throughout portions of the Estrella Planning Area. The Estrella Planning Area is currently very rural in character and is an island of farming activity surrounded by more urban-type development. The area along the north of the Salt River is occupied by agricultural, agribusiness, gravel mining, and vacant land uses, with isolated industrial and residential development.

The Laveen Planning Area land use plan (Maricopa County, 1992b) regulates planning and development activities for approximately 30 square miles of unincorporated Maricopa County south of the banks of the Salt River. The area is generally characterized by rural ranchettes, cultivated farmland, and dairy farms, with a small urban area within the city in the northeastern portion of the planning area. The area, along the south banks of the Salt River, is currently vacant, with a minor amount of developed land and agricultural land uses nearby. Currently, industrial development and a considerable number of auto-wrecking and salvage operations are located in the northeast quadrant closest to the City boundaries (primarily along Broadway) and have had an influence on development in the area. The properties in the area are zoned for Rural Residential, Industrial, and Special Use.

The City of Phoenix General Plan (City of Phoenix, 2001) regulates planning and development activities within incorporated areas of the city in the vicinity of the study area. Additionally, the General Plan considers areas currently outside the jurisdictional political boundaries (unincorporated county lands) for potential future annexation. Through goals, policies and recommendations, the General Plan provides a short- (within the next 10 years) and long-range (10 to 20 years) comprehensive direction for the growth, conservation, and redevelopment of all physical aspects of the city.

As part of the strategic growth concepts adopted by the City of Phoenix, the Estrella and Laveen areas are two of the major target growth areas identified in the General Plan, and are within the study area. The Rio Montana Plan (2000), prepared for the eastern portion of Laveen, identifies "encouraging development and redevelopment along the Rio Salado that will be compatible with the Rio Salado Habitat Restoration Project" as one of the major issues that is unique to the area. Additionally, the Estrella Plan (1999) identifies "encouraging development along the Rio Salado that will be compatible with the new residential character village" as one of the major issues that is unique within the area (City of Phoenix, 2001).

The City of Phoenix recently completed the Rio Salado Pathway feasibility study evaluating the linkage between 28th Street in Phoenix and Priest Drive in Tempe. The pathway is an accessible, shared-use path on the south bank of the river along the 4-mile stretch adjacent to Phoenix Sky Harbor Airport. The long-term vision is of an established linear park that would provide connectivity between various projects on the river corridor.

3.1.4 Environmental Assessment Studies or Reports

In 1987, Dames & Moore, a private engineering consulting firm, completed an investigation of the waste sites within the Salt River bed. The study was performed for the Rio Salado Development District. The study area extended completely through the Phoenix metropolitan area. The study recommends a plan for the complete investigation and remediation of waste sites and provides an order-of-magnitude cost estimate for the implementation of the plan. Sixty-three landfills or dumpsites were identified. The projected costs for investigation and remediation of waste sites range from $49,500,000 to $90,800,000.

In 1994, as a part of the Rio Salado Reconnaissance Study, the Corps of Engineers completed an environmental evaluation. The evaluation presents a brief synthesis of present conditions, active and passive location of landfill sites, potential mitigation of upper aquifer contamination, preservation and/or reconstruction of ecological habitats, and potential opportunities for water resources recreation based on demand and economic feasibility. The study area covered 33 miles of the Salt River through the metropolitan Phoenix area. Included in the evaluation was a field reconnaissance conducted to determine the present habitat values of the vegetation within the Salt River. A total of 29 sites were assessed during the field study.

In 1998, the Corps of Engineers completed an EIS for the Rio Salado Environmental Restoration Project. The EIS and feasibility report were prepared for an ongoing project on the Salt River immediately upstream from the study area.

In 2000, the Corps of Engineers prepared an EIS for the Tres Rios Feasibility Study, another ongoing project on the Salt River. The EIS evaluated the effects of a proposed environmental restoration and flood control project immediately downstream on the Salt River.

In 1997, CH2MHILL prepared the "Salt-Gila River Baseline Ecological Characterization" for the City of Phoenix in their effort to implement a full-scale constructed treatment wetland system at the 91st Avenue WWTP. The characterization includes information for the Salt River area between 75th Avenue to the east and Buckeye Diversion Dam to the west.

3.1.5 Studies/Projects Currently Underway

3.1.5.1 South Mountain Corridor Study

The Arizona Department of Transportation (ADOT) is currently conducting the South Mountain Corridor Study (http://www.dot.state.az.us/ROADS/SouthMtn). The South Mountain Freeway was included in the Regional Freeway System Plan that was approved by Maricopa County voters in 1985. The EIS will first consider whether there is a purpose and need for a project, and if so, will examine the potential social, economic, and environmental impacts of each reasonable alternative, along with ways to lessen those impacts. Currently, several alternatives have been advanced for further study. Several remaining alternatives include crossing the river and project area somewhere between 59th and 91st Avenues. It is assumed that there is potential for a future freeway to cross the project area at some point in the future but that crossing should not adversely affect the Rio Salado Oeste Project. Construction funding for the project is included in the Regional Transportation Plan for 2009-2015.

3.1.5.2 Va Shly'ay Akimel Salt River Feasibility Study

USACE is currently partnering with the Salt River Maricopa Indian Community and City of Mesa in a feasibility study upstream on the Salt River. The study area encompasses a 14-mile reach of the Salt River extending from immediately downstream of the Granite Reef Dam to the Pima Freeway State Route 101 (SR101). The study efforts are directed toward improving and increasing fish and wildlife habitat values and diversity for threatened and endangered species with potential incidental benefits associated with flood damage reduction, recreation, and water quality and supply. The feasibility study was completed in late 2004 and the Chief's Report was submitted in January 2005. A design agreement and plan are being developed and design on the project is expected to begin in 2006.

3.1.5.3 35th Avenue Bridge Improvements

The City of Phoenix has designed and is planning improvements to the 35th Avenue Bridge crossing the Salt River within the study area. The purpose is to improve the safety and operation of traffic along 35th Avenue between Broadway Road and Lower Buckeye Road and to provide an all-weather crossing over the Salt River. The existing 35th Avenue Bridge across the Salt

River was built in 1983 as an emergency repair project to replace a bridge that was washed out by flooding. It was built as a half-bridge and designed to accommodate the 35-year flow event, and was planned to be widened and lengthened in the future.

Currently a design for widening is in progress. The proposed work includes construction of a new 5-lane, 8-pier, 9-span precast concrete I-girder bridge with cast-in-place concrete deck slab to replace the existing two-lane bridge. The bridge will be constructed upstream of the current bridge, which will be demolished after traffic is rerouted onto the new bridge. Old fill material on the north and south sides of the river will be excavated and replaced by the new bridge abutments. Rock protection will be placed at the bridge abutments to protect the new bridge. Additional fill will be removed from the river bed to allow the new bridge to convey the 100-year discharge.

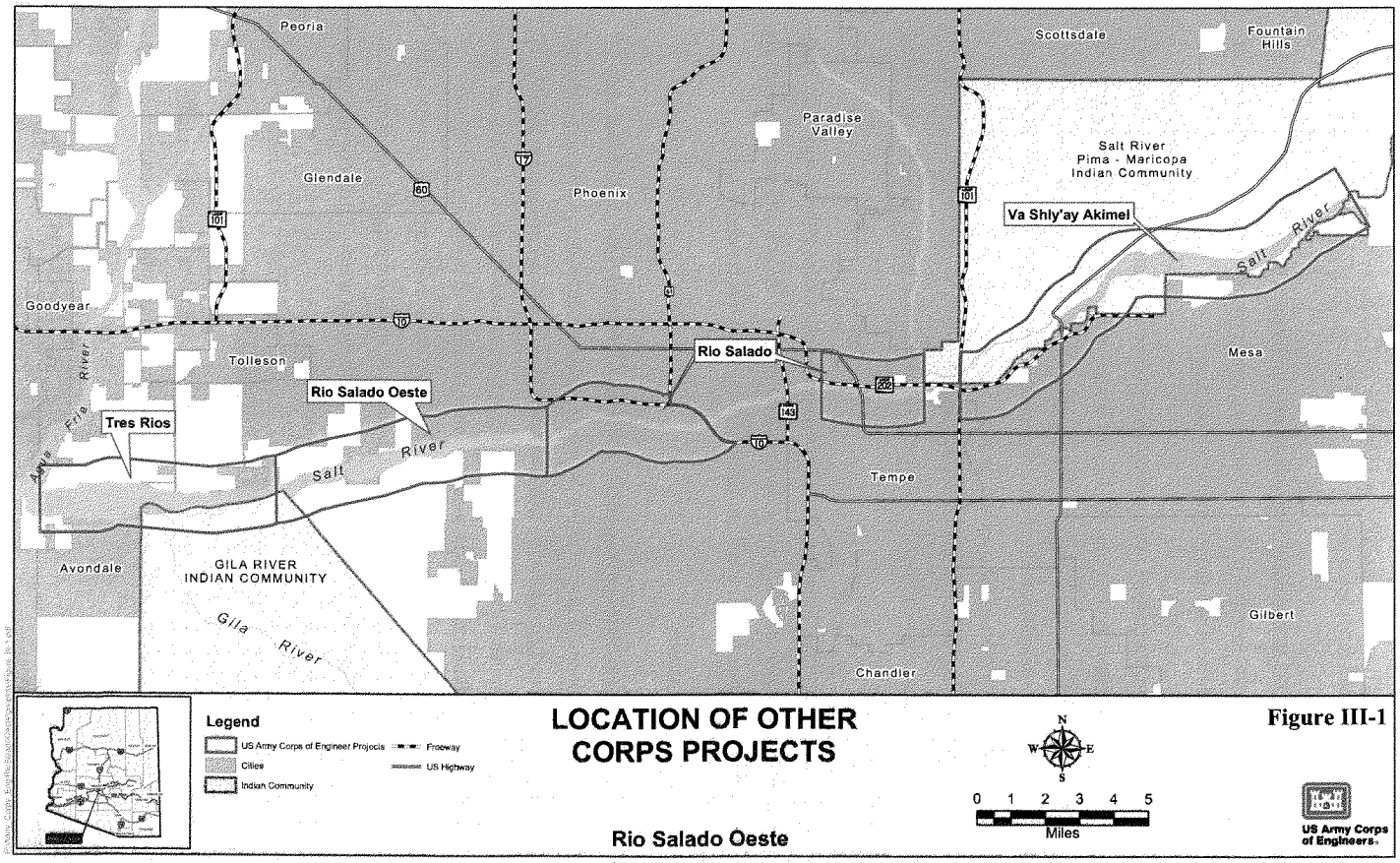
Modifications to this bridge have been considered as part of the future without- and future with-project conditions in planning for the Rio Salado Oeste Project. The new structure would likely be in place prior to construction of any proposal resulting from this feasibility study.

3.1.5.4 Rio Salado Marsh

The City of Phoenix purchased approximately 250 acres of riverbed between 35th and 51st Avenues and is developing a plan to allow the removal of overburden (river soils and aggregate) in a manner that allows aggregate to be removed while leaving a river cross section suitable for restoration. It is anticipated that conditions conducive to marsh land formation will occur as well as improvements to flood control. The assumed future condition of this reach will include removal of approximately 5.03 million tons of material and an active channel of varying width from 300 to 600 feet. The channel will match the elevation of the existing thalweg through the reach, and will be bordered by terraces approximately 500 feet in width. Effects of this on the water surface elevations will be discussed later in this report.

3.2 EXISTING AND ONGOING WATER PROJECTS

The following projects and structures are located within the Salt River watershed. Figure III-1 shows the location of the Rio Salado Oeste Project relative to these other projects.



LOCATION OF OTHER CORPS PROJECTS

Rio Salado Oeste

Figure III-1

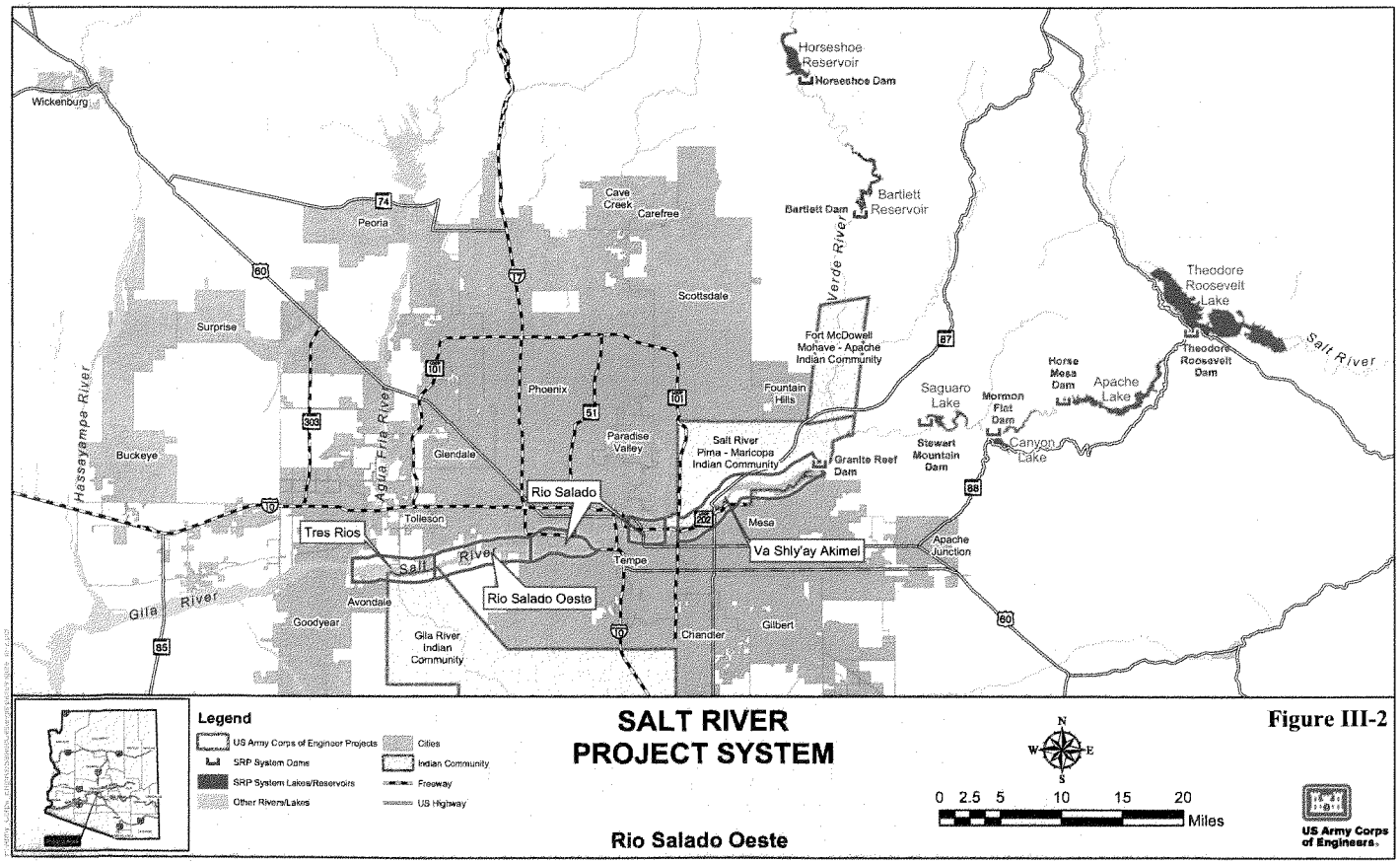
3.2.1 Salt River Project System

Flows in the Salt River are controlled by a series of upstream dams built by USBR and operated by the Salt River Project (SRP) (Figure III-2). The SRP system comprises 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 control. The modifications to the dam began in 1989 and were completed in 1996. The 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 WWTP 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 Sub-regional Operating Group (SROG). 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 the 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. This project is immediately downstream of the Rio Oeste study area.



SALT RIVER PROJECT SYSTEM

Figure III-2

Rio Salado Oeste

3.2.3 Salt River Channelization

In 1996, ADOT and the FCDMC 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 a 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. The dams are located approximately 2 miles apart at the Center Parkway alignment and just upstream of the confluence with Indian Bend Wash. The lake contains approximately 3,500 acre-feet (ac-ft) of 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 place it back into the lake.

3.2.5 Rio Salado Project

Upstream of the Rio Salado Oeste Project on the Salt River is the Rio Salado Project. It is a Corps and City of Phoenix project currently under construction. The project area is broken into two reaches, Tempe and Phoenix. The Tempe reach includes a section of Indian Bend Wash and the confluence with the Salt River and restoration of approximately 150 acres of various habitat types. The Phoenix Reach extends from 28th Street west to the 19th Avenue Bridge, which is the upstream extend of the Rio Salado Oeste study area. The Phoenix reach includes restoration of approximately 550 acres. It includes construction of a low-flow channel in the river bottom, and establishment of open water, wetland marsh, cottonwood/willow, open edges, and mesquite habitat on the river bottom and over banks. The recreational elements associated with this project include trails, scenic overlooks, interpretive centers, gathering areas, parking, restrooms, and shade structures. At the time of writing this document most of the Phoenix reach is completed with the last phase of construction anticipated in 2006/2007.

3.2.6 Tres Rios Project

Immediately downstream of the study area is another Corps and City of Phoenix ecosystem restoration and flood damage reduction project. The project extends approximately 9 miles from the 91st Avenue WWTP to the confluence of the Gila and Agua Fria Rivers. This project is currently in design with the levee under construction.

The recommended plan is characterized by:

- A regulating wetland to even out diurnal variations in treatment-plant discharge
- Constructed wetlands arranged linearly along the north bank of the river
- A pipeline from the overbank wetland leading to riparian corridors west of El Mirage Road
- Open water/marsh areas within the channel west of El Mirage Road
- Distribution of dewatering well water from the treatment plant to large open water/marsh creation areas along the south side of the river
- Flood control levees

3.2.7 Laveen Area Drain Conveyance Corridor

The Laveen Area Drain Conveyance Corridor is part of the Laveen Area Drainage Master Plan and enters the project area at approximately 83rd Avenue. This is a joint project between the FCDMC, City of Phoenix, Maricopa County Department of Transportation, and SRP.

The project includes the design and construction of a conveyance channel capable of containing a 100-year flood event in the vicinity of the existing Maricopa Drain, which runs from 43rd Avenue to the Salt River for a length of approximately 5.8 miles. A flood detention basin at 43rd Avenue and Southern Avenue will mitigate peak flood flows getting to the conveyance channel. The peak discharge at the outfall of the channel for the 100-year storm event is estimated to be 2800 cfs.

Based on previous evaluations of flood hazards within this area, significant floodwater from large storm events ponds along the existing Maricopa Drain. This project will eliminate the potential flood hazard and reduce and/or eliminate potential flood damages. This project consists of channel excavation, road crossings, grade-control structures, tiling and filling in portions of the existing Maricopa Drain, and construction of an earthen low-flow channel. The channel and

basin will be grass-lined to reduce and/or eliminate erosion and sediment transport and to provide landscaping and aesthetics for multiple uses. The project is in construction and is expected to be completed in 2006.

3.2.8 43rd Avenue/Southern Avenue Basin

The 43rd Avenue and Southern Avenue Detention Basin was originally included as part of the South Phoenix Drainage Improvement Project. The detention basin has been designed by the FCDMC. The detention basin site has been acquired by the FCDMC, and is located at the southeast corner of 43rd Avenue and Southern Avenue. The basin includes an inlet structure, an inlet spillway, an outlet spillway, and an outlet structure, which will carry flood water to the existing 43rd Avenue storm drain, which outfalls to the Salt River. The basin was constructed as part of the Laveen Area Conveyance Channel Project. Construction was cost-shared between the FCDMC, City of Phoenix, and Maricopa County Department of Transportation.

The basin has 5:1 side slopes and is surfaced with grass for erosion control and aesthetic purposes. The City of Phoenix plans to use the basin as a park facility. The city will own, operate, and maintain the basin upon completion of construction. This project is scheduled to complete construction in the summer of 2006.

3.2.9 Durango Regional Conveyance Channel and 75th Avenue Storm Drain

The Durango Regional Conveyance Channel (DRCC) and 75th Avenue Storm Drain Project includes the construction of a storm drain along 75th Avenue from Interstate 10 to the Salt River, construction of a detention basin, construction of approximately 1 mile of channel, and construction of a first flush basin. The DRCC was identified in the Durango ADMP. The City of Phoenix and the FCDMC combined two projects, allowing downsizing of the DRCC project features. The City is the lead for design of the project. The City will be the lead for construction of the storm drain and the FCDMC will be the lead for construction of the DRCC. The storm drain is being designed to convey the 10-year flood, and the DRCC is being designed for the 100-year flood. The combined project will reduce flooding along 75th Avenue and in the area north of the railroad. The detention basin will also serve as a City park. Portions of this project are in construction with others scheduled to begin construction in the Spring of 2006.

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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 Rio Salado Oeste study area. The future without-project condition is defined as that condition expected to exist in the absence of any action taken (by the Federal Government) to solve the stated problems and is also described as the No Action Alternative. The future without-project condition forecast provides a description of anticipated actions external to the project and the anticipated consequences of these actions.

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 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 without-project conditions is considered in order 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 resource and recreation studies, and economic analysis.

4.1 HISTORIC CONDITIONS

Historically, gallery forests of cottonwoods and willows covered hundreds of miles along the lower reaches of rivers like the Salt River in the desert southwest. Optimal conditions for these forests were found along the Lower Salt River prior to 1900. Cottonwood and willow forests are found in depositional environments where fine-grained alluvial soils are located on floodplains. These forests commonly occur with other riparian assemblages because fluvial processes (floodplain aggradation and channel meandering) create environmental gradients and mosaics (e.g., water table depth, inundation frequency), which favor diverse riparian species assemblages.

The Lower Salt River was originally a perennial stream fed by snowmelt from the mountains to the east and the highlands to the northeast. Its clear, streaming waters contrasted greatly with the muddy, sluggish Gila River to the south and west. Flows in the river had a distinct seasonal

pattern, with highest flows occurring in December and January and lowest flows in October. The river had many channel meanders, sand bars, and backwater areas that were conducive to riparian growth.

Prior to dam construction in the early 1900s, the Salt River riparian vegetation was dominated by cottonwood, willow, and the various species of mesquite. This suite of vegetation is considered to be representative of the natural "climax community" of species that would be found in an undisturbed riparian corridor along the Salt River. Mesquites 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 mesquites, 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, walnut, and alder trees grew along the margins of the river exhibiting the highest percent of annual recruitment in the secondary channel, and mesquite, creosote bush, Palo verde, and bursage 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. There were several species of fish in the waters, similar to those found in the Gila River.

Large, dense mesquite forests or bosques are found adjacent to natural and created water retention basins, 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 1 mile long and 600 feet wide), but these are small compared to pre-development bosques, which extended for miles. Mesquite bosques usually are found in the drier habitat areas 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.

Beginning in the early 1900s, the historical conditions of the Salt River were altered by manmade activities, including two significant Federal water projects. First, USBR constructed the SRP system, a series of dams in the Salt and Verde River watersheds. The water supply and hydropower benefits that the dams provided led to the economic development of the Phoenix

metropolitan area. Metropolitan Phoenix has grown from a settlement that supplied food and animal feed to the U.S. Army outposts and mines in the area to its current population of 3.2 million people. Though the SRP project has contributed to the economic success of the Phoenix metro area, the extent of the resulting environmental impacts to the Salt River Basin has only recently begun to be studied and understood, leading to the corrective efforts of this and similar restoration studies and projects.

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 groundwater table beneath the river dropped. The soil moisture in the riverbed was virtually eliminated, significantly reducing or eliminating microbial and biochemical processes and nutrient cycling, which directly contributed to the rapid decline and loss of the native cottonwoods, willows, and riparian ecosystem of the Salt River Basin. Most areas of the Salt River are barren today and have been significantly impacted by sand and gravel extraction operations. The vegetation observed in the Salt River corridor today is mostly limited to salt cedar, an invasive non-native species with little habitat value, and fragments of poor-quality native riparian vegetation.

4.2 EXISTING/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 forms the basis against which alternative plans are developed, evaluated, and compared. The term baseline is also used to refer to the existing conditions at the time of a measurement, observation or calculation and will be used occasionally throughout this report.

4.2.1 Geology, Topography, and Geomorphology

Within the study area, the Salt River flows through a major valley with a relatively flat floor of deep alluvium. Soils in the vicinity of the channel are of the hyperthermic torrifluvents association, a group of soils that are well drained to excessively well drained on nearly level or

gently sloping surfaces. They are often sandy to gravelly, but may include lenses of finer particles. These soils are often redistributed by water flows associated with nearby active channels.

Metropolitan Phoenix 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). From the end of the Pliocene until recent (Holocene) time, the basins, including the Salt River Valley, filled with unconsolidated and occasional semiconsolidated 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.

The predominant surface materials within the 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.

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.

Two major soil associations are found within the project study area. Within and immediately adjacent to the river is the Carrizo-Brios Association, with the Gilman-Estrella-Avondale Association to the south. The Carrizo-Brios Association is characterized by deep, excessively drained soils and nearly level to gently sloping, gravelly sandy loams and sandy loams in stream channels on low-stream terraces. The Gilman-Estrella-Avondale Association is characterized by deep, well-drained soils and nearly level loams and clay loams on valley plains and low stream terraces (Maricopa County, 1992).

Flood flows are probably the most important events in the transportation of sediment along the Salt River. Sediment transported in a scour and fill setting by flood flows tends to move in waves or pulses, rather than at a constant rate through time. In essence there are slugs of sediment moving downstream periodically during flow events. Prior to damming of the 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, incision and movement of sediment by these smaller events do not compare to the order of material moved during a flood event.

The Salt River through this reach has been relatively stable but still the riverbanks have moved laterally by as much as one-half mile in some locations during the 130-year record. Much of the lands along the south side of the river have been recovered from the active braided channel

system during the period of historical photos. The meander belt varies from approximately 2 miles in width at 19th Avenue to approximately 4 miles in width at 91st Avenue. Lateral migration would not be expected to exceed these limits.

The river is constrained upstream from 19th Avenue by levees constructed as part of earlier projects. The soil cement levees end just downstream from the 19th Avenue Bridge and the river is unconstrained by levees until just above the 91st Avenue WWTP. River alignment is fixed to some extent by bridges located at 35th Avenue, 51st Avenue and additional proposed bridges for a future freeway crossing in the middle section of this reach. The 35th Avenue Bridge is very small and provides a significant constriction to flows. The other bridges have much larger openings and provide less flow constriction. The recent historical evidence examined here indicates that the project reach is in quasi-equilibrium, although adjustments to bank and thalweg lines within the historical meander belt are possible.

Results of a sediment transport analysis show that sediment dynamics are more significant in the proximity of mining operations. The study also revealed that downstream of 35th Avenue the reach experienced mainly erosion while upstream of 35th Avenue the main process was deposition.

For additional information concerning geology of the study reach, please refer to Appendix A, Hydrology and Hydraulics, and Appendix E, Geotechnical Evaluation.

4.2.2 Hydrology

4.2.2.1 Surface Water Hydrology

The Salt River drains 14,500 square miles of mountainous desert terrain in central and eastern Arizona 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 [USGS], 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 percent to 50 percent. Winters are mild, with mean daily temperatures ranging from 35°F to 70°F.

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 stream flow infiltrated and recharged groundwater upstream of Indian Bend Wash near Scottsdale. Groundwater discharged to the channel to provide perennial base flow in downstream sections of the channel (USGS, 1991). Under 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, in light of the length of periods without flow in a river that is perennial under natural conditions.

Dam System

During the 20th century, the Phoenix area changed from a mainly agricultural region to a mainly 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 river use 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. See table 3.2-1 for a listing of the dams on the Salt, Verde, and Agua Fria and Gila Rivers.

The Salt River Project (SRP) operates six storage dams on the Salt and Verde Rivers and one diversion dam just east of the City of Mesa. Granite Reef Diversion Dam (Granite Reef) does not have any storage capacity. The purpose of this facility is to divert water released from the reservoirs 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 supply the Phoenix Metropolitan Area with water for agricultural and municipal and industrial (M&I) use. Stored water is allocated based on water rights associated with the land in the SRP service area.

All Salt River dams have hydrogenation capacity. Safety of Dams modifications (completed in 1996) to Theodore Roosevelt Dam include a zone for flood control. The total space for water-supply storage behind these dams is 2,025,798 acre-feet (ac-ft) including the cities' new conservation storage, with an additional 556,196 ac-ft for flood damage reduction at Roosevelt Dam. The Roosevelt Reservoir is the largest reservoir of the SRP reservoir system. It stores runoff from about 5,800 square miles of the Salt River watershed.

Downstream of the Stewart Mountain Dam, the Verde River discharges into the Salt River. The drainage area of the Verde River is about 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 Salt River), which provide an additional 287,403 ac-ft of storage. New Waddell Dam is located on Agua Fria River northwest of Phoenix and downstream of the study area.

Table IV-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, mods 1994	812,100
Bartlett	Verde	Bartlett Lake	1939	178,186
Horseshoe	Verde	Horseshoe Lake	1949, mods 1951, 1995	109,217
Stewart Mountain	Salt	Saguaro Lake	1930	69,765
Mormon Flat	Salt	Canyon Lake	1938	57,852
Horse Mesa	Salt	Apache Lake	1927, mods 1992	248,138
Roosevelt	Salt	Roosevelt Lake	1911, mods 1996	1,653,043
Coolidge	Gila	San Carlos Lake	1928, mods 1994	1,222,000
Painted Rock	Gila	Painted Rock Lake	1959	2,500,000

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 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 the Granite Reef Diversion Dam. During normal times, SRP releases water from the reservoirs to meet water needs in the Valley. When the reservoirs approach full capacity, a point which SRP is always fully aware, releases above the water order may b initiated. Water released in excess of the water order typically flows over or around Granite Reef Dam and flows into the normally dry Salt River channel. The actual amount is dependent upon numerous variables including: available storage space, forecasts, downstream impacts and constraints, and desired future storage levels. The Granite Reef Diversion Dam is located about three 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 Salt River), and the South Canal (for the area south of Salt River). The canal system generally follows the topographic contour of the the Phoenix metropolitan area in order

to provide gravity flow delivery of water to agricultural, municipal and industrial users. There are no releases during climatically drier years, as occurred between 1942 and 1964. Except for storm water runoff, groundwater emergence and effluent, the Salt River is dry during those times.

Figure IV-1: Flows in the Salt River on January 19, 2005 (as seen looking NE from an area adjacent to the 51st Avenue Bridge.)

Discharge

Before 1938, an average of 413,000 ac-ft of water flowed through the channel (USACE, 1998). The estimated pre-development, average annual watershed yield was about 1,250,000 ac-ft (USGS, 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 (USACE, 1998).

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 (USACE, 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 cfs.

Beginning on New Years Eve 2004, SRP began releasing water from Bartlett Dam to accommodate storage for rainfall and snowmelt from the Verde River watershed. The highest recent discharge occurred on February 13, 2005, of approximately 35,000 cfs as recorded by the USGS gauge at 51st Avenue (http://waterdata.usgs.gov/az/nwis/rt).

Storm Water

Storm water enters the Salt River at numerous locations in the study area and has the potential to degrade the surface quality of water in the system. 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 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 storm water Arizona Pollutant Discharge Elimination System (AZPDES) permits require each industrial site to have 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.

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. Similar quality issues exist for all water sources in the lower Salt River, namely contamination by VOCs and various metals, ions, nutrients, and herbicides.

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 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. Refer to Table IV-2 for a list of contaminant categories and specific contaminants expected at the Oeste location.

Salt River flows maintain high amounts of mineral content and total dissolved solids (TDS). When flood flows do occur, they commonly violate quality standards for fecal coliform bacteria. 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. The Verde water tends to lower the overall TDS content in flows downstream of their confluence. The quality of water would be sufficient to support native fish species; however, elimination of the base flows does not allow it.

Table IV-2: 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 Agriculture	Infectious disease
Radiological		Mines Natural origin	Carcinogen

Source: Graf et al., 1994

Additional discussion of surface water quality can be found in Appendix D, Groundwater Quality and Hydrogeology Report, and Appendix F, Modified Phase I Environmental Site Assessment (ESA).

4.2.2.3 Groundwater Hydrology

Prior to development of the Phoenix metropolitan area and construction of upstream reservoirs, the Salt River was a perennial stream. The river was a significant source of groundwater recharge in some areas and a recipient of groundwater discharge in other areas. (See Table IV-3

for estimated predeveloped groundwater hydrology budgets for Salt River Valley. As the area began to be settled, irrigation to support crops was obtained by diverting the stream flow into canals. By the 1900s, much of the Salt River Valley was waterlogged due to recharge from canal seepage and deep percolation combined with a lack of groundwater pumping. Beginning in the 1920s, substantial groundwater pumping began for irrigation and to control shallow groundwater levels. Following World War II, advances in drilling and pump technology allowed extensive pumping from deep aquifers to occur. The result of the groundwater pumping practices was extensive overdraft.

Table IV-3: Estimated Pre-Development Groundwater Budget for Salt River Valley

Source of Inflow	Volume (ac-ft/yr)
Stream channel recharge	100,000
Groundwater inflow	30,000
Mountain front recharge	10,000
Total inflow	140,000
Groundwater discharge to stream channel	60,000
Evapotranspiration	76,000
Total outflow	140,000

The groundwater supply beneath the study area is regulated by the Arizona Department of Water Resources (ADWR). To aid in monitoring, ADWR differentiates between groundwater basins. The subsurface geologic conditions in the study reach are within the Phoenix Active Management Area (AMA) of ADWR.

URS Corporation (URS), a private Architectural/Engineering firm conducted a groundwater quality and hydrogeology study for the Rio Salado Oeste Project (April 2002). The current groundwater condition in the study area was presented in the URS study report. According to the report, groundwater generally occurs under unconfined conditions within the Upper Alluvial Unit (UAU). Groundwater flow in the eastern third of the study area (east of 39th Avenue) is generally from the south to north-northwest toward the Roosevelt Irrigation District well field located along or north of Lower Buckeye Road between 19th and 35th Avenues. The groundwater gradient is steepest to the north with values as high as 0.008 ft/ft in the vicinity of 35th Avenue and Lower Buckeye Road. The groundwater-flow direction in the western two thirds of the study area (West of 39th Avenue) ranges from northwest to west. The groundwater gradient flattens to the west with values as low as 0.002 ft/ft. Static water level is relatively

shallow, ranging from 20 to 50 feet below ground surface within the Salt River channel to 60 to 80 feet below ground surface north and south of the river.

Fluctuations in static water level can be as much as 20 to 30 feet on an annual basis due to agriculture pumping demands, and have declined as much as 25 feet in the last five years (Dames & Moore, 1991; Parsons Engineering Science, 2001). Hydrographs of selected wells show this decline is most pronounced in the eastern portion of the site near the Roosevelt Irrigation District well field. The selected wells provided static water levels from both ends of the study area that have the most complete water level records. Contributing factors that may cause the fluctuations are water discharge from the 35th Avenue water treatment plant outfall during winter months that produces groundwater mounding, and related radial flow during periods of discharge and basin-wide groundwater pumping and storm water runoff into the Salt River.

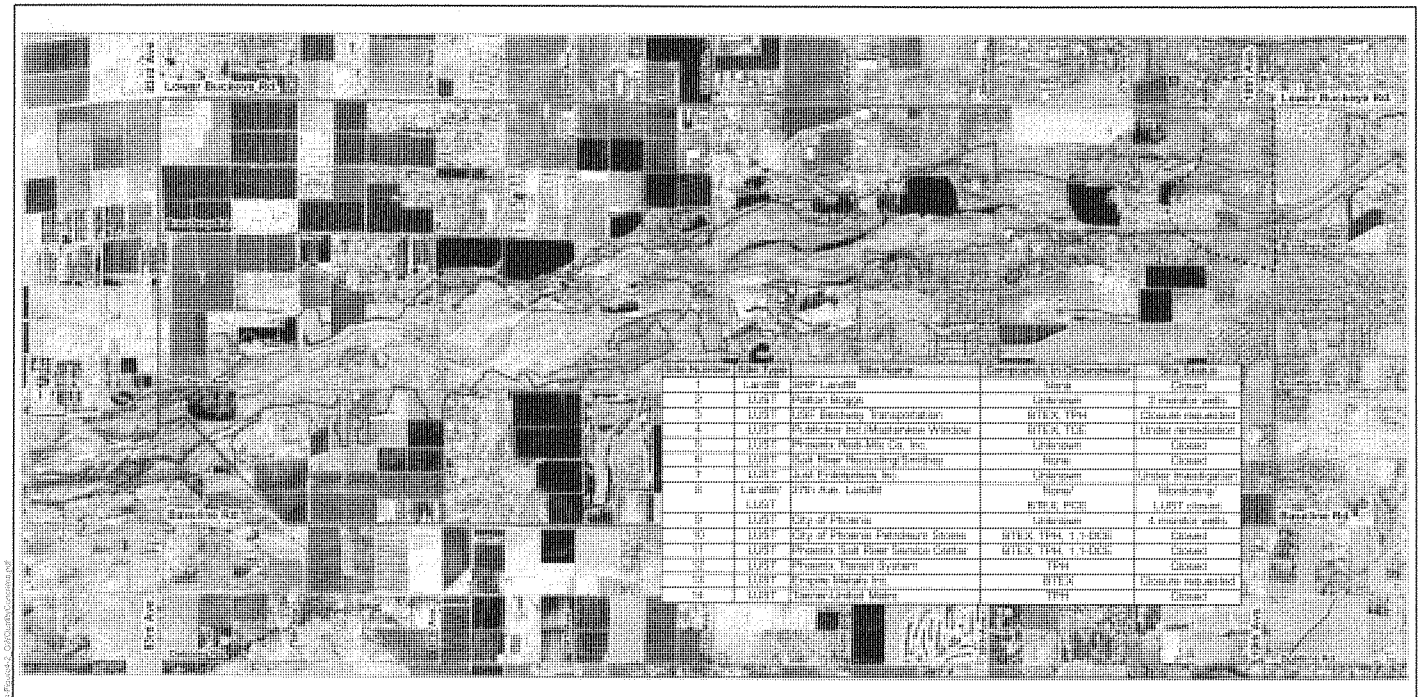
A groundwater contour map of the study area was prepared using ADWR well data from 1997 because it represented the most complete data set available. ADWR collected many water levels from both production and monitoring wells in the month of October, at the end of the pumping season. Water levels represent static values prior to significant precipitation. Some data outside of the study area were incorporated while contouring to fill data gaps. The hydrographs were prepared and reviewed to validate whether the contour map is representative of current conditions. In general the selected wells show a consistent water level decline without radical changes in gradient direction. Therefore, while the groundwater elevation has declined approximately 10 to 20 feet since 1997, the current contours are likely to be similar to the 1997 contours (URS, 2002). For additional information concerning the groundwater hydrology please refer to Appendix C, Groundwater Modeling.

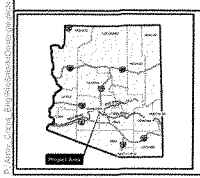
*4.2.2.4 **Groundwater Quality***

When groundwater pumping was initiated in the Phoenix metropolitan area in the 1920s, the groundwater quality, although high in minerals, was considered to be of very good quality. Today, there are a number of groundwater problems in the Salt River Valley. The problems associated with inorganic chemical constituents include high levels of chloride, TDS, nitrates, and salinity. The problems associated with trace organic constituents include the pesticide dibromochloropropane and volatile halocarbons. Most of the regional problems are currently

limited to groundwater in the UAU. Areas of groundwater quality concern are summarized in the April 2000 URS report and depicted on Figure IV-2. Those sites include landfills and Leaking Underground Storage Tank (LUST) sites. There are also two superfund sites in the study area.

Groundwater in the eastern half of the study area has lower TDS than other portions but has been impacted by petroleum releases of several Underground Storage Tanks (USTs) and may have elevated concentrations of 1,1-DCE. In the southwestern part of the study area data indicate elevated concentrations of TDS and nitrates.





Legend

- Project Study Area
- Project Implementation Area
- 27th Ave. Landfill
- Possible extent of 1,1-DCE plume
- 23rd Ave. Wastewater Treatment Plant
- 91st Ave. Wastewater Treatment Plant
- Wells with elevated concentrations of 1,1-DCE
- Sites with known or probable groundwater contamination
- Groundwater investigation sites with no known impacts

March 2005

Source: Groundwater Quality and Hydrogeology Report, (URS 2002a)

AREAS OF GROUNDWATER QUALITY CONCERN

Rio Salado Oeste

N W E S

0 5,000 10,000

Feet

Figure IV-2

US Army Corps of Engineers

The Groundwater Quality and Hydrogeology Report and Modified Phase I Environmental Site Assessment (ESA) are included in Appendix D and Appendix F, respectively, and include much more detailed discussion of water quality.

4.2.3 Hydraulic Conditions

An existing Flood Insurance Study HEC-RAS model from the confluence with the Gila River (River Mile [RM] 199.82) to about 12th Street (RM 214.14) was provided by FCDMC. This model will be referred to as the FEMA model. The FCDMC also provided aerial photographs from 1993 and 1999, an ArcInfo coverage with contours with a 4-foot interval developed for the Salt/Gila River Master Plan (1992), an ArcInfo coverage with the cut lines of 100 of the FEMA model cross sections, and an ArcInfo Triangular Irregular Network (TIN) of the study area including raw data in point files and breakline format also created for the Salt/Gila River Master Plan (1992). The line coverage included cross sections from RM 202.09 to RM 211.12. Cross section 202.09 is located approximately 1,100 feet downstream of 91st Avenue, while cross section 211.12 is about 2,150 feet downstream of 19th Avenue.

The hydraulic model was used to generate water surface profiles and inundation boundaries for a series of frequency flood events ranging from 5- to 500-year return periods. Small flows are generally contained in the main channel, and only the large flows (100-year and 500-year) occupy significant portions of the floodplains outside the river banks.

4.2.4 Water Supply

Since the source of water that provided for the habitat that historically existed on the Salt River has been altered by upstream dams and adjacent development, alternative water sources would be necessary to implement restoration alternatives. Possible sources for that water supply include flood flows, stormwater runoff, effluent, and groundwater. Decisions pertaining to water supply extend beyond source, quality, quantity, and cost but also include existing legal agreements and water rights that apply to both surface and groundwater.

4.2.4.1 ***Effluent***

The City of Phoenix Water Services Department has identified the potential availability of an average 8 mgd of reclaimed water from the 23rd Avenue WWTP. It was recommended that the capacity to handle as much as 20 mgd to accommodate large diurnal variations in flow should be incorporated into the water supply system. Project planning should also account for "no-flow" periods of up to 12 hours. Note: 1 mgd = 1.55 cfs or 3.07 ac-ft/day.

4.2.4.2 ***Storm Water***

Although highly dependent on rainfall and not necessarily a consistent source, storm water runoff must be considered in project planning. Table IV-4 provides initial information pertaining to storm water outfalls, their locations, and sizing. While the outfalls listed in Table IV-4 are present in the study area not all of them currently reach the river channel. The Interior Drainage Report in Appendix B includes a detailed description of potential storm water runoff to the study area.

Table IV-4: Storm water Outfalls within the Study Reach

Outfall #	Site Location	Pipe Size	Comments
SR01	51st Avenue and Salt River - North Side	96 inch	
SR02	43rd Avenue and Salt River - North Side	90 inch	
SR03	35th Avenue and Salt River- North Side	75 inch	
SR04	27th Avenue and Salt River- North Side	72 inch	23rd Ave. WWTP discharges
SR05	25th Avenue and Salt River- North Side	102 inch	
SR06	22nd Avenue and Salt River- North Side	78 inch	
SR30	27th Avenue and Salt River- South Side	108 inch	FCDMC first flush sample sta.
SR47	51st Avenue and Salt River- North Side	48 inch	
SR48	45th Avenue and Salt River- South Side	48 inch	
SR49	67th Avenue and Salt River- North Side	96 inch	FCDMC first flush sample sta.
SR58	35th Avenue and Salt River- N/E Side	60 inch	
SR59	2333 W. Durango (23rd Ave. WWTP east side of 35th Avenue and Salt River) - North Side	48 inch	Part of SR05 conveyance system

Storm water may prove sufficient to support ephemeral wetlands or even riparian habitat in portions of the study area. Table IV-5 on the next page provides a summary of outfalls that provide storm water flows to the river channel and that will be considered to potentially provide source water for restoration features. The modification of storm water outfalls to capture runoff to support habitat will be discussed further later in this report.

Table IV-5: Storm water Outfalls and Estimated Average Runoff in Acre-Feet (AF)

No.	Site Location	Jan (AF)	Feb (AF)	Mar (AF)	Apr (AF)	May (AF)	Jun (AF)	Jul (AF)	Aug (AF)	Sep (AF)	Oct (AF)	Nov (AF)	Dec (AF)	Annual (AF)
SR01[1,2]	51st Avenue and Salt River - North Side	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR02[1,2]	43rd Avenue and Salt River - North Side	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR03[1,2]	35th Avenue and Salt River-North Side	19.5	20.2	25.7	6.5	3.6	3.8	24.2	28.0	25.1	19.0	19.3	29.1	224
SR04[1,2]	27th Avenue and Salt River-North Side	29.6	30.7	39.2	9.9	5.4	5.8	36.8	42.6	38.1	29.0	29.3	44.3	341
SR05[1,2]	25th Avenue and Salt River-North Side	10.9	11.3	14.4	3.6	2.0	2.1	13.5	15.6	14.0	10.6	10.8	16.3	125
SR06[1,2]	22nd Avenue and Salt River-North Side	48.8	50.5	64.5	16.3	9.0	9.5	60.6	70.1	62.8	47.7	48.2	72.9	561
SR07[1,2]	19th Avenue and Salt River-North Side	6.9	7.1	9.1	2.3	1.3	1.3	8.5	9.9	8.8	6.7	6.8	10.3	79
SR30[1,2]	27th Avenue and Salt River-South Side	17.1	17.7	22.6	5.7	3.1	3.3	21.2	24.5	22.0	16.7	16.9	25.5	196
SR31[1,2]	19th Ave, South Bank	20.1	20.8	26.6	6.7	3.7	3.9	25.0	28.9	25.9	19.6	19.9	30.0	231
SR48[1,2]	45th Avenue and Salt River-South Side	142.7	147.6	188.6	47.6	26.2	27.9	177.1	205.0	183.7	139.4	141.0	213.2	1640[3]
SR49[1,2]	67th Avenue and Salt River-North Side	48.5	50.2	64.1	16.2	8.9	9.5	60.2	69.7	62.5	47.4	48.0	72.5	558

1. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
2. Annual runoff volumes were computed from the drainage area versus average annual runoff relationships developed for the Rio Salado Study.
3. 1640-acre feet based upon drainage area; however, it is anticipated that runoff from this will decrease with modification in design/construction.

4.2.4.3 Flood Flows

The Salt River is dry most of the time due to the upstream dams that were constructed for water supply to agriculture and the Phoenix valley. Although the river is subject to flooding, flood water can only be considered a possible supplemental water supply for a restoration project. Discharge-frequency values are provided in Table IV-6 and more detailed information on flood flows can be found in Appendix A, Hydrology and Hydraulics. The 100-year floodplain is shown on Figure IV-3.

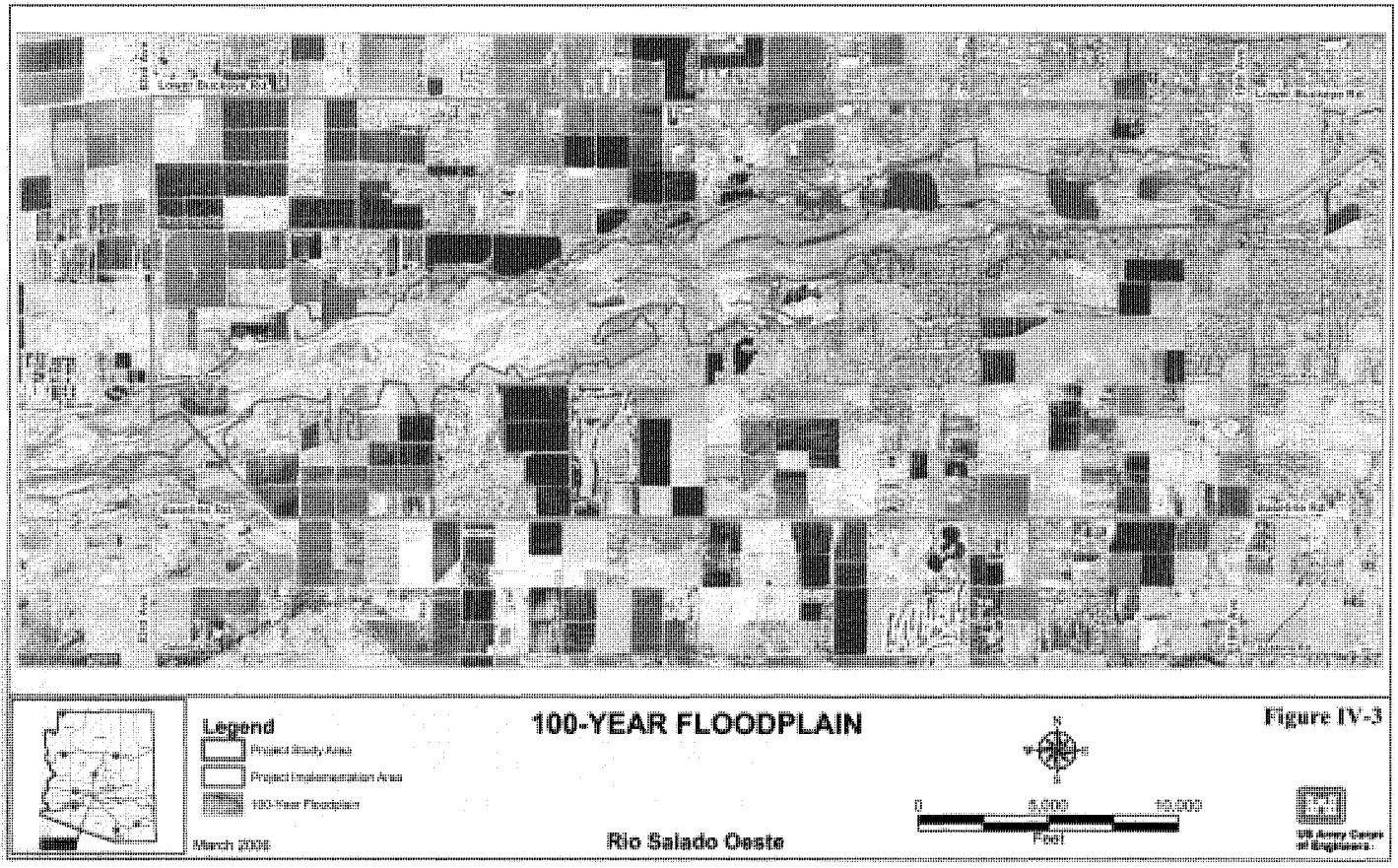
While not necessarily a preferred source for delivery of water and implementation of restoration measures, flood flows need to be considered in plan formulation. In a natural system, they provide the necessary dynamics to maintain the ecosystem and are an important factor in seed dispersal. Measures considered in the formulation of plans should account for the possible damages off loading as well as the potential advantages of flooding—flooding may provide benefits towards project sustainability.

Table IV-6: Discharge-Frequency Values Used in the Existing Conditions Model

Location	Return Period					
	5-yr	10-yr	20-yr	50-yr	100-yr	500-yr
Peak Discharges (ft^3/s) in the Salt River at:						
Central Avenue	20,200	53,000	87,000	135,000	166,000	240,000
67th Avenue	20,000	51,000	84,000	132,000	164,000	237,000

4.2.4.4 Groundwater

The Salt River was once a perennial stream, and groundwater levels were shallow and provided for a significant amount of riparian and wetland habitat. Today, static water level ranges from 20 to 50 feet below ground surface within the Salt River channel to 60 to 80 feet below ground surface north and south of the river. Data indicate that over the past 25 years groundwater elevations in the study area have decreased approximately 15 to 20 feet.


Legend
Project Study Area
Project Implementation Area
100-Year Floodplain
100-YEAR FLOODPLAIN
Figure IV-3
Rio Salado Oeste
March 2004
N
W
E
S
0
5,000
10,000
Feet
US Army Corps of Engineers

Groundwater quality in the eastern half of the study area has been impacted by hydrocarbon releases and elevated concentrations of 1,1-DCE. Elevated concentrations of TDS and nitrates are of concern on the southwestern side of the project area.

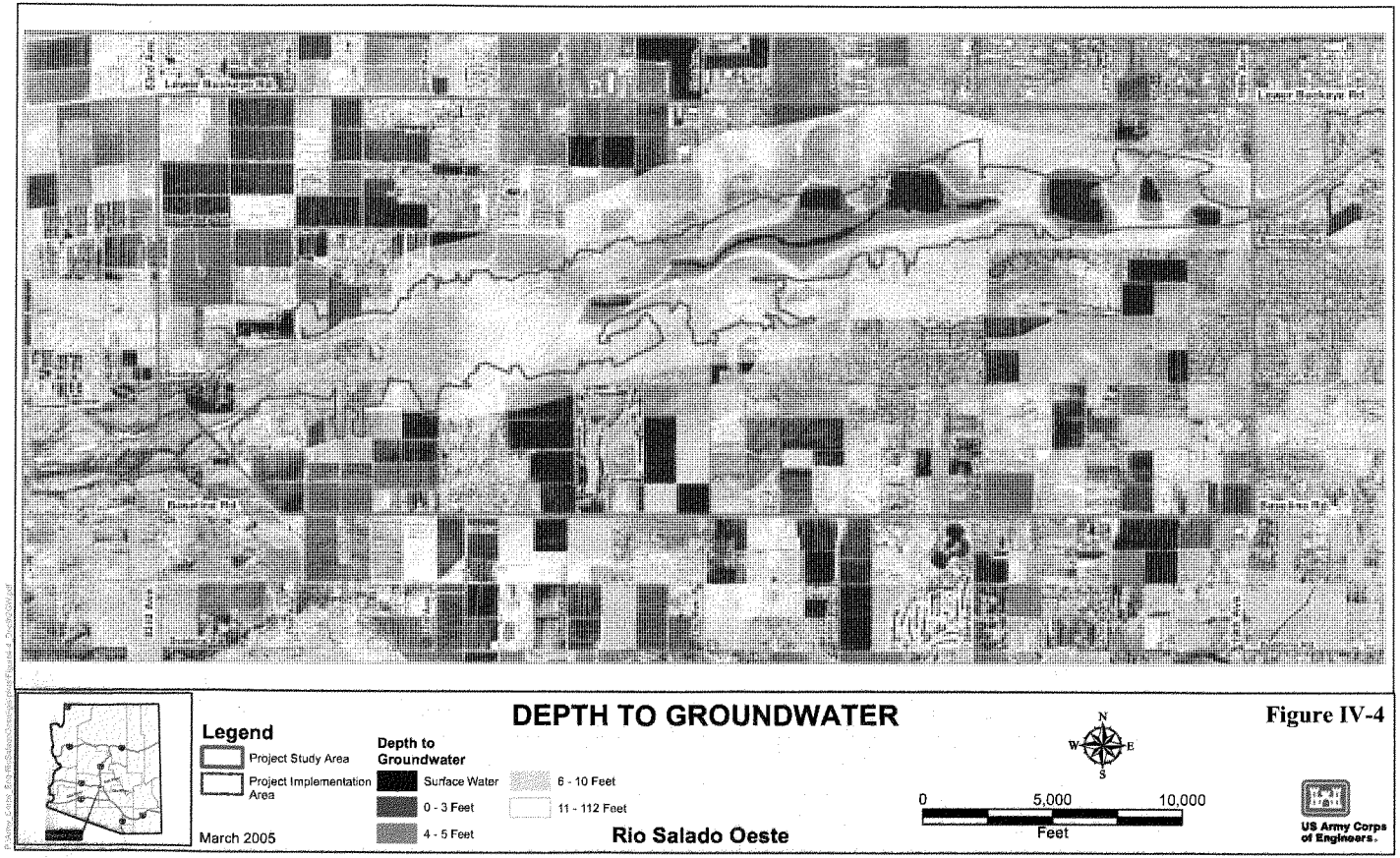
The subsurface geologic conditions in the study reach are within the Phoenix AMA and are regulated by the ADWR. The City has the rights to pumping of groundwater for their service area but would prefer to pursue other sources prior to considering groundwater as a project source. Figure IV-4 depicts an approximation of existing depth to groundwater within the study area, based upon extrapolation of 2002 ADWR well data and observed water levels in excavated gravel pits.

4.2.5 Land Use

The study area is located in a rapidly developing and changing area of metro Phoenix. Land uses range from industrial and commercial to residential and agriculture. Estrella Village and Laveen Village are the two primary planning areas that lie adjacent to the Salt River between 19th Avenue and 83rd Avenue. Estrella Village is characterized by an ample supply of undeveloped land, large parcels, natural and scenic amenities, and excellent transportation access. Approximately 62 percent of the Village is undeveloped, either vacant or with agricultural uses. However, there are at least 21 residential developments in various phases of approval and development.

The Laveen Village contains largely undeveloped and agricultural properties. Primary agricultural crops grown in the area include cotton, citrus, and corn. Farmers, equestrians, and those looking for solitude and mountain access have valued the area. However, development pressures have increased in this area due to its proximity (about 7 miles) to downtown.

Based upon the City of Phoenix General Plan (Revised February 2001), most of the land area on the north side of the river between 19th and 59th Avenues is zoned industrial, with some high-density residential between 43rd and 60th Avenues. From 60th to 83rd Avenues, the primary land use is low-density residential. To the south, some land between 19th and 35th Avenues is zoned as commercial otherwise, the prevailing land use is low- to medium-density residential.


DEPTH TO GROUNDWATER
Figure IV-4
Legend
Project Study Area
Project Implementation Area
Depth to Groundwater
Surface Water
0 - 3 Feet
4 - 5 Feet
6 - 10 Feet
11 - 112 Feet
March 2005
Rio Salado Oeste
N
W
E
S
0
5,000
10,000
Feet
US Army Corps of Engineers.

4.2.5.1 Future Land Use

As of July 2003 there were approximately 35,000 approved lots in the Laveen and Estrella Villages. At this rate of growth it is assumed that by 2009 the majority of the lands adjacent to the river will be developed and converted from agriculture to urban.

4.2.5.2 Aggregate Mining

As seen in Figure IV-5 below, since the construction of upstream dams began controlling the flows in the Salt River, sand and gravel mining operations moved into the riverbed and surrounding floodplain to mine the natural resource. The materials extracted from the river have been used extensively throughout the development of the Phoenix Metropolitan area and have contributed to geomorphic changes to the floodplain and adjacent over bank. Removal of sediments also removes materials that would normally be redeposited during flood events.

Figure IV-5: Aggregate mining within the project area.

There are an estimated 671 acres of sand and gravel mining operations within the 100-year floodplain of the project area. Between 19th and 35th Avenues, the river is lined with operations

and is nearly 100 percent modified. South of the river between 43rd Avenue and 51st Avenue there are mining operations that cross the river just downstream of 51st and extend on the north side to near 63rd Avenue. Two new operations are in the permitting process between 51st and 67th Avenues. It is assumed that the existing mining operations will continue operating until resources and demand dictate that they are no longer feasible in their existing locations. As can be seen to the west of 51st Avenue, new operations will begin in previously un-mined portions of the river, close to new development.

4.2.6 Vegetative Habitat

Historically, the study area supported significant biological resources including extensive riparian and wetland habitats within the floodplain. 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. The Salt River below Granite Reef Diversion Dam is essentially devoid of vegetation. 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. Included in this reach of the Salt River are a large number of open water areas, mostly the results of gravel mining. Adjacent to several of these there is dense vegetation including some cottonwood and willows as well as the occasional cattail or bulrush.

4.2.6.1 Cover Types

A classification system of cover types was developed for this study and is mainly based upon vegetation cover. Cover types were mapped for the length of the study reach and 1 mile on either side of the thalweg, or center of the river channel. Scattered remnants of natural vegetation remain; those cover types include cotton-willow forest, mesquite, scrub-shrub lands, and emergent wetlands. Of those cover types, scrub-shrub lands are the most dominant in the study area, covering approximately 1,200 acres. The scarcest is cottonwood/willow forest, extant within merely 10.5 acres (not including an additional 120 acres in which salt cedar dominates Figure IV-6 below).

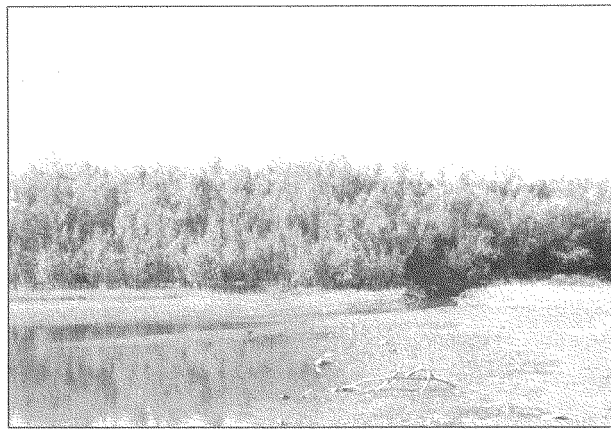


Figure IV-6: Landscape dominated by Salt Cedar (83rd Avenue)

Cottonwood/Willow Forest

Cottonwood/willow forest 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.

Because of the modification of the Salt River system, groundwater elevations have been lowered and have contributed to the decline in cottonwood and willow species. These same conditions have also favored the establishment and dominance of salt cedar. 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 salt

cedar. 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 salt cedar.

Scrub-Shrub Lands

Scrub-shrub lands are common and are present within the active channel of the river occupying 12 percent of the project study area (Figure IV-7). They are dominated by various combinations of burrobush, rabbitbush, quailbush, saltbush, and occasionally by creosotebush. 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. Throughout drainages in the Sonoran Desert there are dense areas of scrublands which are too dense to be considered desert scrub. They usually contain the same species found in the drier desert scrub but area usually more dense and also contain distinctive riparian species including Seepwillow, desert broom, or Desert willow. While river bottom, scrub shrub and riparian scrub are often referred to interchangeably by different disciplines this report will attempt to specify the difference.

Figure IV-7: Scrub-Shrub Lands Dominated by Saltbush and Rabbitbush.

Wetlands (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 and mostly associated with effluent or storm water discharges (Figure IV-8). These features are characterized by either seasonal or perennial open water, and are generally unvegetated when present. Vegetation, when present, consists of scattered patches of Bermuda grass, salt heliotrope, and sedges.

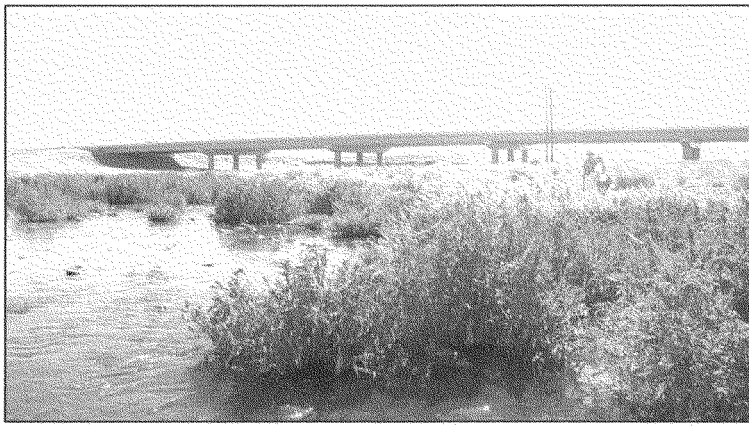


Figure IV-8: Low-Flow Channel with Wetland Vegetation (immediately upstream of 51st Avenue Bridge)

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 adjacent to the project study area on the Gila River Indian Community. Although scattered mesquite occurs throughout the study reach there are no large stands that could be considered mesquite woodlands.

4.2.6.2 ***Habitat Evaluation***

Hydrogeomorphic Modeling Process

The Hydrogeomorphic Modeling (HGM) approach was chosen for habitat evaluation on the Rio Salado Oeste because of its ability to provide an analysis of the processes and conditions necessary for restoration and maintenance of riparian and wetland habitat. The HGM—developed by scientists and the Engineering Research and Development Center (ERDC)—allows existing community characteristics, composition, and function to be compared to fully functional systems. 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. The ability of a riverine system to have and sustain a majority of the identified functional components of a wetland ecosystem directly correlates to the quality, quantity, and type of riparian habitat that can establish and survive.

In arid regions, biological resources are typically concentrated along riparian systems. This feasibility study relies on the results of a Hydrogeomorphic Approach to Wetlands Assessment Methodology to yield quantitative descriptions of biological resources along and adjacent to the Salt River in the study area. HGM was chosen for its broad analysis of processes and conditions necessary for support of riparian habitat. Riparian components including size, substrate characteristics, and species composition will be considered in quantification of the biological resource function and value.

An HGM approach treats the biota of an area as the outcome of an ecological process. It also merges these biological events with hydrologic and geologic process 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, and 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 fully 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 the 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.

Using this methodology, the Salt River was classified as Riverine Over bank. The Salt River is also characterized regionally as arid and Southwestern. As such, the functions developed in an existing Riverine Over bank Subclass model were modified for Arizona low gradient rivers to be applied in the standard HGM approach for this study. The model for Arizona was further calibrated in a workshop with the Environmental Laboratory of ERDC, the Los Angeles District Corps, local sponsor representatives from the City of Phoenix, City of Tucson, Town of Marana, Pima County Flood Control District, Salt River Pima-Maricopa Community, AGFD, U.S. Fish and Wildlife Service (USFWS), and representatives from the scientific community. Field sampling results based on the calibration of the model during the workshop are used in the analysis of alternatives.

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

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

- Organic Soil Flats
- Riverine

The level of variability in the continental-scale wetland hydrogeomorphic classes presented above is too large 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 Rio Salado Oeste 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, five PWAAs were defined for the Rio Salado Oeste Project on the basis of species recognition and dependence, soil types, and topography. The dominant 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.

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. Wetland functions 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, and 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 an FCI.

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 HGM FCI models used in this study are found in Table IV-7.

Table IV-7: Wetland Functions Evaluated

Wetland Function (symbol)	Description
Function 1: Maintenance of Characteristic Channel Dynamics (CHANNELDYN) $(V_Q+V_{FPA}+V_{SED})/3$	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) $(V_{FREQ}*(V_{FPA}+((V_{TOPO}+V_{TVV}+V_{CWD})/3)/2))^{1/2}$	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) $(((V_{TOPO}*V_{FREQ})^{1/2})*(((1 - V_{PORE})+V_{SUBIN})/2))^{1/2}$	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) $(V_{DEPSATSED})$	Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.
Function 5: Nutrient Cycling (NUTRIENT) $((V_{TVV}+(3*V_{AGSA})/4)+((V_{DECAY}*((V_{LITTER}+V_{FWD}+V_{CWD})/3))^{1/2}))/2$	Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
Function 6: Detention of Imported Elements and Compounds (ELEMENTS) $(((V_{FREQ}+V_{SURFIN}+V_{SUBIN})/3)+((V_{AGSA}+V_{LITTER}+(1-V_{PORE}))/3)+V_{TVV})/3$	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.

Wetland Function (symbol)	Description
$((2*V_{FPA})+V_{TOPO}+((V_{CWD}+V_{FWD}+V_{SED}+V_{TVV})/4))/4$	
Function 8: Maintain Characteristic Plant Communities (PLANTS) Cottonwood/willow and Mesquite Communities: $(((((V_{SPECRICH}+V_{WIS}+V_{INVASIVES})/3)*((V_{CANHERB} + V_{CANSHRUB} + V_{CANTREE})/3))^{1/2}) * V_{LANDBUFF})^{1/2}$ Scrub-Shrublands Communities: $(((((V_{SPECRICH}+V_{WIS}+V_{INVASIVES})/3)*((V_{CANHERB} + V_{CANSHRUB})/2))^{1/2}) * V_{LANDBUFF})^{1/2}$ River Bottom Communities: $(((((V_{SPECRICH}+V_{WIS}+V_{INVASIVES})/3)*(V_{CANHERB}))^{1/2}) * V_{LANDBUFF})^{1/2}$	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) $(((V_{VEGSTRATA}+((V_{CWD}+V_{FWD}+V_{LITTER})/3))/2) * V_{LANDBUFF})^{1/2}$	The capacity of the wetland to support animal populations and guilds by providing heterogeneous habitats.
Function 10: Maintain Interspersion and Connectivity (INTERSPERS) $(((V_{FREQ}+V_{TOPO}+V_{CONTIG}+V_{TRIB})/4) * V_{LANDBUFF})^{1/2}$	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 pf the wetland to permit access for terrestrial or aerial organisms to contiguous areas of food and cover.

Selecting and Modifying the HGM Models

In the HGM methodology, an 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 00.00 represents low functional capacity for the wetland and 1.0 represents high functional capacity for the wetland.

FCU is the unit of measure of the ability of a wetland to perform a certain function and is calculated by multiplying an FCI by the area of the wetland. FCI x acreage = FCU. When evaluating restoration alternatives, with-project FCU will be compared to without-project FCU. The change in FCU will be the unit of measurement of the outputs from restoration measures.

Environmental Output

Baseline (existing conditions) results for the Rio Salado Oeste Project area are shown below in Table IV-8. These results show that riparian and wetland habitats within the study area have low functional values and are therefore highly degraded. Figure IV-9 below depicts the FCI graphically.

Table IV-8: Baseline Conditions Analysis Results

Function	Function Name	Baseline FCI	Baseline FCU
01	Maintenance of Characteristic Channel Dynamics	0.23	41.4
02	Dynamic Surface Water Storage/Energy Dis.	0.42	74.9
03	Long Term Surface Water Storage	0.25	45.2
04	Dynamic Subsurface Water Storage	0.44	78.3
05	Nutrient Cycling	0.28	49.6
06	Detention of Imported Elements and Compounds	0.38	66.9
07	Detention of Particulates	0.33	58.9
08	Maintain Characteristic Plant Communities	0.42	74.8
09	Maintain Spatial Structure of Habitat	0.30	53.1
10	Maintain Interspersion and Connectivity	0.23	40.1
	AVERAGE/TOTAL	0.33	583

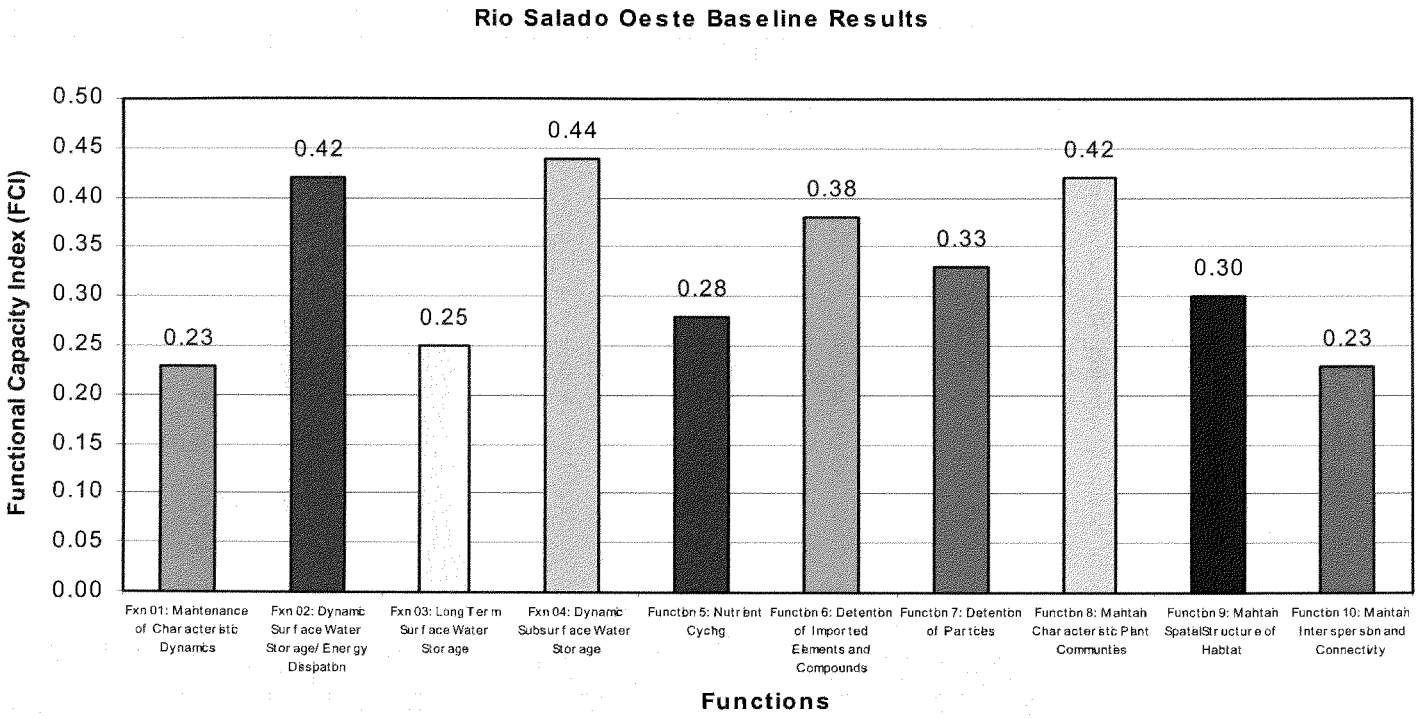


Figure IV-9: FCI for the Rio Salado Oeste Study Area

4.2.7 Hazardous, Toxic, or Radioactive Waste

The presence of Hazardous, Toxic, and Radioactive Wastes (HTRW) within the study area was evaluated for the study. Because of the size of the project study area, approximately 20 square miles total, a typical Phase I ESA was not possible. Consequently, a Modified Phase I ESA was decided to be most appropriate for the size of the project. The basic difference is that a site reconnaissance of every property within the project area would not be conducted, as infeasible. The Modified Phase I ESA was conducted to review past and current land use practices along the site corridor to identify areas of known or suspected contamination that may environmentally impact the subject property. URS completed the assessment under contract to the City of Phoenix. The entire report is found in Appendix F of this report.

The Modified Phase I ESA was accomplished by, and limited to, a visual reconnaissance of the site from existing rights-of-way and public areas, a drive-by survey of the site corridor (or vicinity), a review of publicly available records (including aerial photographs), and a review of pertinent documentation presently and readily available from the client and/or through URS' standard resources. The site corridor is defined as the neighboring properties and facilities along the Salt River within an approximate distance of 1 mile north and south of the river's centerline, the nature of which may adversely affect or have affected environmental conditions at the site due to the presence and/or release of hazardous substances or petroleum products to the environment. The following activities were conducted in accomplishing the Phase I ESA:

- Review of aerial photographs
- Review and interpretation of available archival topographic maps, historical land use maps of the site for information regarding historical site land use that could have involved the manufacture, generation, use, storage and/or disposal of hazardous substances
- Review of the following State and Federal agency lists of known or potential hazardous waste sites, and sites currently under investigation for potential environmental violations as prescribed by the American Society for Testing and Materials. All databases were

searched for areas approximately 1 mile from the Salt River centerline to include the project corridor study area (or buffer area):

Federal National Priorities List (NPL) site list

Federal Comprehensive Environmental Response, Compensation, and Information System (CERCLIS) list

Federal Resource Conservation and Recovery Act (RCRA) CORRACTS TSD facilities list

Federal RCRA non-Corrective Action Report (CORRACTS) Treatment, Storage, and Disposal (TSD) facilities list

Federal RCRA generators list

Federal Emergency Response Notification System (ERNS) list

State lists of hazardous waste sites identified for investigation or remediation:

State-equivalent NPL

State-equivalent CERCLIS

State landfill and/or solid waste disposal site lists

State LUST lists

State-registered UST lists

- Review of previous environmental reports conducted within or relating to the Oeste study area
- Performance of an onsite visual reconnaissance of the subject property and the area within 1-mile of the Salt River centerline in each direction to make visual observations of existing site conditions, activities, and types of land use and businesses within the project corridor area

Sites identified with possible HTRW concerns are for the most part outside the 100-year floodplain and location where project features would be located. Project features are located within the 100-year floodplain and avoid the known HTRW sites. In accordance with Engineer Regulation 1165-2-132, the Corps would not participate in clean up of materials regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or by the RCRA.

4.2.7.1 "Wildcat" Dumping

"Wildcat" or uncontrolled, random dumping of materials has occurred and continues to occur along the river and study area. This dumping includes soils, concrete, asphalt, household and landscape waste, etc. The reach between 35th and 51st Avenues was at one time littered with such waste materials. However, the City of Phoenix has implemented changes that significantly reduced the amount of dumping in this through barricades and increased policing. It should be assumed that some waste is still present within the study area.

4.2.7.2 Landfills

There are three closed landfills within the study area. These include the 27th Avenue Landfill which was closed in 1995, and the SRP landfill (North of the river at 67th Avenue), closed in 2000. The 19th Avenue landfill, located east of 19th Avenue, has been closed and a remediation plan has been implemented. Groundwater monitoring is conducted at the landfills. Although these landfills are within the study area they are outside the possible location for project features and should not have any impact on the project.

4.2.7.3 Leaking Underground Storage Tanks (LUSTs)

Thirteen LUST sites with monitoring wells on record with ADWR were identified within the study area. Description of the sites can be found within Appendix D, Groundwater Quality and Hydrogeology Report. These sites may have impacts to local soil and water conditions but are not considered likely to affect the project to be implemented within the floodplain.

4.2.8 Cultural Resources

4.2.8.1 ***Prehistory***

Paleoindian and Archaic

Thus far there are no known Paleoindian sites in the Phoenix Basin or surrounding environs. Little is known of the archaic occupation of the area, but newly acquired excavation data is becoming available. The current construction boom in Scottsdale has required new surveys,

which in turn has prompted excavation of previously unknown archaic sites. Presently, much of that information is locked up in unpublished, possibly proprietary reports.

Hohokam

The principal prehistoric cultural manifestation in the project area is the Hohokam culture. Hohokam is a Pima word that means "those who have gone" (Gladwin and Gladwin, 1933), or more poetically, "those who have vanished" (Wormington, 1973). The name Hohokam has endured and is still the preferred name in spite of the renaming of some other prehistoric cultures being renamed. The four southern O'odham tribes crafted a policy statement that stated, "We recognized Indian Tribes have mutually agreed to promote and protect the archaeological artifacts and remains of our ancestors, the Hohokam..." (SRPMICC, 1989).

4.2.8.2 History

The potential value of the Salt River was realized when, in 1867, John W. "Jack" Swilling first ventured from Wickenburg to John Y. T. Smith's Hay Station, approximately 4 miles from present-day Phoenix (Granger, 1960). In 1867, as a farmer visiting Smith's Hay Station, he observed the long, low earthen ridges radiating out from the Salt River and concluded that these were the remnants of a long-forgotten irrigation system (SRP, 1979; Myers, 1961). This observation prompted him to envision the irrigation potential of the Salt River.

Other canals followed Swilling's Ditch, developing the agricultural potential of the Salt River Basin. The Maricopa Canal was completed in 1869, the Arizona Canal in 1887, and the Highlands Canal was constructed in 1888. The early canals were beset by their own problems stemming from Salt River floodwaters. Flooding washed out the diversion dams, leaving the headgates high and dry and rendering them useless (Walker and Bufkin, 1986). A number of the historic canals were reconstructed from the old Hohokam canals. The only functional difference between the Hohokam and modern canals is the lack of drop structures and drainage canals in the Hohokam systems, according to Nials and Gregory (1989).

By 1871, Phoenix was an official town. The number of townspeople had risen to 300, a far cry from the old Smith Hay Station: population 1. All the original lots had been sold and the town

was formally mapped. Phoenix was one-mile-long and one-half mile wide, and encompassed 96 blocks. Washington Street was the first main street running east-west. The Salt River Valley Post Office was moved to Phoenix, and the first County election was held. In 1872, the 320-acre town site of Phoenix was officially filed in Prescott.

4.2.8.3 ***Previous Work in the Study Area***

The earliest known archaeological work in the vicinity of the Rio Salado Oeste project area included Adolph Bandelier and Frank Cushing's studies in the 1880s of Pueblo Grande, approximately 15 miles to the east (Downum and Bostwick, 1993:17-21), and investigations of the prehistoric Hohokam canals (Hodge, 1893; Patrick, 1903).

The eastern portion of Cashion Ruin was recorded by Frank Midvale in 1923. Turney documented the western portion of Cashion Ruin in 1925 with updates in 1929 and 1935. Cashion Ruin was recorded again and trenched in 1939 by Audie R. Kelley as part of the Salt River Valley Stratigraphic Survey financed by the U.S. Works Progress Administration and headquartered at Pueblo Grande Museum under Director Odd Halseth (Downum and Bostwick 1993:212-220).

Glen Rice (personal communication 1999) said that Midvale's Canal Cashion may not have actually been a canal, and that Midvale's site map was of an area south of the site's actual location. During the Museum of Northern Arizona's (MNA's) excavation of the Cashion Site, Antieau (1981) noted that he was unable to locate the Canal Cashion and three Casa Grande-type ballcourts, probably due to this locational error. Midvale mapped all the ruins in the Palo Verde project area right-of-way in 1967 and in some cases corrected Turney's locations (cf. Legend on Midvale's map of the Cashion ruins in Antieau (1981:42). Antieau's excavations verified that Turney was correct and Midvale was incorrect (Antieau 1978).

Following Turney, Frank Midvale developed an interest in prehistoric irrigation and spent the 1920s, 30s, and 60s investigating every lead he could in an attempt to retrace the flow of irrigation water through the Salt-Gila Basin (Antieau 1981:8). He had also mapped the 5 sites that were excavated by the MNA for the Palo Verde Nuclear Generating Station Wastewater Conveyance System.

The Cashion site, NA 14690, was excavated by the MNA in 1977 and 1978 (Antieau 1981). Midvale originally mapped the Cashion site in 1927 when he called it Los Conejos (Antieau 1981:144). Estimated to cover approximately 640 acres, the Cashion site was listed on the National Register of Historic Places on December 19, 1978 (Reference No. 78000547). It is the largest site excavated near the confluence of the Salt and Gila Rivers, one of the largest and the most complex in the Salt-Gila River Valley (Stein, 1977), and it equals Snaketown in size (Antieau, 1981). Encompassing dates from A.D. 500 - 1150, the Cashion site was occupied from the Pioneer through the Classic Periods (Stein, 1977; Antieau, 1981). By the end of the Classic Period, Cashion was largely abandoned.

4.2.8.4 Records and Literature Search

For the purposes of the record and literature investigation, the following description was used. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to approximately Baseline Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres, and almost entirely of the outfalls and adjacent or nearest terrace.

A literature search of the proposed project APE was performed through the Arizona State Museum, Arizona State Office of Historic Preservation, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed the APE.

4.2.8.5 Recommendations

Geoarchaeological investigations were conducted for the Tres Rios project (Onken et al. 2004), which provide a very good reconstruction of the floodplain history just west (downstream) of the Rio Salado Oeste Project, at the junction of the Salt and Agua Fria Rivers with the Gila River. The results of the Tres Rios geomorphological investigation suggest that 94% of that project area has no or low sensitivity for buried prehistoric sites.

Given the Oeste project's location upstream of Tres Rios, it is reasonable to conclude that the alluvial stratigraphy of the lower Salt River might be comparable. The entire length of the Salt River within the Oeste project boundary appears to have been more disturbed than downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. A letter was sent to the Arizona State Historic Preservation Officer (SHPO) on July 6, 2005 with our determinations in accordance with 36 CFR 800.4(d). We received a letter of response dated August 10, 2005. This letter concurred with the APE as described in Section 4.4.5 above. The SHPO requested a written report of the survey conducted by Corps personnel. A Memorandum of Record (MFR) was completed describing the survey conducted in March 2004. Copies of all these documents can be found in the EIS.

All supporting documentation required under 36 CFR 800.11(d) has been provided to the SHPO, this includes the draft environmental impact statement (EIS). The archeologist representing the City of Phoenix has received copies of SHPO communications in addition to a copy of the draft EIS.

4.2.8.6 Native American Concerns

Section 106 of the National Historic Preservation Act, as amended 16 U.S.C. 470 et seq. and the American Indian Religious Freedom Act of 1978, Public Law 95-341, 42 U.S.C 1996 require consultation and Coordination with Indian Tribal Governments all require that government agencies consult with Native Americans to determine their interests in federal projects.

Letters including project descriptions and requests for comments were sent to the interested tribes noted below on July 6, 2005. The MFR was transmitted to the tribes on October 6, 2005. Ak-

Chin Indian Community, Gila River Indian Community, Hopi Tribe, Pascua Yaqui Tribe, Salt River Pima-Maricopa Indian Community, Tohono O'odham Nation, and Yavapai-Apache Nation. The draft EIS has been provided to the above groups for comment.

4.2.9 Socioeconomics

Benefits and costs for flood damage reduction analysis was computed at FY05 price levels, but was recomputed at 5 1/8%. Costs for the restoration and recreation alternatives are FY06 price levels, and we are using 5 1/8%. Since no flood damage reduction alternatives are being pursued, additional price level update of the structure inventory was not necessary. The period of analysis is 50 years. The Base Year for economic computations is 2010.

4.2.9.1 Flood Damages

SRP maintains four dams on the Salt River, as well as two on the Verde River, of which only one dam on the Salt River has flood-control capacity. Granite Reef Diversion Dam is located about 5 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 SRP is forced to release water over Granite Reef Dam into the normally dry Salt River.

Historical Flood Damages

The highest release from Granite Reef Dam since the construction of the Salt and Verde River dams occurred in February 1980, when 178,000 cfs was released because of heavy rains and rapid snowmelt in the watersheds. All downstream bridges through Phoenix were forced to close during that flood except the Central Avenue Bridge. Subsequently, most of the remaining bridges crossing the Salt River have been rebuilt to withstand flow rates of 200,000 cfs and greater. (However, the Roosevelt Dam has been modified so it is unlikely that such a large release would occur.)

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 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.

Floodplain Boundaries

An inventory of structures possibly susceptible to damage, and estimates of the value of these structures must first be developed in order to determine potential flooding damages. Floodplain boundaries depicted in Appendix A were used to determine properties susceptible to flooding up to the 500-year floodplain. The Rio Salado Oeste 500-year floodplain encompasses a large area, primarily to the south of the Salt River.

The floodplain has been further segmented into sub-areas, or Reaches, for analysis purposes. Those reaches are shown in Table IV-9 below. Critical factors used to determine reach boundaries include discharge/frequency characteristics, overflow spatial characteristics, and economic activity. Table IV-9 below provides a summary of reach characteristics, including approximate upstream and downstream boundaries.

Table IV-9: Floodplain Reach Definitions

Reach Name	Upstream Limit	Downstream Limit	Notes
1L	75th Ave.	91st Ave.	Only a few structures in this reach
2L	67th Ave.	75th Ave.	Small number of large-lot industrial and agricultural properties/structures along Southern Ave.; some residential development along Baseline Road
2R	67th Ave.	75th Ave.	Small number of structures at northwest corner of Roeser & 67th
3L	51st Ave.	67th Ave.	Under existing conditions, reach includes residential development at downstream end – northwest of Baseline and 67th. Removed under Base Year conditions
4L	43rd Ave.	51st Ave.	Small number of structures along 51st Ave. north of Southern
4R	43rd Ave.	51st Ave.	Includes a few structures just west of 51st Ave. adjacent to floodway
5L	35th Ave.	43rd Ave.	Large residential development in this reach on south side of Salt River; most of development removed from floodplain under Base Year conditions
5R	35th Ave.	43rd Ave.	Mostly industrial structures, concentrated south of Lower Buckeye, between 35th and 39th Aves
6L	27th Ave.	35th Ave.	Limited industrial/commercial development, primarily along Broadway Road
6R	27th Ave.	35th Ave.	Mostly industrial structures, concentrated along east side of 35th Ave., Lower Buckeye to floodway
7R	19th Ave.	27th Ave.	Small number of structures near 27th Ave. on north side of Salt River under existing conditions – removed under Base Year conditions

* 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. Table IV-10 shows that there are approximately 386 structures in the Rio Salado Oeste 500-year floodplain. Of these, 59 percent are residential (single-family residential/multi-family housing [SFR/MH]). Roughly 139 structures are located within the 100-year floodplain boundaries (about 36 percent of the structures in the 500-year floodplain). Reach 5L contains the majority (51 percent) of floodplain structures. This area contains numerous structures, primarily residential (including both single-family residences and mobile homes). Structures in this area are generally of fair to low-cost construction. Most single-family residential structures are of

block construction. The other area with the greatest number of structures is within Reach 6L (19 percent), east of 35th Avenue on the south side of the Salt River.

Table IV-10: Number Of Structures

Structure Type	100-Year	500-Year
SFR	15	207
MH	19	22
Industrial	78	114
Office/Commercial	27	43
Public	0	0
Total	**139**	**386**

Without-Project Damages

Expected annual damages by reach and structure type are shown on Table IV-11. Damages to industrial and agricultural structures and contents, primarily located in Reaches 2L and 5R, comprise most of the expected annual damages. This is attributable to the fact that these two reaches contain structures in close proximity to the floodway, and therefore are susceptible to more frequent flood events. It should be noted that these results reflect planned bridge improvements at 35th Avenue. Preliminary analysis indicates that expected annual damages without these improvements would be substantially higher (approximately $670,000 vs. $235,000).

Without-project damages by event for Base Year conditions, as calculated by the HEC-FDA program (see Table IV-11). 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 20-year event are approximately $1.14 million. A majority of these damages are attributable to one parcel within Reach 5R. There are approximately 11 industrial structures on this parcel (located adjacent to the floodway on the west side of 35th Avenue) owned by a metal scrap recycling business.

Table IV-11: Without-Project Damages by Reach & Event (Base Year – 2010)

(in $1,000s)

Reach	10-year	20-year	50-year	100-year	500-year
1L	$ -	$ -	$ -	$ 1	$ 13
2L	$ -	$ 88	$ 754	$ 1,183	$ 1,561
2R	$ -	$ -	$ -	$ 8	$ 30
3L	$ -	$ -	$ 10	$ 87	$ 254
4L	$ -	$ 4	$ 52	$ 90	$ 125
4R	$ -	$ -	$ -	$ -	$ 10
5L	$ -	$ -	$ 59	$ 1,163	$ 4,039
5R	$ 38	$ 1,050	$ 2,615	$ 3,929	$ 5,633
6L	$ -	$ -	$ 52	$ 378	$ 1,056
6R	$ -	$ -	$ 2	$ 78	$ 659
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 38	$ 1,142	$ 3,544	$ 6,917	$ 13,380

Damages increase significantly for the 50-year event, and approximately double subsequently for the 100-year and 500-year events. A majority of the damages for these flood events are expected to occur in Reaches 5R and 2L (primarily industrial properties) and 5L (which is the reach with the large residential development discussed previously).

4.2.9.2 Demographics

Population

The southern portion of the study area lies in the southwest portion of the City of Phoenix, which has a total population of 1,321,045 (U.S. Census Bureau, 2000). Table IV-12 shows the 2000 population and household characteristics for the county and study area. In 2000, the county population totaled 3,072,149 (U.S. Census Bureau, 2000). The 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, respectively (MAG, 2002). The study area makes up only 0.1 percent of the total county population (U.S. Census Bureau, 2000).

Table IV-12: 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	3,027,366	2.67	763,110	3.21
Study Area	48,854	11,504	3.93	9,362	4.20
Source: U.S. Census Bureau, 2000					

Population Projections

Table IV-13 displays population estimates and growth projections for Maricopa County and the City of Phoenix, obtained from the MAG and U.S. Census Bureau Web sites. Strong growth for the county and city is expected through year 2050, although the rates of growth will be substantially lower than those experienced in the past decade.

Table IV-13: Projected Population and Annual Growth Rate (AGR) for Maricopa County and the City of Phoenix

Year	Maricopa County	AGR	City of Phoenix	AGR
1995	2,529,000		1,154,000	
2000	3,072,000	4.0	1,321,000	2.7
2010	3,710,000	2.0	1,544,000	1.6
2020	4,516,000	2.0	1,796,000	1.5
2050	7,265,000	1.6	2,568,000	1.2

Source: U.S. Census Bureau and Arizona Department of Economic Security

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.

Ethnicity

The approximate population breakdown of the county by ethnicity is 66.2 percent White, 24.8 percent Hispanic, 3.5 percent African American, 1.4 percent American Indian and Alaskan Native, 2.1 percent Asian, 0.05 percent Native Hawaiian or other Pacific Islander, 0.1 percent other races, and 1.5 percent two or more races (U.S. Census Bureau, 2000). The ethnic composition of the study area differs from that of the county as a whole, most notably in the proportions of White and Hispanic residents (refer to Table IV-14). The proportions of the other

races do differ as well, although not as much. The approximate population breakdown in the study area is: 24.3 percent White, 62.0 percent Hispanic, 5.9 percent African American, 6.2 percent American Indian and Alaskan Native, 0.3 percent Asian, 0.06 percent Native Hawaiian or other Pacific Islander, 0.09 percent other races, and 0.85 percent more than two races.

Table IV-14: 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%
Rio Salado Oeste Study Area	11,714	2,918	3,019	166	31	47	30,543	416
Percent of Study Area Total	24.0%	6.0%	6.2%	0.3%	0.1%	0.1%	62.5%	0.9%

Source: U.S. Census Bureau, 2000

Income

Table IV-15 shows median household income for residents within Maricopa County and the study area for the year 1999. In 1999, the median household income for the county was $45,358; the median household income for the study area was substantially less, at $27,847 (U.S. Census Bureau, 2000).

Table IV-15: Median Household Income in the Vicinity of the Study Area

Jurisdiction	Median Income Amount
Maricopa County	$45,358
Study Area	$27,847

Source: U.S. Census Bureau, 2000

Additional demographic information can be found in Appendix F, Modified Phase I Environmental Site Assessment, and Appendix G, Economic Evaluation.

4.2.10 Real Estate

The majority of the land within the project area is privately owned. Within the floodplain, or the area where restoration measures will be proposed, this ownership includes sand and gravel companies, the State of Arizona, Maricopa County, and the City of Phoenix (Figure IV-10). The City of Phoenix currently owns approximately 511 acres in the project area and has a Recreation and Public Purposes Lease on an additional 159 acres of Bureau of Land Management property. A general summary of ownership of land within the 100-year floodplain is presented in Table IV-16. See Appendix G, Economic Evaluation, for more details.

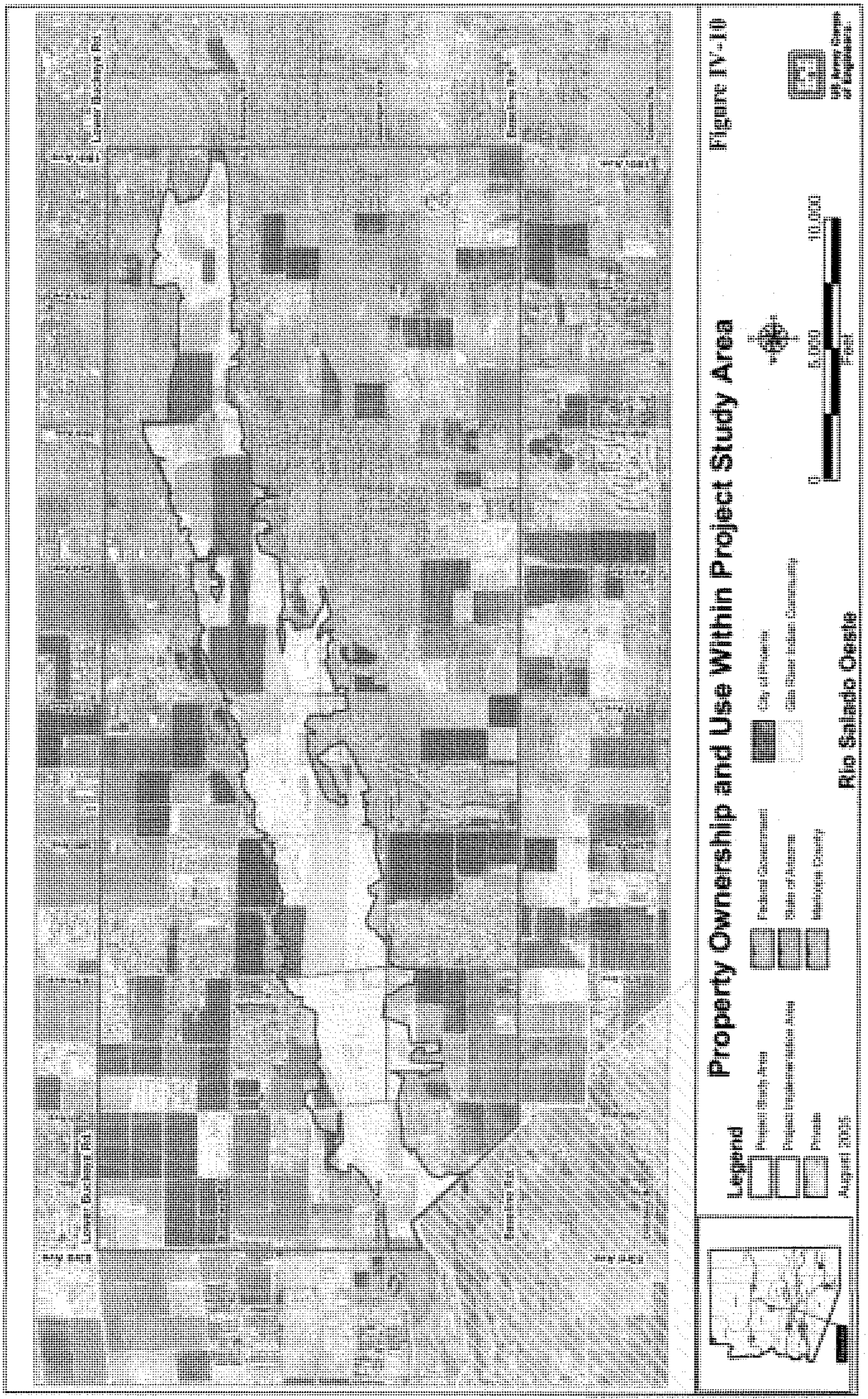
Table IV-16: Property Ownership within the Study Area (100-Year Floodplain)

Owner Type	Acres
City of Phoenix	511
Maricopa County	118
State of Arizona	261
Federal	190
Private	2094
Total	3174

4.2.11 Recreation

4.2.11.1 Nearby Recreation Resources

Arizonans place high importance on the State's outdoor recreation resources. In the 1994 Statewide Comprehensive Outdoor Recreation Plan survey, 94 percent of respondents stated that parks and recreation areas are important to their everyday lifestyles. 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, although it is likely that many visitors would be drawn from even greater distances.


Property Ownership and Use Within Project Study Area
Figure IV-10
Legend
Rio Salado Oeste

Estrella Mountain Regional Park, South Mountain Park, and Papago Park are three of the largest recreation areas nearby the study area. Estrella Mountain Regional Park is owned and managed by the Maricopa County Parks and Recreation Department. The rugged and scenic Sierra Estrella Mountains are the most dominant features of Estrella Mountain Regional Park. The terrain of these mountains is characterized by very steep slopes, numerous rock out-crops, shallow soils, and sparse desert vegetation.

South Mountain Park is located about 3 miles south of the Salt River. It 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 United States. It is bounded on the north by Baseline Road and on the south by Chandler Boulevard, and is over 3 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 exceeds 2 million.

In addition to South Mountain Park, the Phoenix Mountain Preserve is the other major mountain-preserve area in greater Phoenix. Located in the northeastern section of the city, the Phoenix Mountains comprise 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, Phoenix Mountain Park (formerly Squaw Peak), and Shaw Butte recreation areas. These parks include extensive trails systems, picnic areas, and

restrooms. North Mountain recreation area also features basketball and volleyball facilities and a playground. The combined visitation at North Mountain and Phoenix Mountain Park and Recreation Area has totaled approximately 1.5 million in recent years.

Study Area Recreation Resources

Recreation in the study area 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 portion of the Salt River that passes through the City of Phoenix has, until the recently authorized Rio Salado and Tres Rios Projects and the upstream Tempe Town Lake, consisted of dry river bottom. As a result, virtually no recreation activities took place.

The only improved recreation area adjacent to the Salt River was Rio Salado Park, which is located at 12th Street and Elwood. The park encompasses about 14 acres and contains picnic facilities and racquetball and basketball courts. Most of the users are employees who work at industrial businesses located in the area. According to the City of Phoenix Parks Department, fewer than 200 people visit the park on a weekly basis (or fewer than 10,400 annually). There are currently no plans for expansion of the park, and visitation is not expected to increase in the absence of a Corps project.

The following shows the names and annual visitation for other community parks in the Phoenix area.

Table IV-17: Parks and Annual Visitors for Community Parks

Park	Visitation	Features
Hayden Park	121,000	14 acres, with picnicking, softball, basketball, playground, restrooms
Estaban Park	58,000	62 acres, with picnicking, softball, soccer, volleyball, tennis, playground, restrooms
El Prado	61,000	40 acres, with swimming pool, softball, picnicking, playground, restrooms
Cesar Chavez	310,000	353 acres, with 25-acre lake with fishing/sailing/canoeing, picnicking, restrooms
Encanto	1,200,000	63 acres, with fishing lagoon, 18-hole golf course, clubhouse, swimming pool, racquetball, tennis, basketball, softball, children's play area
Echo Canyon	350,000	387 acres with hiking trails.

The Rio Salado Project stretches from an upstream limit of 28th Street to a downstream limit of 19th Avenue (which is the upstream limit for this study) and comprises environmental restoration and passive recreation components along the Salt River. Approximately 5 miles (and 580 acres) of the Salt River will be restored to create riparian and wetland habitat. Passive recreation facilities, including over 10 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, an equestrian staging area, signage, and landscaping. Recreation activities provided by the plan include walking, hiking, biking, horseback riding, rollerblading, 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 expected to exceed 500,000.

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 2 miles downstream. The river's flood control conveyance capacity is retained through the use of a system of rubber dams that 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.

While water is a highly attractive feature for recreationists, park trails and facilities have presently been planned away from the Gila River. Once the county completes its Sun Circle Trail System through this reach of the Gila and Salt Rivers, recreation use patterns are expected to expand throughout the study area. The Sun Circle Trail, a component of the National Recreation

Trail system, is a 110-mile loop encompassing the Phoenix metro area. The trail offers a unique opportunity for hiking, horseback riding, and bicycling throughout the urban area. Approximately 70 percent of the Sun Circle trail system is in place. The county has an agreement with the FCDMC to establish the Sun Circle Trail within the flood control district corridor from Skunk Creek to the Gila River–Salt River confluence. The Rio Salado Oeste Project is an excellent opportunity to designate a segment of the Sun Circle Trail. This would benefit Tres Rios, Rio Salado, and Rio Salado Oeste with a major nonmotorized travel way connecting the three river-restoration projects to the other valley areas.

Educational Opportunities

There are no formal environmental-education opportunities associated with the existing Salt River corridor in the study area. As agricultural land near the river is converted to residential, the need for recreation will increase. The 27th Avenue Solid Waste Recycling Facility (just north of the river) has an existing environmental-education master plan. The facility provides tours for children and adults. The 23rd Avenue WWTP also does environmental-education programming and touring for water treatment. These existing facilities provide an opportunity to link environmental education that could be developed for a restored river corridor. Upstream of the study area, the Rio Salado Project will include over 10 miles of trails, an environmental-education facility, and passive recreation opportunities. Passive recreation facilities are also planned downstream for the Tres Rios Project. There are opportunities to link recreation facilities at the study area with those that will be constructed upstream and downstream.

4.2.12 Summary of historic and existing conditions

As can be seen by the existing conditions presented in this section, the problems associated with this reach of the Salt River are significant. Federal dams constructed in the early 1900s on the upper Salt and Verde Rivers have limited flows in the lower Salt River. In pre-settlement times, the Salt River was one of the few perennial streams supporting riparian areas of the 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 was degraded significantly. The upstream Federal water

projects curtailed year-round water flows and converted the once perennial Salt River into a dry riverbed devoid of habitat. In addition, the area is experiencing rapid growth and most areas adjacent to the river have been or are being developed. Only sporadic vegetation exists in the study area today, and those few native vegetation communities are seriously degraded. However, many opportunities to address problems through environmental restoration measures do exist. Since recreation opportunities in the study are limited and since recreation is compatible and desired in conjunction with ecosystem restoration, they will be evaluated during plan formulation. Although not repeated in this chapter, detailed description of additional resources and areas of environmental compliance are included in the companion Environmental Impact Statement.

4.3 EXPECTED FUTURE WITHOUT-PROJECT CONDITION (2010-2060)

The future without-project condition is defined as that condition expected to exist in the absence of any action taken (by the Federal Government) to solve the stated problems. 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.

4.3.1 Hydrology

The hydrologic analysis for Rio Salado Oeste first considered baseline conditions. Baseline flow rates for the Salt River were available from a 1996 Corps analysis of the river, completed as part of a modification project for the Roosevelt Dam. This report contained flow rates for the 5-, 10-, 25-, 50-, 100-, and 500-year events along the river at Central Avenue and 67th Avenue. The flow rates at these two locations were similar to each other for each event, and overall the flow rates varied from 20,000 to 240,000 cfs with the 100-year event equating approximately 166,000 cfs. The values presented from this analysis were for baseline hydrologic conditions.

For future hydrologic conditions, the same flow rates as the baseline conditions were used. However, a continuous hydrograph of the Salt River was used to simulate the erosion and deposition for the study reach. This hydrograph had a period of record from 1889 to 1993, and

the worst 50-year period (1889 to 1938) effectively represented the period of record for use in the future-conditions models. The peak flow in this period was about 190,000 cfs, which placed it between the 100- and 500-year events in magnitude. After the sediment simulation, the n-year flood events described above were used to simulate the future without-project condition. For purposes of ecosystem restoration it was assumed that base flow is virtually non existent with the exception of storm water runoff and effluent which is discussed in Section 4.2.4 Water Supply.

4.3.2 Hydraulic Conditions

For the hydraulic analysis of current conditions, the effective HEC-RAS (RAS) model that was created as part of the FEMA Flood Insurance Study of this portion of the Salt River was used. The cross sections from this model that were located between 19th Avenue and 91st Avenue were extracted and supplemented with additional cross sections. Terrain data for all of these cross sections was mostly acquired from a TIN terrain data set created for the Salt/Gila River Master Plan completed in 1992. Additional terrain data were taken from available two-foot contours and 30-meter Digital Elevation Maps. Other changes made to the effective RAS model included slight modifications to the Manning's *n* values, the addition of new bridges at 27th and 51st Avenues, and the adjustment of the ineffective flow areas. The discharges used in this model were taken from the 1996 Corps report mentioned earlier. It is unclear how these flows compared to the flows found in the effective FEMA model.

The results of these updated baseline models were compared to the effective FEMA model. From the downstream end of the models to River Station 204.25, the profiles were essentially identical. At this location, the geometries began to differ between the two models, and this difference caused the updated model to have an elevation 0.45 foot higher than the FEMA model. Between Stations 204.34 and 205.15, the differences between the models increased, with the FEMA model calculating elevations 0.6 to 2.54 feet higher than the updated model. In this area, most of the differences were attributed to variations in the placement of ineffective flow areas. Between Stations 205.25 and 206.51, the two profiles approached each other to within 0.4 foot. However, between Stations 206.6 and 207.07, where there are mining pits within the channel that were handled differently by each model, the updated model produced elevations 0.53 to 2.07 feet higher than the FEMA model. At cross section 207.34, the updated model was 0.78 foot higher,

but the difference approached zero at sections 207.48 and 207.49. By Station 207.53, the updated model was 0.49 foot higher. Between Stations 207.62 and 208.75, the models once again produced nearly the same results, but between cross sections 208.85 and 209.24, the update model generated values 0.46 to 2.15 feet higher. Over the remainder of the models, which extended from Station 209.42 to 211.54, the models produced significantly different results based on the differing geometries used to represent the 35th Avenue Bridge.

For analysis of future without-project conditions, the changes to the bed profile were predicted over the next fifty years due to erosion. The geometry from the current conditions RAS model were used to create a sediment-transport model. The sedimentation model used was HEC-6T, and this model produced results within 10 percent or within 1 foot of the depths in the existing conditions RAS model, whichever was smaller, for the 5-, 10-, and 100-year events under fixed bed conditions.

The Corps program SAMAID was used to determine the most appropriate sediment transport relationship, and this investigation determined that Madden's 1985 modification of Laursen's equation and Yang's equation were the best and second best choices, respectively. Based on its use of Yang's equation in previous studies of the Salt River upstream and downstream of this project's extent, Yang's equation was chosen to model the future conditions sediment transport.

The sedimentation model was then run over a 50-year period using the Salt River hydrograph from 1889 to 1938, and bed profiles were output at the end of each ten-year interval. For ease of modeling computations, all of the relevant 105 years of historical discharge information were effectively represented by needing only to simulate the period of record from 1989 to 1939. In addition, the constructed continuous 50-year hydrograph also reflects Salt River flood flows that have been normalized by flow regulation at the upstream Roosevelt Dam. The results of this model were used to create the geometry for the future-conditions RAS model. Overall, areas along the Salt River with ongoing mining operations experienced the greatest changes. In areas where mining was not present, the bed changes reached a maximum of 5.8 feet after 50 years with an overall average change of 1.9 feet.

Five new RAS models representing future conditions in 10, 20, 30, 40, and 50 years were created from the bed profiles predicted by the HEC-6T model. Otherwise, the future RAS models used parameters identical to those found in the existing-conditions RAS model. Overall, the future-conditions RAS models had smoother water surface profiles based on a smoothing of the stream bed over time. The major differences in water surface elevation occurred upstream of the 35th Avenue Bridge, with the future RAS models predicting lower water surface elevations due to erosion at this bridge. There are some other small stretches of the Salt River where moderate decreases in water surface elevations occur over time, but overall the future conditions RAS models mostly predicted decreases in the water surface profile of less than 1 foot within the study reach.

4.3.3 Biological Resources

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. 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. These include a number of open water areas that are essentially old or abandoned borrow pits resulting from sand and gravel mining. Dense vegetation dominated by tamarisk or salt cedar, with some cottonwood and willows as well as the occasional cattail or bulrush, lies adjacent to some of these abandoned pits. Without the project, the biological resources within the study area are expected to continue to degrade. Without modifications to improve the functional components and improve the efficiency and effectiveness of the water resources available the diversity of species that are currently supported are expected to decline, and most of the remnant high value habitat (cottonwood, willow, and mesquite bosque) would be replaced with undesirable invasive plant species would become or devoid of vegetation altogether.

Habitat Evaluation

Table IV-18 below displays cover types and projected acreages in the study area (100-year floodplain only) and how they are projected to change under future without-project conditions.

Figure IV-11 shows that the without-project AACFU output is forecast to remain essentially unchanged (the slight decline from 583 AAFCU to 579 AAFCU is due to rounding error).

Key assumptions in projecting the future conditions include:

- All remaining agricultural land (133 acres) will be developed within five years.
- Remaining cottonwood/willow forest will decrease from 112 acres to 25 acres over 50 years due to reduced water supply, increased urbanization, and expansion of non-native saltcedar.
- Emergent wetlands will decrease slightly from 30 to 25 acres but will remain in areas of surface discharge and stormwater outfalls. O&M activities at these outfall locations will disturb and result in periodic reductions in quantity and quality of the existing emergent wetland areas
- The amount of dry river bottom is expected to increase from 66 acres to 71 acres, as the wetlands are lost.
- The amount of open water will decrease from 240 to 80 acres as other uses for effluent and dewatering are established. Existing areas of open water will likely be converted to bare earth or support undesirable low-value and/or non-native and invasive species, eventually converting to scrub-shrub and desert-wash cover. The amount of scrub shrub will increase from 1,566 to 1,653 acres.
- It is not possible to project acreage changes in sand and gravel operations, but it is assumed that some operations will go out of operation while others start operating. In general, these activities would migrate downstream, to the west end of the study area following the urban development.
- The reduction in water supply and decrease in surface flows will result in the reduction and/or elimination of one of the key mechanisms that drive many biochemical and biogeochemical processes that are associated with movement and cycling of nutrients.

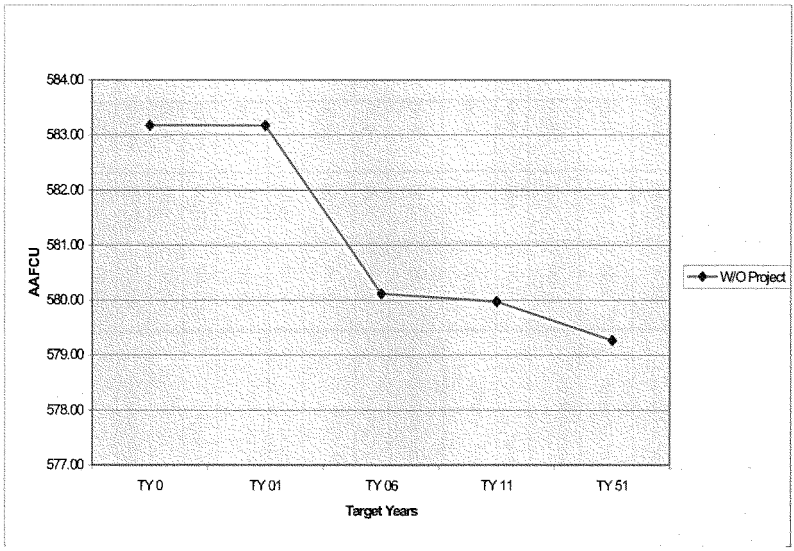


Figure IV-11: Future Without Project

- No establishment of new: cottonwood/willow forest, wet river bottom, emergent wetlands, open water, or mesquite woodlands or bouquets is expected.
- There will be a decrease in the connectivity and spatial structure of the remnant high-value cottonwood/willow strands and a disconnect between the authorized Rio Salado Restoration and Tres Rios Demonstration Projects.
- The biological diversity within the study area is expected to decrease with the reduction in high valley cottonwood/willow forest for cover, breeding, nesting, foraging, and fledging activities. The reduction of open water and emergent wetland areas reduces and/or eliminates a key habitat or life history/cycle component for many native wildlife species and neo-tropical migratory songbirds and over-wintering waterfowl and wading birds.
- The disturbance from unregulated recreation, OHV traffic, and "wildcat" dumping is expected to continue and potentially increase in some areas, further degrading the riparian system and the remaining higher value remnant habitat it currently supports.

Table IV-18: Cover Types and Projected Acres Without Project

COVER	DESCRIPTION	Target Year 0	Target Year 01	Target Year 06	Target Year 26	Target Year 51
AGCROP	Farms and croplands in the uplands - dairy, cotton, and alfalfa	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing cottonwood/willow forests in the active channel	112.00	112.00	80.00	50.00	25.00
DITCHES	Existing ditches in the uplands	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing emergent wetlands in the uplands - cattails, cienegas and grasses	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing mesquite woodlands - on the terraces and in the active channel	0.00	0.00	0.00	0.00	0.00
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00
NEWCWWFOR	Newly planted cottonwood/willow forests in the active channel	0.00	0.00	0.00	0.00	0.00
NEWDRYRVRBOTTOM	Newly developed dry river bottom areas in the active channel – largely unvegetated	0.00	0.00	0.00	0.00	0.00
NEWMESQUIT	Newly planted mesquite woodlands - on the terraces and in the active channel	0.00	0.00	0.00	0.00	0.00
NEWOPENWAT	Newly developed open water in the active channel	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing open water in the active channel - inactive sand and gravel operations	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing river bottom in the active channel - largely unvegetated	66.00	66.00	71.00	71.00	71.00
SCRUBSHRUB	Existing scrub-shrub lands in the active channel - rabbitbush, quailbush, ironwood, and saltbush	1566.00	1566.00	1598.00	1628.00	1653.00
SANDGRAVEL	Existing sand and gravel operations/extractions in the active channel	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00
URBAN	Existing residential, industrial and transportation avenues in the uplands	327.00	327.00	460.00	460.00	460.00
	TOTAL ACRES:	3148.00	3148.00	3148.00	3148.00	3148.00

4.3.4 Land Use

Based upon the City of Phoenix General Plan (Revised February 2001), most of the land area on the north side of the Salt River between 19th Avenue and 59th Avenue is zoned as industrial, with some high-density residential between 43rd Avenue and 60th Avenue. From 60th Avenue to 83rd Avenue, the primary land use is low-density residential. South of the Salt River, there is some land between 19th Avenue and 35th Avenue zoned as commercial. Otherwise the prevailing land use designation is low- to medium-density residential. Estrella Village and Laveen Village are the two primary planning areas that lie adjacent to the Salt River between 19th Avenue and 83rd Avenue. Estrella Village is characterized by an ample supply of undeveloped land, large parcels, natural and scenic amenities, and excellent transportation access. As noted on the City of Phoenix Web site, the village also poses unique challenges given the isolation of its existing residential neighborhoods and the extensive industrial activities that have developed over the years. Approximately 62 percent of the Village is undeveloped, either vacant or with agricultural uses. However, there are 21 residential developments in various phases of approval and development (Figure IV-12). Over 8,000 new single-family housing units were

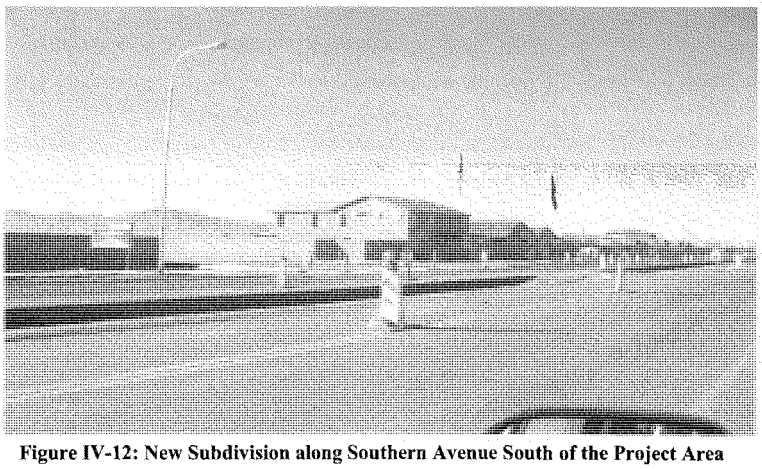


Figure IV-12: New Subdivision along Southern Avenue South of the Project Area

approved in this area in 1999 alone. Primary agricultural crops grown in the area include cotton, citrus, and corn. Farmers, equestrians, and those looking for solitude and mountain access have valued the area.

Land use is quickly changing within the study area as farmland is quickly converted to residential subdivisions, and associated commercial development follows. The study team assumed that within 5 years the lands adjacent to the floodplain would all be developed in some way, maybe sooner. Lands within the floodplain, however, are not expected to be developed unless by future aggregate operations or closure of existing operations.

4.3.5 Recreation

Based upon conversations with representatives from the City of Phoenix Parks and Recreation Department, the AGFD, and other agencies, the proposed habitat and recreation features would attract visitors throughout the Phoenix Valley region. 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, although it is likely that many visitors would be drawn from even greater distances. Currently, there are no recreation features that exist in this reach of the Salt River. The activities that do take place in the river corridor in general serve to accelerate the rate of degradation. As the area degrades over time, fewer people will select the study area for recreational activities.

The Tres Rios Project just downstream of the study area will provide recreation opportunities. The Tres Rios Project is located immediately downstream of the study area, beginning at the 91st Avenue WWTP. 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. That project is currently in design and will be constructed within the next several years.

Over the period of analysis it is assumed that the City of Phoenix will develop smaller community parks in the neighborhoods surrounding the study areas.

Maricopa County has approved and begun implementation of the Maricopa Trail. The trail plan is a continuous nonmotorized trail system covering multiple jurisdictions around the county connecting regional parks. The entire loop is 242 miles and will be implemented over the next eight to ten years. The loop intersects the Salt River between 83rd and 91st Avenues and proceeds southward towards South Mountain. The Maricopa County Regional Trail System Plan identifies projects on the Salt River as potential and in the case of Rio Salado existing trail systems that would connect to the regional trail system.

4.3.6 Economics

4.3.6.1 Results – Future Conditions (2059)

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 re-compute expected annual damages under future conditions. The results are summarized in Table IV-19. A more detailed description of the estimates can be found in Appendix G, Economic Evaluation.

Table IV-19: Without-Project Expected Annual Damages – Future Conditions (2059) ($1,000)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
1L	$ -	$ -	$ -	$ -	$ -
2L	$ 4	$ 16	$ 1	$ -	$ 21
2R	$ -	$ -	$ -	$ -	$ -
3L	$ 2	$ -	$ -	$ -	$ 2
4L	$ 1	$ -	$ -	$ -	$ 1
4R	$ -	$ -	$ -	$ -	$ -
5L	$ 8	$ 4	$ 1	$ -	$ 13
5R	$ -	$ 98	$ 14	$ -	$ 112
6L	$ 1	$ 5	$ 2	$ -	$ 8
6R	$ -	$ 1	$ 1	$ -	$ 2
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 16	$ 124	$ 19	$ -	$ 159

Without-project expected annual damages actually decrease from about $245,000 under Base Year conditions to about $159,000 under future conditions (a drop of about 35 percent). Water surface elevations are generally lower throughout the study area under future conditions due primarily to projected channel degradation and resulting in creases in channel capacity (refer to Appendix A, Hydrology and Hydraulics).

Equivalent annual damages were computed based upon forecast annual damages using a discount rate of 5 3/8 percent (see Table IV-20).

Table IV-20: Without-Project Equivalent Annual Damages (50 Yrs, 5 1/8 Percent) ($1,000s)

Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
1L	$ -	$ -	$ -	$ -	$ -
2L	$ 7	$ 24	$ 2	$ -	$ 32
2R	$ -	$ -	$ -	$ -	$ -
3L	$ 2	$ -	$ -	$ -	$ 2
4L	$ 2	$ -	$ -	$ -	$ 2
4R	$ -	$ -	$ -	$ -	$ -
5L	$ 24	$ 4	$ 1	$ -	$ 29
5R	$ -	$ 126	$ 16	$ -	$ 142
6L	$ 1	$ 6	$ 3	$ -	$ 10
6R	$ 1	$ 2	$ 2	$ -	$ 5
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 37	$ 161	$ 24	$ -	$ 222

As shown on Table IV-21, equivalent annual damages are concentrated in a few reaches. Reach 5R accounts for about 60 percent of total without-project damages. This reach contains a small concentration of industrial structures along 35th Avenue, primarily south of Lower Buckeye Road. There are several parcels with multiple structures that are within the 50-year floodplain, and just outside the 20-year floodplain. The risk and uncertainty analysis indicates that these structures may be flooded by events more frequent than the 20-year event.

Table IV-21: Without-Project Equivalent Annual Damages (in $1,000s)

Reach	Structure and Content	Cleanup	Temp. Housing	Total
2L	$ 32	$ 10	$ 0.4	$ 42
3L	$ 2	$ 1	$ 0.1	$ 3
4L	$ 2	$ -	$ 0.1	$ 2
5L	$ 29	$ 4	$ 0.9	$ 34
6L	$ 10	$ 3	$ 0.1	$ 13
Total - S. of River	$ 75	$ 18	$ 1.6	$ 95
5R	$ 142	$ 5	$ -	$ 147
6R	$ 5	$ 0.5	$ -	$ 6
Total - N. of River	$ 147	$ 6	$ -	$ 153
Total	$ 222	$ 24	$ 2	$ 247

Note: Damages for Reaches Not Shown are Minimal

On the south side of the Salt River, Reach 2L has the highest amount of expected annual damages. Damages in this reach are attributable to the proximity of several structures to the floodway on the north side of Southern Avenue between 75th and 67th Avenues.

The highest concentration of residential damages is located in Reach 5L. Although there are nearly 200 structures in this reach, damages are limited due to the low per-unit structure values and because most are outside the 100-year floodplain. Most of the structures in this reach are located just southwest of Broadway Road and 35th Avenue.

The only other reach with significant damages is Reach 6L. This reach includes industrial and commercial structures located along Broadway Road between 35th and 27th Avenues.

Impact of Assumed Rio Salado Marsh on Without-Project Damages

Under existing conditions there is potential for flood damages in the study area. However, the planned improvements to the 35th Avenue Bridge and the Rio Salado Marsh that will take place from 37th to 51st Avenues virtually eliminate the potential for damage in the adjacent reaches. Additional floodplain delineations showing Base Year floodplain boundaries with both the bridge improvements and the channel excavation have not been prepared. However, water surface profiles have been developed, and an analysis of these water surface profiles shows that the potential for flooding in the 35th Avenue area is greatly reduced.

A detailed analysis of without-project flood damages reflecting the assumed Rio Salado Marsh between 37th and 51st Avenues has not been completed. However, water surface profiles have been developed for with-project alternatives that reflect the impacts of both the excavation and the features of the alternatives. It has been determined that the impacts of the excavation, particularly in Reach 5 area, are significant. In fact, it appears that the additional channel capacity created by this excavation will greatly reduce the potential for any flooding in this area. As this was the primary damage area under previous assumptions, the removal of the flood threat for this area essentially leaves only minor residual flooding, primarily in Reach 2, under without-project conditions.

CHAPTER V
PLAN FORMULATION AND EVALUATION

This chapter presents the results of the plan formulation process used in the development of alternatives to address the planning objectives for the Rio Salado Oeste 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. Each plan is evaluated for its ability and extent of meeting the specified planning objectives and constraints, as well as 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 to each other. A benefit-cost analysis is conducted to prioritize and rank flood damage reduction alternatives. 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 displaying Federal interest. A locally preferred plan may be recommended and approved if the non-Federal sponsor desires other acceptable project features than those in the National Economic Development (NED) or National Ecosystem Restoration (NER) Plans.

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. Although they are considered in plan formulation they should not be confused with planning objectives for which solutions will be formulated or plans recommended. 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 initial public meeting was held on September 13, 2001. Meetings and presentations were also held with the Rio Salado and Tres Rios Advisory Committees to seek stakeholder and agency input. Areas of concern included technical considerations based upon the specifics of the study, vector control, flood damage reduction, and opportunities for recreation. Additional public meetings are being scheduled to correspond with release of the Draft Feasibility Report.

The planning effort included extensive involvement by the various offices of the City of Phoenix, as well as agencies (e.g., USFWS, FCDMC, AGFD). Numerous plan formulation workshops and 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.

5.2.2 Problems

- 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 plants, no longer exist 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.

- The construction of dams has reduced natural flooding. Records show that there were two to four floods per year prior to dam construction in 1941. These changes in the river system have adversely impacted the surface/groundwater interactions and sedimentation dynamics that are important for sustaining and regenerating riparian vegetation.

- The greater Phoenix area is lacking in significant riparian habitat areas with supporting recreation facilities. The major 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. There are no formal existing recreation or environmental-education opportunities associated with the existing river corridor. As agricultural land near the river is converted to residential, the need for recreation will increase. The 27th Avenue Solid Waste Recycling Facility (just north of the river) has an existing environmental-education master plan. The facility provides tours for children and adults. The 23rd Avenue WWTP also does environmental-education programming and touring for water treatment.

- Land use changes, including landfills and sand and gravel mining, bridges, pipes, stabilization measures, and outfalls, have degraded and are contributing towards continued degradation of the river corridor.

- Unsuitable bank conditions exist at many locations. Surface dumping and manmade bank changes have resulted in a degraded and unsafe bank in many locations.

- Previous reports identified the existence of contaminated sediments, including contamination by DDT, from approximately 51st Avenue continuing downstream. The contaminated sediments have been documented to extend continuously in the Salt-Gila River corridor all the way to the Corps-owned-and-operated Painted Rock Dam, near Gila Bend, Arizona. Although a previous report cited concern about the presence of DDT in the sediments from 51st Avenue downstream, there has not been a recent detection of it within the project area.

- Flooding and drainage problems exist in the Salt River. Contributing to these problems are flooding and drainage issues addressed by the Laveen and Durango Area Drainage Master Plans, which are being prepared by the MCFCD.

- Contributing interior drainages lack current hydrology information at all discharge points into the Salt River. Adequate points of disposal do not exist at many interior drainage discharge locations.

- There is a flooding problem on the south side of the river, within the 100-year floodplain, between 67th Avenue and 75th Avenue.

- Existing cultural resources need protection from erosion and vandalism.

- The extent and significance of existing cultural resources are unknown.

5.2.3 Opportunities

- There is an opportunity to restore degraded river and adjacent overbank area by restoring perennial base flow conditions. There is an opportunity to link other upstream and downstream projects to provide a continuous restoration and flood control corridor.

These would include the authorized Rio Salado Project and the authorized Tres Rios Project.

- There is an opportunity to utilize groundwater for restoration and other needs, as agricultural groundwater pumping phases out. This opportunity may be the greatest in the Laveen area.

- There is an opportunity to simulate the natural flood regime to sustain and regenerate riparian vegetation.

- There is an opportunity to increase recreation opportunities by taking advantage of existing open water bodies, locations in the river, and adjacent properties as potential recreation sites (i.e., public fishing areas). There is also an opportunity to incorporate trails and other passive recreational features. The existing WWTPs on 27th Avenue and 23rd Avenue provide an opportunity to link environmental education that could be developed for a restored river corridor.

- There is an opportunity to reduce and/or modify land use changes (i.e., landfills and sand and gravel mining, bridges, pipes, stabilization measures, and outfalls) that have degraded and are contributing towards continued degradation of the river corridor.

- There is an opportunity to restore degraded and unsafe banks in the river corridor.

- There is an opportunity to remove contaminated sediments from portions of the study area. This would be a local sponsor responsibility.

- There is an opportunity to reduce flooding and drainage problems in the Salt River floodplain including along the south side of the river between 67th Avenue and 75th Avenue.

- There is an opportunity to protect existing cultural resources from erosion and vandalism.

- There is an opportunity to document the extent and significance of existing cultural resources.

- There is an opportunity to use effluent water from the 23rd Avenue WWTP to supplement surface water and groundwater sources for restoration and other needs. The plant produces a high quality effluent, which meets the water quality standards for numerous uses including Partial Body Contact, Fish Consumption, Aquatic and Wildlife (effluent dependent), Agricultural Irrigation, and Agricultural Livestock.

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 the 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 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 indices (not monetary units).

One purpose of this feasibility study is to determine if ecosystem restoration with incidental flood damage reduction and recreation in this reach of the Salt River are consistent with the Federal objectives stated above.

5.3.2 Specific Planning Objectives

Clear statements of specific planning objectives and constraints act as basic building blocks for developing alternative management measures and plans to alleviate stated problems and achieve opportunities. 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, specific planning objectives were identified for this feasibility effort. The water and

related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. The planning objectives listed below reflect the problems and opportunities and represent desired positive changes along the Rio Salado Oeste reach:

- Restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish, and wildlife species.
- Reduce flood damages to infrastructure and structures.
- Improve passive recreation and environmental-education opportunities.

5.3.3 Planning Constraints

The feasibility of restoring the river over this reach will be challenging. Surface water from storm drains and shallow aquifer groundwater is of poor quality and sporadically available. Land adjacent to the study reach causes additional challenges. Once the mining operations in the area are concluded, the final configuration of the abandoned operations will place additional land use burdens on the community.

These problems, however, may become integral components of the environmental restoration of the river. Abandoned gravel operations can be incorporated as water features into a restoration plan. Water quality improvement can be obtained through incorporation of wetlands into the restoration plan.

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in the reconnaissance study and considered in this feasibility study are as follow:

- In the 2000 reconnaissance report it was stated that, "51st Avenue to Painted Rock Dam may soon be designated as a state superfund site." This constraint was listed due to a study finding organochlorines in the Salt and Gila Rivers. Since then there has been no listing of the area as a "state superfund site" but the reach is on the EPA 303(d) list of impaired waters. The Arizona Department of Environmental Quality is planning to initiate monitoring and investigations in 2008 and complete TMDLs in 2010 to deal with

the legacy pollutants (DDT, toxaphene, and chlordane). There are no known site-specific areas of contamination that may affect a restoration project.

- Coordination is required with Federal Aviation Administration (FAA) to minimize bird strikes within a 5-mile radius of the Sky Harbor International and Goodyear airports. FAA's regulations oppose open water within 10,000 feet of the airport operational taxiway. In addition, safety must be kept as a priority within a 5-mile radius of the airport. However, the Rio Salado Oeste study area is well outside the zone of concern of local airports.
- Proposed restoration features must be coordinated with the proposed South Mountain Freeway, which will cross the river corridor.
- Existing Federal, State, county, tribal, and private land ownership, including sand and gravel ownership and leases, will impact real estate appraisals and acquisitions.
- Issues associated with existing landfills must be incorporated into plan formulation efforts. The plan must not alter the migration of contamination plumes from landfills nor increase leachate from existing landfills.
- AMA water conservation requirements associated with the State of Arizona Groundwater Management Act must be adhered to.
- The project must not impact the safety of existing bridges.
- Because the introduction of water bodies could provide increased opportunities for mosquito breeding, vector control should be incorporated into the design, operation, and maintenance aspects of the project.
- The existing level of flood protection must be maintained. The addition of vegetation must not compromise the level of flood protection in the channel. Project-induced bank erosion must be avoided.
- Potential damage to restored habitat areas from flood flows should be prevented. Restoration features should benefit from, or take advantage of, the infrequent flood flows, with a goal towards self-sustaining regeneration and recruitment from restored seed sources.

- Restoration features and implementation must be compatible with continued operation of sand and gravel mining in the river corridor.
- The proposed project must have strong public support.

5.4 DEVELOPMENT OF ALTERNATIVE PLANS

Alternative plans were developed during this feasibility study to meet the specified problems and opportunities and planning objectives and constraints. As such, the alternatives described in this feasibility report are not proposals for actual construction, nor are they of sufficient design detail to be constructed. Following the completion of the feasibility report, EIS, public feedback, and project authorization by Congress, if such action occurs, detailed design analysis and preparation of plans and specifications would take place.

Alternatives plans have been formulated in consideration of current Federal, State, and local planning and environmental guidance, laws, and policy concerning ecosystem restoration, flood damage reduction, recreation, water quality, and related purposes, to:

- Comply with the National Environmental Policy Act (NEPA) and other environmental laws and regulations.
- Restore a diversity of riparian and associated floodplain fringe habitats to a more natural state.
- Provide an acceptable means of capturing storm water or relocating other existing water sources and conveying it into restored habitat areas.
- Maintain or enhance existing conveyance of peak discharges and ensure that the system of stormwater collection would not increase flood flows or worsen flooding conditions downstream in existing developed areas.
- Address specific flooding problems within the floodplain.
- Produce NER benefits while positively contributing to the NED Account, Regional Economic Development (RED) Account, and the Other Social Effects (OSE) Account.
- Provide decision-makers with information that could be utilized to help determine the balance between construction costs, real estate costs, and social issues and concerns.

- Provide a framework for responding to future urban development in the floodplain consistent with Executive Order 11988.
- Match existing and proposed improvements, where possible, to take advantage of local improvements and to be consistent with the future master planning efforts of the local community.

5.5 ALTERNATIVE DEVELOPMENT AND EVALUATION PROCESS

The feasibility study process involves successive iterations of alternative solutions to the defined problems. These solutions are based upon the study objectives and constraints and address problems and opportunities that have been previously defined. As part of Federal guidelines for water resources projects, there are general feasibility criteria that must be met. According to USACE Engineering Regulation (ER) 1105-2-100 for planning, a project in a Feasibility Report or GRR must be analyzed with regard to the following four criteria:

Completeness Does the plan include all necessary parts and actions to produce the desired results?

Effectiveness Does the alternative substantially meet the objectives? How does it measure up against constraints?

Efficiency Does the plan maximize net NER and/or NED benefits?

Acceptability Is the plan acceptable and compatible with laws and policies?

In the initial phase of the study, measures were developed to satisfy the four feasibility criteria. This initial list of measures to be evaluated (Section 5.6) was based on public input and suggestions, experience with similar projects, and technical considerations based upon the characteristics of the area.

An assessment of the need for flood damage reduction measures is presented in Section 5.7.1. The combination of measures for ecosystem restoration that formed a preliminary array of 20 alternative plans is addressed in Section 5.7.3. After the initial analysis and screening of the preliminary alternative plans, a secondary array of twelve more refined alternative plans was developed (Section 5.7 4). Key features common to the alternatives are described in more detail in Section 5.7.5. Section 5.8 describes the final array of five action alternatives. Each alternative

plan was then independently evaluated and compared to the No Action Alternative. The final array of alternatives was analyzed and compared to use as the basis for selecting the recommended plan (Section 5.9).

5.6 PRELIMINARY MANAGEMENT MEASURES

A management measure is a feature or activity at a site that addressed one or more of the planning objectives. A wide variety of measures are being considered, some of which may be found to be infeasible due to technical, economic, or environmental constraints. Each measure will be assessed and a determination will be made regarding whether it should be retained in the formulation of alternative plans. Descriptions of the preliminary measures considered in the reconnaissance phase of the study are presented below.

- **Create Water Supply:** A water supply and distribution system will be formulated as part of the feasibility study. The system is required in order to return some form of surface (base flow) and groundwater hydrology to the river, as required to support the other objectives. Potential sources of water supply include discharges from the 23rd Avenue WWTP, groundwater, groundwater wells, storm-drains and other interior drainage tributaries. Therefore, human intervention and infrastructure measures would be required in order to reestablish base flow conditions.

- **Establish Mesquite Bosque:** Establish mesquite trees at higher elevations from the river bottom. These areas would include terraces and overbank areas. Low-water-use irrigation or site conditions would need to be implemented in order to establish and maintain the mesquite trees. Once established, mesquite trees are expected to not require continuous water supply or maintenance.

- **Create Cottonwood/Willow Gallery:** Plant and establish cottonwood and willow tree plant communities along the wetted perimeter (fringe area locations within the river). The adjacent fringe areas where the plants would be established include the areas around existing open water areas, created wetlands, and flowing water.

- **Establish Wetlands:** Establish wetlands at appropriate locations in order to create a diverse and high-value project habitat. Appropriate locations for wetlands would be

determined during the feasibility phase, but typically involve river backwater areas or ponded water locations.

- **Incorporate Existing Ponds:** Utilize existing open-water areas created by abandoned gravel mining operation to create habitat and recreation areas. The habitat and recreation would take advantage of the existing open-water value to further increase project outputs.

- **Create Base Flow:** Return the conditions of a perennial environment to the study area. This linear feature would also support appropriate plant communities, such as cottonwood/willow galleries and aquatic riparian vegetation.

- **Incorporate Vector Control:** Incorporate mosquito-control measures as an integral part of the selected plan design and maintenance.

- **Clean-Up Debris:** Clean-up debris and reshape the bank and channel where manmade changes have occurred, to create a suitable restoration substrate. This is expected to be site specific and details would be determined during the design phase.

- **Improve Levee/Channel:** Evaluate flood control levees and/or channel improvements to improve conveyance capacity at flood problem locations.

- **Create Recreational Corridor:** Incorporate trails and other passive recreational features in support of the other restoration management measures. In addition to trails, these features could include access locations, signage, and comfort stations to support eco-recreation activities.

- **Consider Cultural Resources Mitigation:** Incorporate cultural resources mitigation features, if feasibility analysis determines cultural mitigation is required as part of the recommended plan.

Locally implemented non structural measures for restoration such as allocation of water for restoration, zoning controls, elimination of aggregate mining, land set asides, re-operation of Salt River Project Dams, and BMP's were also recommended for consideration. However, most of these measures are both impractical and publicly infeasible. Allocation of water, zoning controls and land set asides by themselves would not provide a solution to the

degradation that has occurred and the existing zoning regulations and Best Management Practices contribute to reducing the decline of remaining habitat value to the extent possible. Re-operation of dams and elimination of aggregate mining are both infeasible and publicly unacceptable solutions as they would affect both the regional water supply and economy.

5.7 ALTERNATIVE DEVELOPMENT

The eleven preliminary measures described above were refined and incorporated into the development of alternatives discussed below. Those refinements and modifications to alternatives were completed in plan-formulation meetings with numerous study participants, and took into account study findings and public/agency input.

5.7.1 Flood Damage Reduction

Evaluation of flood damages and solutions to reduce those damages was a large part of this study. The flood damage reduction analysis was performed first to determine what measures could be implemented to reduce damages and if they were economically justified. Alternatives evaluated to reduce flood damages included levees, channelization, floodwalls, and relocation. Those alternatives focused on reducing damages from the 100- and 500-year events. While there are damages from the more frequent events (see Appendix G, Economic Evaluation) those damages are mainly to a single parcel and are less likely to be economically justified for flood damage reduction measures than the larger, less frequent events. After completing an initial evaluation of flood damage reduction measures, a proposed plan to modify the reach of river between 35th and 51st Avenues was proposed by the City of Phoenix. That plan, described in section 3.1.5 Rio Salado Marsh, is considered to be part of the future without-project and future with-project condition. Most damages previously considered as without-project conditions are reduced by that action. Results of the analysis below are left in this report for informational purposes.

5.7.1.1 Structural Measures

Structural measures include construction of structures to reduce damages and are most effective when damages are concentrated. In this case, damages are most concentrated in Reach 5. Although there are damages in Reach 2L, the structures are dispersed and the construction of

levees or channels in that reach does not appear to be feasible, either technically or economically.

Levees: Two levee scenarios were evaluated including extension of a levee for approximately 5,000 feet along the north bank and for approximately 6,000 feet along the south bank (Figure V-1). These levees encompass most of Reaches 5 and 6. Each levee would have a top width of 12 feet and a slope of 3:1. A 100-year level of protection for the two reaches would be approximately 3 feet high and a 500-year level would be 6 feet high. Construction of levees on both banks would be necessary to prevent flooding on

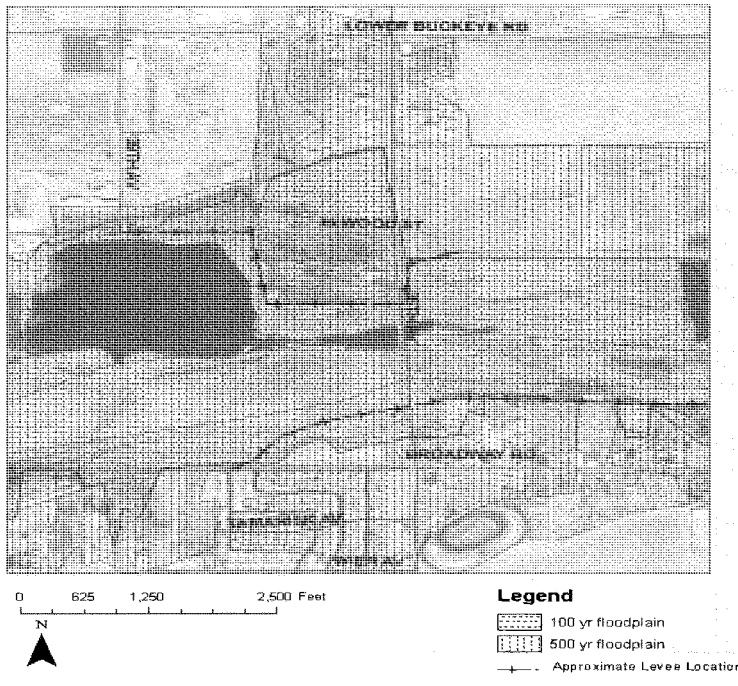


Figure V-1: Approximate Levee Locations

the opposite bank of the river. Since the damages within the two reaches appeared to be marginal for justifying levee construction, a preliminary construction estimate was calculated. This estimate used unit costs from the Tres Rios Project downstream to develop a preliminary estimate of $2,022,000.

Channel: Excavation and construction of a low-flow channel to pass flood flows for both the 100- and 500-year events were calculated. The excavation required for the Reaches 5 and 6 Channelization Alternative extends from Station 209.69 to 208.1, a distance of 1.59 miles, and includes excavation of approximately 1.4 million cubic yards (c.y.) of material. Modeling showed that for the 500-year level of protection this excavation would need to extend from Station 210.7 to 207.9, a distance of 2.27 miles, and would require the removal of approximately 2.4 million c.y. of material. Cost estimates for this alternative were estimated at $9.3 million for the 100-year and $16.6 million for the 500-year level of protection.

Results

For a flood control alternative to be feasible and economically justified, the benefits that it delivers (damages reduced) must exceed the costs to implement.

Levee: Table V-1 shows that the cost of implementation is more than the benefits produced from constructing levees. This analysis was preliminary to determine if further refinement of the structural alternatives and more detailed estimates were warranted. The results with benefit/cost ratios of less than 1:1 led the study team to consider other alternatives to reduce flood damages.

Table V-1: Benefit/Cost Analysis - Levee Improvements

	Without Project	100-Year	500-Year
EAD			
Reach 5L	$ 32,400	$ 29,800	$ 10,300
Reach 5R	$ 127,800	$ 53,900	$ 12,800
Total	$ 160,200	$ 83,700	$ 23,100
Annual Benefits			
Reach 5L		$ 2,600	$ 22,100
Reach 5R		$ 73,900	$ 115,000
Total		**$ 76,500**	**$ 137,100**
First Cost		$ 2,148,000	$ 2,636,000
IDC		$ 60,000	$ 73,000
Investment Cost		$ 2,208,000	$ 2,709,000
Annual Cost		**$ 133,000**	**$ 163,000**
Net Benefits		($56,500)	($25,900)
Benefit/Cost Ratio		**0.58**	**0.84**

Note - Does not include any Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs and does include the Lands, Easements, Rights-of-way, Relocations, and Disposal Areas (LERRD) estimate.
EAD = Equivalent Annual Damages
IDC = Interest During Construction

Channel: Table V-2 below summarizes the analysis of benefits for channelization of the reaches of the river where damages are greatest. The cost of implementation significantly exceeds the benefits that could be expected.

Table V-2: Benefit/Cost Analysis – Channel Improvements

	Without Project	100-Year	500-Year
EAD			
Reach 5L	$ 32,400	$ 6,100	$ 800
Reach 5R	$ 127,800	$ 48,900	$ 20,600
Reach 6L	$ 14,300	$ 2,900	$ 1,900
Reach 6R	$ 4,800	$ 400	$ 200
Total	$ 179,300	$ 58,300	$ 23,500
Annual Benefits			
Reach 5L		$ 26,300	$ 31,600
Reach 5R		$ 78,900	$ 107,200
Reach 6L		$ 11,400	$ 12,400
Reach 6R		$ 4,400	$ 4,600
Total		**$ 121,000**	**$ 155,800**
First Cost		$ 10,019,000	$ 17,819,000
IDC		$ 278,000	$ 494,000
Investment Cost		$ 10,297,000	$ 18,313,000
Annual Cost		**$ 619,000**	**$ 1,101,000**
Net Benefits		$ (498,000)	$ (945,200)
Benefit/Cost Ratio		**0.20**	**0.14**

Note - Does not include any Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs or Lands, Easements, Rights-of-way, Relocations, and Disposal Areas (LERRD) costs.
EAD = Equivalent Annual Damages
IDC = Interest During Construction

5.7.1.2 Non-Structural Measures

Non-structural measures reduce flood damages without significantly altering the nature or extent of flooding by changing the use of the floodplain or accommodating existing structures within the floodplain. The non-structural measures evaluated here include floodwalls and relocation. Cost estimates for nonstructural measures were adapted from the National Flood Proofing Committee.

Flood Walls: Concrete floodwalls that are confined to specific parcels were evaluated. Elevations of either 2 or 4 feet high were the options considered. Parcels that could be protected with a floodwall were identified. Estimates were made of the length of floodwall around each structure necessary to prevent inundation. It was assumed that

floodwalls would be more suited to and more likely to be feasible for commercial/industrial rather than residential structures.

Relocation: Purchase and relocation of structures within the floodplain was evaluated also. This would include purchase of a property at fair market value, allowing the owner to relocate to a different location. Relocation was considered only for residential structures; relocation of commercial/industrial structures is highly unlikely to be feasible.

Results

Table V-3 below summarizes the results for those parcels that were evaluated either for floodwalls or for relocation. The results of the benefit/cost analysis were negative for all but one individual parcel. The Economic Evaluation (Appendix G) presents a more detailed analysis that was completed for that parcel. The parcel is a scrap-metal processing facility located at the northwest corner of the 35th Avenue Bridge. Because the property is occupied by a single owner/beneficiary, it is not eligible for Federal involvement in a cost-shared flood damage reduction project. However, the preliminary analysis shows that construction of floodwalls at that structure may be feasible. The single owner/beneficiary issue does not preclude local or private interests from implementing such measures to reduce damages.

Summary

Analysis of flood damages within the study reach showed that there are approximately $236,000 in expected annual damages to structures. The area with the most damages is the industrial area between 35th and 43rd Avenues on the north of the river. Damages also occur in Reach 5R, with additional damages across the river in Reach 5L in an area including residential, commercial, and industrial property. Reach 2L is made up of large-lot industrial and agricultural properties, but these are widely dispersed in the floodplain.

However, flood damage reduction alternatives do not meet the criteria for being economically justified at this time as the costs to implement the measures exceed the damages that they would prevent. One parcel did have a benefit/cost ratio greater than 1:1 and flood damage reduction measures may be economically justified, but Federal policy prohibits single-beneficiary

Table V-3: Non-Structural Flood Damage Reduction Alternatives

Rio Salado Oeste

Non-Structural Flood Damage Reduction Alternatives - Preliminary Benefit/Cost Analysis (in $1,000s)

		Relocation Benefit/Cost Analysis			2' Floodwall Analysis					4' Floodwall Analysis			
Parcel	Approx EAD ($1,000s)	Estimated Reloc Costs	Reloc. Costs Annualized	Relocation B/C	Cost/Parcel	Annualized	Max Benefit	Approx Benefits	Approx BC	Cost/Parcel	Annualized	Approx Benefits	Approx BC
10544007B	$ 4.9				$ 280	$ 17.5	$ 4.9	NJ		$ 411	$ 25.6	NJ	
10546004B/4G	$ 83.4				$ 331	$ 20.6	$ 83.4	$ 24.2	1.17	$ 486	$ 30.3	$ 51,161	1.69
10471005	$ 0.6				$ 284	$ 17.7	$ 0.6	NJ		$ 417	$ 26.0	NJ	
10471007Y	$ 0.9	$ 79	$ 4.9	0.18									
10471007X	$ 1.9	$ 88	$ 5.5	0.34									
10471007F	$ 2.0	$ 179	$ 11.1	0.18									
10471015	$ 7.8				$ 123	$ 7.7	$ 7.8	$ 4.9	0.63	$ 181	$ 11.3	$ 6.5	0.57
10471014	$ 4.2				$ 72	$ 4.5	$ 4.2	$ 3.1	0.70	$ 105	$ 6.5	$ 4.2	0.64
10471007L	$ 2.5				$ 128	$ 8.0	$ 2.5	NJ		$ 188	$ 11.7	NJ	
10471013A	$ 2.4				$ 129	$ 8.0	$ 2.4	NJ		$ 189	$ 11.8	NJ	
10483003C	$ 5.3				$ 155	$ 9.7	$ 5.3	NJ		$ 227	$ 14.2	NJ	
10483002N	$ 0.8	$ 269	$ 16.7	0.05									
10463004A	$ 1.0	$ 44	$ 2.8	0.37									
10569008D	$ 3.7				$ 294	$ 18.3	$ 3.7	NJ		$ 432	$ 26.9	NJ	
10568002A	$ 1.1				$ 220	$ 13.7	$ 1.1	NJ		$ 324	$ 20.2	NJ	
10550002A	$ 0.7				$ 82	$ 5.1	$ 0.7	NJ		$ 121	$ 7.5	NJ	

Relocation scenario analyzed for parcels with residential structures
Floodwall scenarios analyzed for industrial/commercial parcels
NJ = Not Justified - based upon maximum potential benefits

involvement in a project. Therefore, there is no Federal interest in primary-purpose flood damage reduction alternatives.

River channel restoration is being considered as a measure within the ecosystem restoration component of this project and may have incidental benefits of reducing flood damages. That component will be discussed further later in this report.

5.7.2 Ecosystem Restoration

Project features were developed that will meet the primary project objective of ecosystem restoration while observing the constraints. The following list of restoration measures was derived from the initial list of management measures used in the reconnaissance phase and further developed based upon experience from similar restoration projects, technical considerations based upon the study area, input from the public and non-Federal sponsor, and coordination with other agencies.

Channel Restoration: A restored channel would provide a connection through the study reach, connecting upstream and downstream projects. Restoration would be accomplished by grading and terracing to restore an active channel through the entire reach.

Stormwater Outfalls: Existing outfalls would be modified to discharge to a concrete/stone channel that flows onto the river terrace, and the water would be directed toward the low-flow channel. Within that channel there would be a low weir to capture the low flows and allow floodwaters to pass. The weir would direct flows to a stormwater wetland constructed for the purpose of harvesting and improving the water qualtity of storm water and supporting adjacent habitat. Although the wetland would in some cases be ephemeral, it would provide habitat value.

Cottonwood/Willow: This measure would restore riparian cottonwood/willow stands adjacent to water sources and low terraces throughout the study area. Cottonwood/willow would be dominated by Fremont's cottonwood (*Populus fremontii*) and Gooding's willow (*Salix gooddingii*).

Mesquite: Mesquite habitat would be restored over a potentially large portion of the project area. Mesquite bosques would be dominated by velvet mesquite (*Prosopis velutina*), with scattered screwbean mesquite (*Proposis pubescens*) and some understory shrubs such as desert thorn (Lycium spp.) palo verde (*Cercidium floridum*) and brittlebush (*Encelia farinose*), and forbs.

Wetlands: Although rare in the Southwest wetland existed in the Salt River, and other Arizona rivers, in combination with the other riparian habitat types. In less degraded systems such as the Hassuyampa, Verde or San Pedro emergent wetlands can still be found. Cattail, willow, bulrush and other emergent wetland vegetation dominate emergent wetlands found in those natural systems. Due to the porous nature of soils now found in this project area, modificatoins will be required to assist in maintaining surface water. Excavation and layering of a silt/clay soil substrate approximately 12 inches thick is assumed to be sufficient to reduce permeability.

Lakes: There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to restore the floodplain landscape and improve the functionality of these features. Although lakes are not necessarily consistent with historic, conditions they are existing features of the landscape for which restoration measures are being formulated to restore the area to a less degraded condition.

Invasive Species Control: Invasive species such as saltcedar (Tamarix spp.) and Arundo (*Arundo donax*) would require removal and management with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. Saltcedar is currently found in stands throughout the study area. Arundo, although not yet a significant problem in Arizona, is a problem in neighboring California. A stand of Arundo can be found on the south side of the river near a stormwater outfall at 43rd Avenue.

Water Supply: In addition to the stormwater runoff that would be harvested with the modificiatoin of stormwater outfalls, additional water supply would be required. Effluent from the 23rd Avenue WWTP is available for the restoration project. This

would also require construction of a pump and piping system to deliver water throughout the project area.

5.7.3 Preliminary Array of Alternatives

The preliminary measures described above were combined into alternatives with consideration of combinability and dependence. Table V-4 lists the preliminary alternatives considered for implementing ecosystem restoration. Development of those alternatives assumes that restoration of all specific habitat types is dependent on both water supply and control of invasive species. It was also assumed that restoration in the vicinity of the gravel pits (lakes) is dependent on both restoration of various riparian habitats and water supply.

Ctiteria were established to determine what alternaive plans to consider further. Those criteria are listed below. The criteria are meant to be a qualitative evaluatoin as to whether the plans meet minimum standards for being carried forward and evaluated in detail.

5.7.3.1 Screening Criteria

Principles and Guidelines describes the use of four evaluation criteria, two of which were applied at this phase of plan formulation. The other two criteria (efficiency and acceptability) not considered at this time will be evaluated and compared to the final set of alternatives in more detail, and described later in the report.

Completeness: "Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects".(P&G Section VI.1.6.2(c)(1)). This is the consideration as per whether the alternative includes all of the necessary actions to carry out the objective. The table below lists + or – depicting whether or not the team thought the individual alternative contained all necessary components to achieve the objective of restoration.

Effectiveness: "Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities." (P&G Section VI.1.6.2(c)(2)). In order to provide an initial measurement of how the effectiveness of the alternatives contribute to the planning objective (restoration) they were considered against the potential for restoring the most significant habitats. The significance of

riparian habitat has been discussed earlier in this report. Restoration goals pertaining to different riparian habitat cover types were developed with the recommendation of the USFWS and AGFD. Those include in priority order: cottonwood/willow, mesquite, wetland, and open water. To be minimally acceptable for further consideration it was decided that to be effective an alternative needs to include restoration of at least two significant habitat types.

Flooding: Since this is an urban environment with development adjacent to the river the consideration of induced flooding is an important one. Alternatives that install significant vegetation to the floodplain—but neither include channel restoration nor restrict the location of that vegetation—could raise water surface elevations and should be avoided. Therefore those alternatives were dropped from further consideration at this point in the study.

This preliminary screening of alternatives reduced the 20 alternatives to 12, including no action. It was meant to narrow the focus to those alternatives that are suitable for further detailed consideration.

Table V-4: Preliminary Screening of Possible Alternatives

#	Description	Complete	Effective	Flooding
1	No Action	-	0	Y
7	Water Supply	-	0	Y
8	Water Supply, Invasive Control	-	0	Y
2	Invasive Control	-	0	N
3	Channel Restoration	-	1	N
4	Channel Restoration, Invasive Control	-	1	N
9	Water Supply, Channel Restoration	-	1	N
10	Water Supply, Channel Restoration, Invasive Control	-	1	N
11	Water Supply, Channel Restoration, Emergent, Invasive Control	-	1	N
12	Water Supply, Channel Restoration, Mesquite	+	2	N
13	Water Supply, Channel Restoration, Mesquite, Emergent, Invasive	+	2	N
14	Water Supply, Cottonwood, Channel Restoration, Invasive	+	2	N
15	Water Supply, Cottonwood, Channel Restoration, Emergent, Invasive	+	2	N
5	Storm Water	+	3	N
6	Storm Water, Channel Restoration	+	3	N
16	Water Supply, Cottonwood, Channel Restoration, Mesquite, Invasive	+	3	N
17	Water Supply, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
18	Water Supply, Storm Water, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
19	Water Supply, Lake, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
20	Water Supply, Lake, Storm Water, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N

Note: Effectiveness: Numbers designate number of habitat cover types that would be restored by that alternative. For example the number 2 indicates that 2 habitat types would be restored.
+ or – indicate if that alternative meets the subject criteria as described.

5.7.3.2 Alternative Formulation Rationale

The above alternatives are combinatoins of measures that could be implemented at any location within the study area. The next step in formulating alternatives was to begin placing these features into suitable locations within the project area. For that purpose, measures have been broken into two categories: site-specific and systemic.

Site-Specific Measures:

Site-specific measures are dependent on the location of a specific feature already in place, such as a gravel pit, channel, or stormwater outfall. Site specific conditions at the various locations throughout the study area provide opportunities for restoration.

Lake Restoration: This feature would occur at existing gravel pit lakes within the study area. Specifically, the large lakes in the vicinity of 27th and 37th Avenues (Figure V-2) are focus sites. Lake restoration is dependent on both riparian and wetland restoration

and must be combined with those measures for success. Control of water levels is also necessary for success. This may be accomplished by modifying the substrate to make it impermeable and providing water supply.

Figure V-2: Abandonned Gravel-Pit "Lake" (37th Avenue)

Stormwater Outfalls: There are restoration opportunities at existing stormwater outfalls sited throughout the study area (Figure V-3 and Table V-5). Specific restoration would follow recommendations considering runoff amount, soil conditions, location in

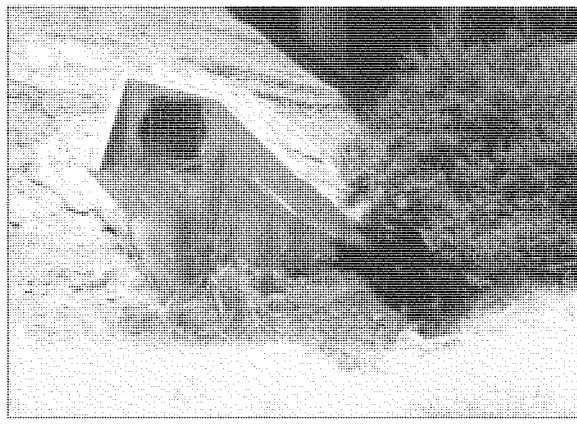


Figure V-3: Stormwater Outfall at 19th Avenue

floodplain, and existing habitat. Further information on the individual stormwater outfalls is included in Appendix M, Wetland Restoration.

Table V-5: Summary of Stormwater Outfalls with Recommended Restoration Potential

Location	Restoration
19th Avenue NW	Mesquite Bosque/Palo Verde
19th Avenue SW	Wetland and Riparian Corridor
27th Avenue SE	Wetlands and Riparian
35th Avenue NW	Cottonwood/willow
43rd Avenue N	Wetland/Cottonwood-Willow
43rd Avenue S	Wetland
51st Avenue NW	Wetland/Mesquite
67th Avenue	Wetland/Cottonwood-Willow

Although stormwater runoff is seasonally inconsistent, observations in the study area indicate that there is sufficient runoff to support wetland vegetation. In many cases the existing vegetation is mostly exotic. Table V-6 below lists the locations of each stormwater outfall and the amount of habitat acreage that could be supported by the water available at each site. Potential runoff at each storm drain was calculated using the seven inches of annual rainfall and the drainage area size. Since there is not a consistent supply

of water, a conservative estimate was used to calculate water available to support habitat. The acreage of habitat that could be supported was based on utilizing one-half of the estimated water supply currently found at each site. It was assumed that when stormwater wetland is combined with cottonwood/willow riparian, the wetland would utilize one-third of the potential supply, with the cottonwood/willow utilizing the remainder.

Table V-6: Restoration Potential at Each Stormwater Outfall

Location and Estimated Runoff (ac-ft)			Acreage of Habitat		
	Estimated	1/2	Cottonwood/ Willow	Mesquite	Wetland
19th Ave NW	79	39.5		13	
19th Ave SW	231	115.5	10		4
27th Ave SE	196	98	8		4
35th Ave NW	224	112	14		
43rd Ave N	274	137	11		5
43rd Ave S	Unknown			x	x
51st Ave NW	274	137		30	5
67th Ave N	558	279	23		10

Note: Assumed water demand (ac-ft/acre): Cottonwood/willow = 8, Mesquite = 3 , Wetland = 9.

Channel Restoration: This measure is largely based upon historic conditions, hydraulics, and geomorphology. Therefore, implementation of this measure would be mainly within the 10-year area of inundation. Restoration would be accomplished through grading and excavation of materials to recreate a natural channel through the study reach. Channel restoration would serve several purposes: it would link upstream and downstream river reaches, transport low flows to adjacent habitats, convey flood flows, and reduce flood elevation on adjacent terraces and floodplains.

Systemic Measures

Systemic measures could be applied anywhere within the project area but would be based upon specific criteria for location. For example, all of the revegetation strategies, including establishment of cottonwood/willow, mesquite, and emergent wetland cover types, are systemic measures. In this case, existing data (soils, groundwater depth, flood elevation, etc.) was used to help determine optimum placement of individual habitat cover types. However, data was lacking in sufficient detail to do so across the entire area.

Floodplain Location: Elevation within the floodplain was a siting constraint adopted by the study team. Construction of permanent infrastructure and installation of woody vegetation would avoid the 10-year area of inundation and maintain an active channel to convey flood flows and minimize losses of project features during flood events.

Water Availability: Consideration was given to the availability of water (surface water, runoff, stormwater outfalls, or groundwater) at a given site or the liklihood of delivering water to that area cost effectively.

Ecological: Siting of restoration features took into account ecological conditions and strived to place restoration features in the most natural locations within the floodplain as possible. Doing so would produce a sustainable and successful restoration project and minimize operations and maintenance (O&M) costs. Cottonwood/willow cover type was placed either near the channel where the 10-year event would provide a wetted area, or where possible surface runoff would contribute the same effect. Mesquite bosques were located at the first floodplain terrace, and mesquite (xeric) higher in elevation in the floodplain.

5.7.4 Screening of Second Array of Alternatives

Although the second array of alternatives appeared to be complete and effective at meeting the restoration objective, the study team observed that further refinement would be necessary to aid the selection process. One final screening process was carried out by the study team using the following criteria:

1. Cottonwood-willow cover type is widely recognized as a significant and scarce cover type in the Desert Southwest. The Arizona Nature Conservancy (1987) rates the cottonwood-willow community as North America's rarest forest type. Its significance can also be seen in the literature, for example the highest population densities of non-colonial nesting birds in North America, are found in the cottonwood forests of central Arizona (Johnson 1971, Carothers et al. 1974). Cottonwood-willow is an important component of a functioning riparian ecosystem, it is present at all of the reference sites referred to in functional modeling, and meeting the objective of restoration requires that it be included. Therefore the study team determined that not

including cottonwood-willow would not be acceptable or effective and alternatives not including it should not be carried forward into detailed evaluation.

2. Existing storm water outfalls within the study area provide opportunities for restoration and for potential water harvesting. Outfalls include the inexpensive opportunity of providing additional water to the project area and associated restoration features. Since the watershed is developed tributaries to the river have been replaced by outfalls. The decision was made that the storm water measure is a necessary component to any alternative because of the restoration opportunities and potential water source. Therefore, alternatives not including that individual component should be eliminated from further consideration.

3. Channel restoration an important project component for various reasons. It provides a connection to other projects, is a potential means of water distribution, is important for the ecosystem, and contributes to reducing flooding potential. Therefore, alternatives not including that component were not considered.

Table V-7 shows the second array of alternatives along with the reasons for dropping individual alternatives from further consideration. As noted in the table at least 3 of the alternatives not only fail to meet criteria listed above but also are very similar to other alternatives.

Table V-7: Second Array of 12 Alternatives

#	Preliminary Alternatives	Reason Dropped
1	No Action	
2	Storm Water	3
3	Storm Water, Channel	
4	Water Supply, Channel, Mesquite	1
5	Water Supply, Channel, Mesquite, Emergent, Invasive	1
6	Water Supply, Cottonwood, Channel, Invasive	2
7	Water Supply, Cottonwood, Channel, Emergent, Invasive	2, similar to alternative 8
8	Water Supply, Cottonwood, Channel, Mesquite, Invasive, added Storm Water	
9	Water Supply, Cottonwood, Channel, Mesquite, Emergent, Invasive	2, similar to alternative 10
10	Water Supply, Storm Water, Cottonwood, Channel, Mesquite, Emergent, Invasive	
11	Water Supply, Lake, Cottonwood, Channel, Mesquite, Emergent, Invasive	2 water, with inclusion of it same as alternative 12.
12	Water Supply, Lake, Storm Water, Cottonwood, Channel, Mesquite, Emergent, Invasive	

The study following set of five alternatives were carried further for development of designs and cost estimates. Those alternatives are:

1. No Action
2. Storm Water and Channel
3. Water Supply, Cottonwood, Channel, Mesquite, Invasive, Storm Water
4. Water Supply, Storm Water, Cottonwood, Channel, Mesquite, Emergent, Invasive
5. Water Supply, Lake, Storm Water, Cottonwood, Channel, Mesquite, Emergent, Invasive

5.7.5 Detailed Description of Project Measures

5.7.5.1 Provide Water Supply

Project water is a constraint and a limiting factor across all alternatives. The project area can be split into two reaches based on water supply: (1) 19th to 51st Avenues where effluent and storm water are primary sources and (2) 51st to 83rd Avenues where groundwater is more likely to be

shallow enough to support vegetation after it is established. Water supply and distribution has been evaluated and planned by the City of Phoenix and is described in more detail within Appendix J, Design and Cost Estimate.

Effluent: Effluent from the 23rd Avenue WWTP is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. This would require construction of a means to deliver effluent to the project from the 23rd Avenue Plant.

Storm Water: Stormwater outfalls within the project area have been identified and possible discharges from them quantified. This includes 8 different outfalls from which an estimated average of 2,863 ac-ft was estimated to discharge based upon a 7-inch annual rainfall. Additional future outfalls may be implemented by the county at 51st Avenue (south) and 75th Avenue (north). While not a reliable constant source of project water, there are opportunities for future use of this water with proper design at the outfall locations. Currently, various forms of habitat are being supported by stormwater runoff, and design of a restoration plan would include site-specific measures maximizing use of that runoff.

Groundwater: Depth to groundwater through the project area varies from an average of 20 to 60 feet. In general, the depth to groundwater decreases to the west end of the study area where dewatering is required at 91st Avenue. In an analysis of ADWR well data and interpolation of surface water in gravel pits, there appears to be a zone of shallow (20-feet deep) groundwater between 51st and 19th Avenues in the river channel. This is likely due to excavation and is known to fluctuate as much as 20 feet annually (Rinker Materials Observation). Groundwater is being pumped in the vicinity of 23rd Avenue for sand and gravel mining where it contributes to the large lake near 27th Avenue. It was also assumed that the lake in the vicinity of 37th Avenue was excavated to groundwater depth, although observations in 2004 appear to indicate that the level has dropped significantly and that the elevations in the lake appear to be influenced more by effluent discharge.

Supply Well: A supplemental well providing up to 1.85 mgd from the Upper Alluvial Unit is part of the proposed system. This would provide redundancy in the event that there is a prolonged outage and effluent becomes unavailable for a period of time.

5.7.5.2 Provide Water Distribution

A water distribution system is needed to deliver water from the sources described above through the study area to locations of revegetation.

Flood Irrigation: Flood irrigation may be accomplished through a series of canals or channels delivering water to revegetation sites. Distribution within the revegetation sites may be through a braided network of channels. Effluent and pumped groundwater may be utilized for flood irrigation.

Drip Irrigation: This would be a temporary drip irrigation system consisting of small diameter pipes and drip emitters. Pumping would be required as a portion of this system. Drip irrigation works best with groundwater; effluent tends to clog the system and requires high maintenance.

Stormwater Harvesting: This measure is similar to creating a perched aquifer by providing water to a location with a below-grade low permeable layer. Although this could be accomplished with any water source and proper site-specific soil conditions, it appears that at several of the stormwater outfalls, similar conditions already exist. At constructed wetlands or ponds, a design option may include features that allow or encourage subsurface recharge to percolate down gradient and provide moist conditions, thereby irrigating adjacent vegetation.

5.7.5.3 Revegetation

Cottonwood/Willow

Due to groundwater depth, cottonwood/willow habitat could only be restored in proximity to existing or future surface water. This habitat would require a constant water source for the life of the project unless it can be verified that groundwater would be available within 6 to 7 feet of surface—in which case surface water would only be required for the first five years. Cottonwood/willow habitat would also require richer soils than some other habitat types.

Generally, cottonwoods occur at a greater distance from surface water than willows. Willows require more moisture at the surface for optimal growth. Besides cottonwoods and willows, plant species that would be included in the restoration of this habitat include Baccarus sp., arrowweed, and possibly ash. Cottonwood/willow would be dominated by Fremont's cottonwood (*Populus fremontii*) and Gooding's willow (*Salix gooddingii*). Other understory species would be planted, depending upon individual site conditions, but could include arrowweed (*Pluchea sericea*), elderberry (*Sambucus mexicana*) or burrobush (*Hymenoclea spp.*).

Two planting options are being considered for establishment of cottonwood willow. It is assumed that a combination of techniques would be utilized with specific planting techniques to be determined during project design.

Plant Poles: Plant poles are dormant pole cuttings harvested from living woody plants and planted vertically into the substrate. Poles need to be 3 to 4.5 inches in diameter and at least 6 to 8 feet long. Unless planted in saturated soils or near stable groundwater, temporary irrigation would be required. Pole plantings of cottonwood and willow have shown high rates of success with this technique. Plant materials should be available nearby, and may even be obtained from the other Salt River projects.

Plant Containers: Nursery grown potted containers would be planted on site. One gallon containers have shown the greatest success rates (80 percent +) at Lower Las Vegas Wash, Nevada. They are also the least expensive container plants available. Plantings would require a source of irrigation, at least temporarily.

Mesquite

This habitat would be restored over a potentially large portion of the project area. It would require periodic watering for the first five years after planting, although with less frequency than cottonwood/willow. Watering could possibly be discontinued after five years or when roots are expected to reach groundwater. Mesquite bosques would be dominated by velvet mesquite (*Prosopis velutina*), with scattered screwbean mesquite (*Proposis pubescens*), and some

understory shrubs, such as desert thorn (Lycium spp.) palo verde (*Cercidium floridum*), brittlebush (*Encelia farinose*), and forbs.

Bosque: Mesquite bosques are commonly found 5 to 20 feet above the river channel where water is adequate. They require a water table, or semi-saturated soil conditions 10 to 30 feet below the surface elevation and rely on occasional saturated conditions 1 to 3 feet below the surface. Soil requirements range from fine to gravelly, with some rocky areas. The mesquite bosques would be planted with a density of approximately 100 velvet mesquite, 10 screwbean mesquite, and 40 understory shrubs per acre. Understory forbs will also be planted using a seed mix.

Xeric: In locations throughout the study with less water supply, xeric stands of mesquite would be established. It is assumed that mesquite will survive under drier conditions and on higher terraces than mesquite bosque. Planting densities would be less, with approximately 25 velvet mesquite, 5 screwbean mesquite, and 10 understory shrubs per acre.

Riparian scrub shrub

As was discussed in Chapter IV the study area contains substantial acreage of scrub shrub habitat. Although portions of that cover type will be converted to the other riparian habitats others will be maintained, as they provide connection between other habitat types and contribute to the important mosaic of vegetative cover types that maximizes structural habitat complexity. It is assumed that some portions maintained will remain a more xeric desert scrub but others adjacent to the wetter riparian habitats will develop into more distinctive riparian cover containing species such as Seepwillow, desert broom, or Desert willow. Estimated acreages for both scrub shrub and riparian scrub are included in the listed acreages with each alternative below. It is estimated that if the active river channel is approximately 500 acres between 25 to 60% will be occupied by riparian scrub in the with project conditions depending on water supply.

5.7.5.4 Wetlands

Wetlands can consist of open water, submerged vegetation, or mud flats, all requiring a high water table at or near the surface. Due to the porous soils found in this project area, lining the

site would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is 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.

Stormwater Wetland: Stormwater wetland restoration would take place at individual stormwater outfalls. Techniques would be site specific and would include grading or excavation, removal of exotics, and planting of suitable vegetation for the site conditions. Supplemental water would be required via an irrigation source, and structures would be installed to contain high-energy inputs and avoid erosion during storm events.

Emergent Wetland: Emergent wetlands contain primarily cattails (*Typha domingensis*), tule (*Scirpus acutus*), and sedges (Carex spp.). Because the river will not flow year round, the wetlands would need to be constructed specifically to retain water. In addition to grading and excavation, an impermeable layer would be added to retain water on site.

5.7.5.5 Lake "Gravel Pit" Restoration

There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to better utilize the existing water and improve the functionality of these features. The existing banks would need to be reshaped for public safety and restoration. Potential substrate modification may be required to reduce the annual fluctuation in the lake levels. In addition, aeration would need to be considered to retain water quality.

Grading: Banks would be reshaped to create "irregular random terraces" (variable in length, width and depth below the water surface) that would become submerged to different depths to provide more diversity in the littoral zone. This is the nearshore area where sunlight penetrates all the way to the sediment and allows aquatic plants to grow. The irregularity and randomness of the terraces provides more opportunities for the establishment of submerged, floating, and emergent vegetation and a more diverse and natural shoreline habitat. The random terracing would provide different thermo strata for aquatic organisms, potentially improving mixing and maintaining a less stratified body of water, making it less susceptible to turnover (reducing oxygen levels). These terraces or

shelves may be exposed periodically, functioning as emergent wetlands or mud flats during seasonal fluctuations in the lake level. The terraces, when exposed, provide an opportunity for voluntary native vegetation to become established. When these areas are again submerged, some vegetation would persist and that which cannot would contribute to the organic content of the benthic zone. The productivity of the benthic zone is largely dependent on the organic content of the sediment and amount of physical structure.

Substrate: It would be necessary to modify the substrate of existing bodies of water within the study area to implement restoration at the lakes. This may include the addition of impermeable materials to both maintain water elevations and grow vegetation. There are some preferred alternatives for lake bottoms that improve the benthic zone productivity. There are tradeoffs in productivity, refuge, diversity, and food production associated with the various lake bottom characteristics. A sandy substrate contains relatively small amounts of organic matter for organisms and provides limited protection from predation. Higher plant growth is limited and sparse in sandy sediment; the sand is unstable and nutrient deficient. A rocky bottom has a high diversity of potential habitats offering protection (refuge) from predators, substrate for attached algae, and pockets of organic "ooze." A flat mucky bottom offers abundant food for benthos organisms; however, there is less protection and the diversity of structural habitats may be reduced unless higher plants colonize the lake bottom.

5.7.5.6 Invasive Species Management

Invasive Species Removal/Control: It would be necessary to remove and manage invasive species such as saltcedar and Arundo with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. Saltcedar is currently found in stands throughout the study area. Arundo, though not yet a significant problem in Arizona, is a problem in neighboring California. A stand of Arundo can be found on the south side of the river near a stormwater outfall at 43rd Avenue.

5.7.5.7 River Channel Restoration

Project implementation would restore the river channel to a more natural state based on hydraulics and geomorphology. This would be accomplished by grading and terracing to help restore an active channel through the entire reach. Average depth of grading is assumed to be 5 feet, with a width varying from 200 to 400 feet. The average width of the river channel ,including adjacent river terrace, thorughout the study area will be approximatley 500 feet. The channel design passes a 5-year event (~22,000 cfs) with occasional flooding on the terrace 2 to 4 feet depth at 1-7 cfs. Due to a drop in the channel downstream of the 35th Avenue Bridge, a grade control structure is recommended in that vicinity. At this time, erosion and scour do not appear to be a concern with project features or infrastructure. However, should it appear in future analysis that it is a concern, appropriate protection would be included. An estimated 660,000 c.y. would be removed from the channel to implement this measure. Material removed would be native riverbed material and would utilized on site for terracing and construction of other project components, such as lake restoration.

River channel habitats

As discussed earlier in this report the river channel itself can include different habitat cover types depending on site specific conditions. These may include dry river bottom, emergent wetland, riparian scrub or desert scrub. The team assumed that after construction a low flow channel similar to that in the Rio Salado Project area and the existing channel in the reach near 43rd Avenue would become established. The total acreage of this low flow channel through the project reach was assumed to be 170 acres. It was projected that between 10-20% of that would become vegetated with emergent wetlands. The remainder of the channel will vegetate with either riparian scrub or desert scrub depending on conditions within this active channel.

5.8 THIRD/FINAL ARRAY OF ALTERNATIVES

While evaluating the future conditions that would occur with each of the five remaining alternatives, the study team decided that different scales of restoratoin at the lakes should be evaluted. These included differeng levels of restoration based mainly on different water levels within the gravel pit lakes. These were developed by the study team and made the final array of project alternatives, which then became seven, including the No Action Alternative. Note that Alternatives 3 and 4 were nearly identical, apart from the emergent wetlands in Alterative 4. These two very similar alternatives were therefore combined as Alternative 4. The final set of project alternatives is shown in Table V-8 below, including short descriptions and the restored acreage associated with each alternative. Plates depicting each alternative and features therein are included at the end of the report.

1. **No Action**: No Federal Action to be conducted and no habitat restored. This is the future without-project condition.

2. **Storm Water and Channel:** This alternative includes the modification of existing stormwater outfall areas to improve retention and water spreading as well as increase the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th Avenue to 83rd Avenue. No additional water source is included in this alternative other than temporary irrigation to establish vegetation.

3. **This alternative was merged with Alternative 4 below.**

4. **Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent:** This alternative includes the features described in Alternative 2 and adds supplemental water supply in the form of effluent. It also includes restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue. At locations identified as suitable throughout the project area, cottonwood/willow and mesquite cover types would be restored. This alternative

would also address the management, control, and removal of invasive species within the study area.

5. **Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake:** This alternative includes the features described in Alternative 4 and adds lake restoration at the existing gravel pits at 27th and 37th Avenues.

5A. **Wetland restoration in lieu of permanent open water and lakes:** In lieu of lake restoration, this alternative includes regrading the existing gravel pits to restore them to the floodplain, and restoring emergent wetland and riparian areas.

5B. **Hybrid of 5 and 5A:** This alternative includes restoration of one gravel pit to a wetland/riparian complex, and the other to include the lake.

Table V-8: Final Array of Restoration Alternatives Evaluated

Action Alternative	Cover Type	Acres
2. Storm Water and Channel	Cottonwood/Willow	66
	Mesquite	43
	Open Water	0
	Scrub Shrub*	305
	Wetlands	28
	Channel **	
	Low flow channel	170
	In-Channel Wetlands	17
	Riparian scrub	125
4. Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent	Cottonwood/Willow	348
	Mesquite	409
	Open Water	0
	Scrub Shrub*	63
	Wetlands	33
	Channel **	
	Low flow channel	170
	In-Channel Wetlands	34
	Riparian scrub	165
5. Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake	Cottonwood/Willow	375
	Mesquite	417
	Open Water	40
	Scrub Shrub*	92
	Wetlands	76
	Channel **	
	Low flow channel	170
	In-Channel Wetlands	34
	Riparian scrub	296
5A. Wetland/riparian restoration in lieu of permanent open water and lakes	Cottonwood/Willow	375
	Mesquite	417
	Open Water	0
	Scrub Shrub*	52
	Wetlands	156
	Channel **	
	Low flow channel	170
	In-Channel Wetlands	34
	Riparian scrub	296
5B. Hybrid of 5 and 5A with one gravel pit restored to a lake and the other wetland//riparian complex	Cottonwood/Willow	375
	Mesquite	417
	Open Water	20
	Scrub Shrub*	52
	Wetlands	136
	Channel **	
	Low flow channel	170
	In-Channel Wetlands	34
	Riparian scrub	296

* Scrub shrub acres are dispersed among and between the other restored cover types within the floodplain.
** Note that the acres of river channel is made up of (low flow, wetland, or riparian scrub)

Comparison and Evaluation of the Third Array of Alternatives

5.8.1.1 Water Supply and Water Budget

Water sources within the project area available for the alternatives are evaluated within Appendix A, Hydrology and Hydraulics. Available sources for the project include effluent and harvested storm water. Approximately 8 mgd (8,961 ac-ft/yr) of effluent would be made available from the 23rd Avenue WWTP. Stormwater runoff within the project area was also calculated based upon average monthly rainfall in Phoenix, and approximately 2,900 ac-ft can be expected to runoff into the project area from the approximately 8 adjacent outfalls. Water demand for individual alternatives is summarized in Table V-9 below, with more detail included in Appendix B, Water Budget Report and Interior Drainage Report.

Table V-9: Water Demand for Alternative Plans

Alternative	Water Demand (A/F)	Water Demand (mgd)
Alternative 2	1,583	1.41
Alternative 4	4,701	4.20
Alternative 5	7,752	6.92
Alternative 5A	9,293	8.30
Alternative 5B	9,234	8.24

5.8.1.2 Hydraulics

The hydraulic model of the study area was modified to reflect with-project conditions for a range of modifications including low, medium, and high amounts of vegetation restored in the floodplain. The high end of the range mimics Alternative 5. Results indicate that with-project conditions do not induce flood damages anywhere in the study area. Detailed results of the modeling can be found in Appendix A, Hydrology and Hydraulics.

5.8.1.3 Cultural Resources

While there are cultural resources at sites adjacent to the project area, surveys conducted by a Corps of Engineers staff archaeologist failed to locate any cultural material within selected portions of the project area. Based upon the reconnaissance survey, level of previous disturbance, and data provided from the geological assessment downstream in the Tres Rios Project area, the Corps believes that the potential for buried archaeological resources is low. If

project alternatives change or additional information is located, further surveys and coordination with the SHPO would be completed. More detailed description of cultural resources and reasons for this determination are provided in the Environmental Impact Statement.

5.8.1.4 Hazardous, Toxic, or Radioactive Waste

A groundwater quality analysis and a Modified Phase I ESA were completed during the study and may be seen in Appendix D and Appendix F, respectively. Landfills, LUSTs, and groundwater contamination are known to occur within the study area. This includes an area in the vicinity of 19th Avenue with elevated concentrations of 1,1 DCE. Although these sites mentioned above are known to exist adjacent to the river, they have been avoided throughout the plan formulation process, to the greatest extent possible, in accordance with Corps guidelines.

Experience during construction of the Rio Salado Project upstream has shown that due to the nature of the riverbed and dumping that has occurred over the years, it is likely that debris would be unearthed during excavation. This could include inert construction debris, tires, or miscellaneous household waste. The reach of the river between 35th and 51st Avenues has a high occurrence of illegal dumping of household and landscape waste, as well as occasional construction debris. Much of this area has been cleaned and monitoring has increased, though some waste is likely to remain.

A remediation and management plan would need to be developed for unknown HTRW and other deleterious material encountered during construction. Project features are for the most part located within the 100-year floodplain and avoid the known HTRW sites. In accordance with Engineer Regulation 1165-2-132, the Corps would not participate in clean-up of materials regulated by the CERCLA or by RCRA.

5.8.1.5 Environmental Benefits

Riparian ecosystems in the Southwest are invaluable. Although they represent less than 1 percent of the region's area (Knopf, F. L., 1989), a large proportion (75 to 80 percent) (Gillis 1991) of vertebrate wildlife species depend on riparian areas for food, water, cover, and migration routes. Riparian zones also improve water quality because they filter sediments and nutrients. Accumulated sediments in riparian zones store large amounts of water, which helps sustain

stream flow during drier times. Estimation of environmental benefits was accomplished using the functional model described in Section IV and in Appendix I, Functional Assessment Methodology.

Refined Alternatives

Four additional alternatives were evaluated during policy review to assure that the Cost Effectiveness and Incremental Cost Analysis provided an evaluation of alternatives covering a full range of both output and cost . These alternatives include:

Partial: This alternative restores only the portion of Salt River from 19th to 35th Avenues without any restoration of existing gravel pit lake. It includes capture of storm water from only 4 outfalls. Approximately 270 acres are required for this alternative and restored areas include 15 acres of emergent wetlands, 30 acres of cottonwood-willow, 30 acres of mesquite, and 75 acres of riparian scrub. In addition the low flow channel would encompass approximately 48 acres.

Refine 1: This alternative includes restoration of the river channel from 19th to 83rd Avenues, modification of existing storm water outfalls and restoration of associated habitats and restoration of the two existing gravel pit lakes. Approximately 1024 acres are required to implement this alternative. Acres restored with this alternative include: cottonwood-willow 210, mesquite 56, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 2: This refinement restores the river from 19th to 83rd Avenues and includes the same features as Alternative 5A but is scaled back to restore much less cottonwood-willow and mesquite habitats. Approximately 1300 acres are required to implement this alternative. Acres restored include: cottonwood-willow 204, mesquite 110, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 3: This refinement also restores the river from 19th to 83rd Avenues without restoration of the gravel pit lakes and less acreage of cottonwood-willow and mesquite. Approximately 1130 acres are required to implement this alternative. Acres restored include: cottonwood-willow 169, mesquite 102, wetlands 92, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Functional Capacity Index

The Functional Capacity Index (FCI) describes the quality of the functional capacity of the habitat. Of the 10 functions evaluated in the without-project conditions, all had low to moderate functional capacity. Implementation of project alternatives caused an increase in each FCI, with the average increasing by approximately 30 percent and into the ranges considered moderate to moderate-high functional capacity. The most improved functions included Function 1 (Maintenance of Characteristic Channel Dynamics), Function 7 (Detention of Particles), and Function 10 (Maintain Interspersion and Connectivity). Those functions showing the least improvement included Function 4 (Dynamic Subsurface Water Storage), Function 5 (Nutrient Cycling), and Function 6 (Detention of Imported Elements and Compounds). Table V-10 below displays the FCI for the baseline condition as well as for each alternative.

Table V-10: With-Project Functional Capacity Indices (FCI)

Function Name	Existing	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B	Partial	Refine 1	Refine 2	Refine 3
Fxn 01: Maintenance of Characteristic Dynamics	0.23	0.27	0.4	0.39	0.4	0.39	0.25	0.27	0.28	0.27
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.42	0.45	0.57	0.57	0.57	0.57	0.45	0.49	0.50	0.49
Fxn 03: Long Term Surface Water Storage	0.25	0.27	0.34	0.33	0.34	0.34	0.27	0.29	0.30	0.29
Fxn 04: Dynamic Subsurface Water Storage	0.44	0.50	0.51	0.51	0.52	0.52	0.47	0.51	0.51	0.50
Function 5: Nutrient Cycling	0.28	0.28	0.33	0.33	0.34	0.33	0.27	0.29	0.28	0.27
Function 6: Detention of Imported Elements and Compounds	0.38	0.39	0.45	0.45	0.46	0.45	0.38	0.39	0.40	0.39
Function 7: Detention of Particles	0.33	0.36	0.48	0.47	0.48	0.48	0.34	0.38	0.39	0.38
Function 8: Maintain Characteristic Plant Communities	0.42	0.43	0.51	0.51	0.51	0.51	0.42	0.44	0.45	0.44
Function 9: Maintain Spatial Structure of Habitat	0.30	0.32	0.42	0.41	0.42	0.41	0.30	0.32	0.33	0.32
Function 10: Maintain Interspersion and Connectivity	0.23	0.29	0.33	0.34	0.34	0.34	0.25	0.28	0.28	0.28

Acres Restored

In the future without-project condition, existing cottonwood/willow cover type was projected to decrease from 112 acres to 25 acres, and existing wetland was projected to decrease from 30 to 25 acres as well. It is assumed that the quality of that habitat would be low with high concentrations of invasive species such as salt cedar. Although there are scattered mesquite trees within the study area, none are dense enough to consider a mesquite cover type.

Alternative 2 relies mainly on restoration at storm water outfalls and restoration of the river channel itself without large amounts of restoration elsewhere. Alternatives 3 through 5A all maintain and improve the highly degraded 112 acres of cottonwood/willow, and include restoration of mesquite and wetland habitats. Alternative 5A, which has the highest AAFCU outputs, includes restoration of 375 acres of cottonwood/willow, 417 acres of mesquite, and 190 acres of wetlands, including restoration of two large gravel pits within the floodplain. Also included in this alternative are 348 acres of scrub shrub and 170 acres of river channel. Acres restored of the Refined Alternatives are described on the preceding pages and are a smaller iteration of the previous alternatives ranging from 230 to 1300 acres.

Average Annual Functional Capacity Units (AAFCUs)

Based upon the functional assessment completed for this study, the number of acres and functional capacity indices were projected in order to derive with-project estimates AAFCUs. The same methodology that 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. As a reminder, the Functional Capacity Unit (FCU) represents the factor of habitat quality multiplied by the quantity or FCI from above multiplied by acreage of habitat restored.

Table V-11 shows the results. The proposed alternatives result in increased AAFCUs (relative to without-project conditions) ranging from 51 for Alternative 2 to 267 for Alternative 5A.

Table V-11: With-Project Average Annual Functional Capacity Units (AAFCUs)

Target Year	Without Project	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B	Partial	Refine 1	Refine 2	Refine 3
T0	583	583	583	583	583	583	583	583	583	583
T1	580	619	691	766	791	778	609	732	736	626
T6	580	627	717	796	822	809	611	749	754	649
T26	579	635	755	828	857	842	616	771	776	674
T51	579	633	775	851	879	865	612	779	785	682
Average (T0-T51)	580	631	745	820	847	833	613	764	768	667
Increase		51	165	240	267	253	33	184	187	87

As can be seen in the table above, the without-project conditions change only slightly over 50 years; the existing conditions within the project area are highly degraded and are not expected to

change without some action. Each column numbered with different alternatives displays the number of FCUs that are expected in that year, with the associated features of that alternative. The overall increase shown at the bottom of the table is the expected benefits to be accrued with that alternative between project year 1 and project year 50.

Associated Planning and Future Conditions

With any proposed project the associated local planning and zoning adjacent to the project area will affect each alternative similarly. The City of Phoenix has existing zoning regulations in place that in combination with a constructed restoration project will continue to ensure that any project implemented will not be adversely affected by development changes. Best Management Practices are in place as they relate to storm water outfalls entering the river and those will remain in tact in the future. The area adjacent to the Rio Salado Project upstream has an area plan and overlay district titled "Beyond the Banks" as described in Section 3.1.3. That connection between a restored river and adjacent community could expand downstream to the Rio Salado Oeste project area.

5.8.1.6 Costs

Project Construction Costs

Preliminary costs were developed for each project alternative. Estimates utilized a contingency of 25 percent of the First Cost and allowed 10 percent of the First Cost for engineering and design. One percent and 6 1/2 percent were utilized in estimating Engineering During Construction (EDC) and Construction Management. The Gross Investment for an alternative includes the first cost added to the other costs defined above plus Interest During Construction (IDC) calculated at the current 5.125 percent interest rate. Detailed cost estimates can be found in Appendix J, Design and Cost Estimate.

Real Estate

The proposed project features are located on areas of land that can be best described as the river corridor and floodplain mostly occurring within the 100-year 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 and recreation. The lands are all undeveloped with the principle economic or industrial use being sand and gravel extraction. For project planning, an average cost of $20,000 per acre was utilized.

Operation and Maintenance (O&M) Consideration

A priority during formulation of project alternatives was to minimize flood damages to project features. Therefore, the placement of plantings or infrastructure within the 10-year area of inundation was avoided to the extent possible. However, any river restoration project is inherently at risk of some damage by flood flows and inundation. O&M costs would include replacement of vegetation and structures damaged during flood events, wetland and channel maintenance, invasive species control, and inspections and surveys. Annual O&M costs for the alternatives range from $101,000 to nearly $2,200,000. The Monitoring and Adaptive Management estimates range from $697,000 to approximately $5,200,000.

Associated Costs

For the duration of project, authorization the Non-Federal sponsor must provide sufficient water supply for construction, operation, and maintenance of the project. The cost of providing this water is 100 percent non-Federal. Based on current and future water demand, a unit cost of $106 per ac-ft of CAP water was used.

Table V-12 below displays a summary of project costs for each alterative evaluated. Detailed cost estimates are provided in Appendix J, Design and Cost Estimate.

Table V-12: With-Project Average Annual Costs by Alternative (in $1,000s)

	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B
Construction	$12,227	$39,496	$92,549	$67,556	$80,052
Contingency (25%)	$3,057	$10,375	$9,874	$16,889	$20,013
PED/EDC (11%)	$1,345	$4,345	$10,180	$7,431	$8,806
S&A (6.5%)	$795	$2,567	$6,016	$4,391	$5,203
Real Estate	$21,994	$36,313	$49,485	$49,485	$49,485
Subtotal	$39,417	$92,594	$181,367	$145,752	$163,560
Monitoring & Adapt. Mgmt.	$697	$2,251	$5,275	$3,851	$4,563
Total First Cost	**$40,114**	**$94,845**	**$186,642**	**$149,603**	**$168,123**
IDC	$2,020	$8,463	$19,066	$15,322	$17,195
Gross Investment	$42,134	$103,308	$205,708	$164,925	$185,318
Annualized Investment Cost	$2,353	$5,769	$11,486	$9,209	$10,348
Associated Cost (Water Supply)	-	$331	$654	$817	$811
O&M	$101	$1698	$2,224	$2,080	$2,137
Total Annual Cost	**$2,454**	**$7,797**	**$14,364**	**$12,106**	**$13,296**

Table V-12 Continued

	Partial	Refine 1	Refine 2	Refine 3
Construction	$8,456	$47,909	$39,149	$16,084
Contingency (25%)	$2,114	$11,977	$9,787	$4,021
PED/EDC (11%)	$930	$5,270	$4,306	$1,769
S&A (6.5%)	$550	$3,114	$2,545	$1,045
Real Estate	$8,438	$31,319	$39,625	$32,375
Subtotal	$20,488	$99,589	$95,413	$55,295
Monitoring & Adapt. Mgmt.	$482	$2,731	$2,232	$917
Total First Cost	**$20,971**	**$102,320**	**$97,644**	**$56,212**
IDC	$1,050	$10,469	$10,030	$5,813
Gross Investment	$22,021	$112,789	$107,674	$62,025
Annualized Investment Cost	$1,230	$6,298	$6,012	$3,463
Associated Cost (Water Supply)	$53	$276	$286	$212
O&M	$365	$980	$2,011	$2,003
Total Annual Cost	**$1,648**	**$7,553**	**$8,309**	**$5,678**

Cost-Effectiveness and Incremental Cost Analysis

Cost-Effectiveness (CE) and Incremental Cost Analyses (ICAs) were performed on the above alternatives. CE 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 incremental cost per unit for maximum level of output is determined. The intent of the incremental analysis is to identify increases in cost relative to output.

Table V-13 summarizes average annual output and cost by alternative, as well as average annual cost per AAFCU. Figure V-4 below depicts graphically the comparison of annual costs versus annual benefits for the alternatives.

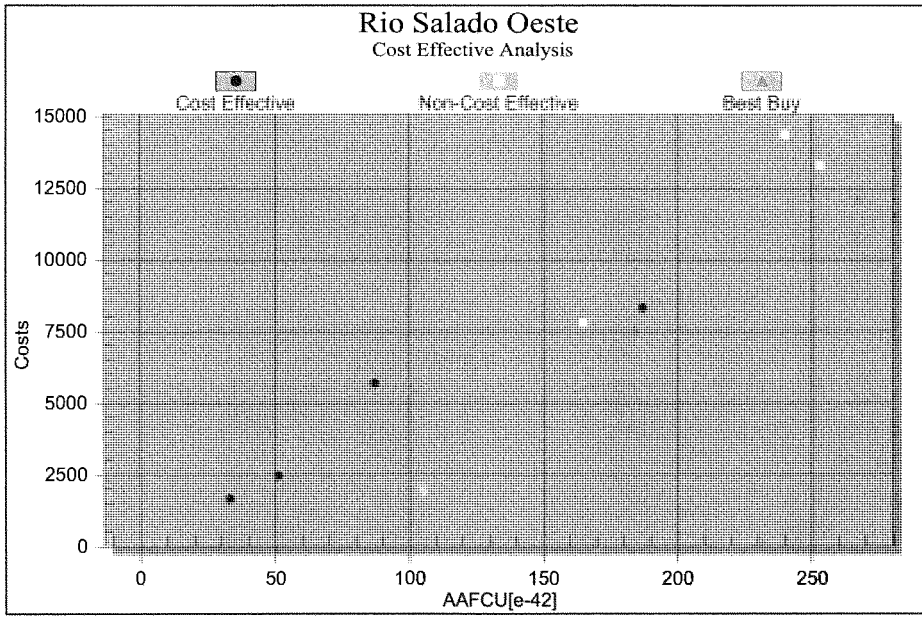
Table V-13: Average Annual Costs Per Annual FCU by Alternative (in $1,000s)

Alternative	AAFCU	AA COST	AAC/AAFCU
Alt 2	51	$2,454	$47.94
Alt 4	165	$7,797	$47.19
Alt 5	240	$14,364	$59.76
Alt 5A	267	$12,106	$45.30
Alt 5B	253	$13,296	$52.59
Partial	33	$1,684	$49.34
Refine 1	184	$7,553	$41.05
Refine 2	187	$8,309	$44.52
Refine 3	87	$5,678	$65,41

Cost Effectiveness Analysis

Alternatives are considered cost effective if there are no other alternatives that 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. As can be seen in Figure V-4 there are six cost effective alternatives, Alternatives 4, 5, and 5B are not cost effective.

Figure V-4: Cost Effective Analysis



Incremental Cost Analysis

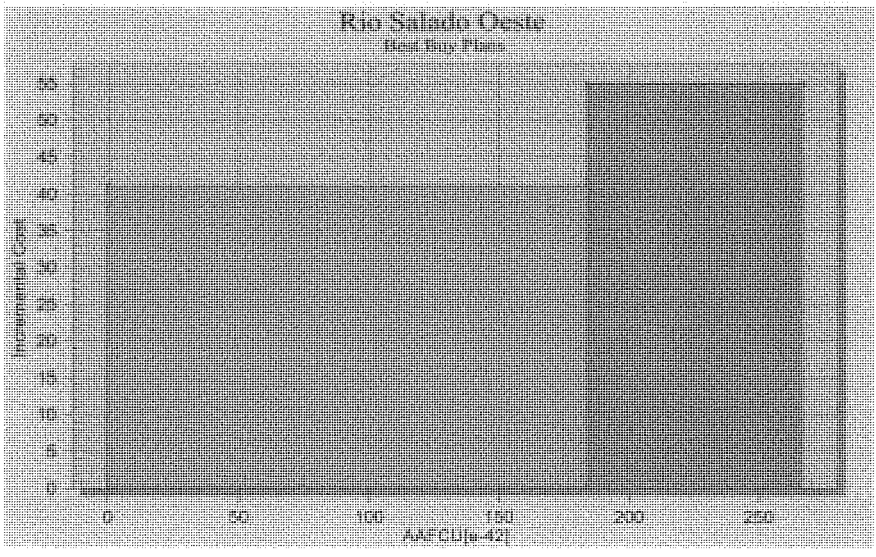
ICA goes beyond cost effectiveness analysis to consider the incremental change in cost and outputs from one alternative to the next. As you step through the successive levels of outputs in the AAFCU column in Table V-14 below you can see an increasing level of outputs (AAFCU's) from 184 to 267. Likewise the annual cost increases. The incremental increase in cost between alternatives displays the additional cost to implement one alternative over the next and likewise the benefits over the next. This information can be used to weigh the difference in levels of cost versus benefits and contributes to the plan selection process. Incremental cost analysis is also used to identify "best buy" plans. Best Buy plans are those that have the lowest incremental

average annual cost per incremental increase in output. The two best buy plans are shown in Table V-14 and Figure V-5 below.

Table V-14: Incremental Cost Analysis

	AAFCU	Annual Cost	Cost/AAFCU	Incremental Cost/Incremental AAFCU
Refine 1	184	$7,553	$41.05	$41.0
Alt 5A	267	$12,106	$45.34	$54.7

Figure V-5: Incremental Cost Analysis



As can be seen above, Alternative Refine 1 provides 184 AAFCU and Alternative 5A provides 267. The AAC/AAFCU for Alternative 5A is about ten percent higher than Alternative Refine 1, and the incremental AAC per incremental AAFCU is about 33 percent higher than Alternative Refine 1. However, Alternative 5A provides 83 AAFCUs more than Alternative Refine 1, representing an increase in output of over 45 percent. .

5.8.1.7 Recreation

The Rio Salado Oeste Project provides a unique opportunity to enhance resource-based recreation and environmental education. The restoration of the dry Salt River channel would bring a riparian open space feature to the rapidly expanding Laveen and Estrella Planning Areas. Rio Salado Oeste would provide a habitat and recreational connection to the desert riparian habitat corridor created by the Rio Salado and Tres Rios Projects. By connecting the 7-mile gap between the two projects, Rio Salado Oeste would enhance the unique recreation and education opportunities for residents and out-of-town visitors. Drawing on a population base of over two million in the Valley, it is estimated that visitation to the Rio Salado Oeste Project would exceed 350,000 annually (see Table V-15). Primary use times for this unique resource would coincide with the "visitor season" between October and May when temperatures are moderate.

Table V-15: Rio Salado Oeste Recreation Plan Baseline Visitation Estimate

	Days	Turnover/Day	Visits*
Winter (Oct-May)	243		
Prime Time	78	1.50	160,875
Non-Prime Time	165	.50	113,438
Winter Total			274,313
Summer (Jun -Sep)	122		
Prime Time	36	1.00	49,500
Non-Prime Time	86	0.25	29,563
Summer Total			79,063
Grand Total (by vehicle)			**353,376**
Add - Arrive by Alternative Mode (10%)			35,338
Total Visitation			**388,714**
Less Transfers (10%)			38,871
Baseline Visitation for Benefit Analysis (rounded)			**350,000**

Note: Based upon parking capacity for 500 spaces.
Average of 2.75 Persons/Vehicle

The City of Phoenix developed the recreation plan for the project, which may be found in Appendix L, Recreation. The plan is consistent with Corps policy on development of recreation at ecosystem restoration projects as outlined in Policy Guidance Letter No. 59, USACE 1998. Major recreation features include multipurpose trails, shelters, signage, shelters, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and 5 smaller access points for walk-in use. Additionally, 9 minor points for walk-in access from adjacent neighborhoods may be completed but are not part of this project. Table V-16 below includes the recreation features and associated cost estimates.

Although an environmental education center is planned and described in the Recreation Appendix L, it is not a cost-shareable portion of the project and would be a local sponsor cost.

Table V-16: Rio Salado Oeste Recreation Plan with Costs

Component	Quantity	Unit Cost	Recreation Cost
Site Preparation			
Site Prep to include: clearing, grubbing, and grading	9	Lump Sum	$250,000.00
Vegetative Restoration (Drive in Access)	4	Lump Sum	$600,000.00
Vegetative Restoration (Walk in Access)	5	Lump Sum	$75,000.00
Access and Circulation			
Entry Road w/Turnaround to include: curb, gutter, driveway, & road	4	Lump Sum	$600,000.00
Parking lot	500	$1500/space	$750,000.00
Sidewalks and Ramps	40,000 sf.	$6.00 each	$240,000.00
Multi-Use Trails (24mi * 5280 * 5ft)	47000	$6.00 / sy	$282,000.00
Bridges and Culverts (small) @ Canals, and Localized Drainage Areas	10	$7,500 each	$75,000.00
Protection Access Control			
Access Control Gates (vehicular)	10	$7,500 each	$75,000.00
Access Control Gates (pedestrian)	18	$3,500 each	$63,000.00
Handrails	5,000 l.f.	$50.00 each	$250,000.00
Guardrails	3,000 l.f.	$50.00 each	$150,000.00
Fencing	5,000 l.f.	$30.00 each	$150,000.00
Walls	1,500 l.f.	$125.00 each	$187,500.00
Security lights	100	$4,000 each	$400,000.00
Signage			
Entrance identification signage	8	$15,000 each	$120,000.00
Traffic Control (vehicular)	20	$500 each	$10,000.00
Traffic Control (pedestrian)	27	$500 each	$13,500.00
Instructional/Directional	45	$500 each	$22,500.00
Shelters			
Picnic (large)	5	$60,000 each	$300,000.00
Picnic (small)	5	$25,000 each	$125,000.00
Restroom Facility/Comfort Station	5	$250,000 each	$1,250,000.00
Shelter w/Bulletin Boards	4	$25,000 each	$100,000.00
Trail Shelter w/Railing (large)	9	$40,000 each	$360,000.00
Trail Shelter w/Railing (medium)	4	$30,000 each	$120,000.00
Trail Shelter w/Railing (small)	10	$20,000 each	$200,000.00

Utilities			
Municipal Water Supply and Wastewater Disposal	5	Lump Sum	$500,000.00
Storm Drainage	4	Lump Sum	$80,000.00
Drinking Fountain w/Chiller	12	$5,000 each	$60,000.00
Electical	4	Lump Sum	$200,000.00
Park Furniture			
Benches:	14	$1,500 each	$21,000.00
Off-the-Shelf	40	$800 each	$32,000.00
Recycled/Custom	50	$500 each	$25,000.00
Picnic Tables	40	$1000 each	$40,000.00
Trash Receptacles	75	$500 each	$37,500.00
Interpretive Guidance Media			
Display Boards	50	$600 each	$30,000.00
Interpretive Markers	100	$600 each	$60,000.00
Bulletin Boards	9	$2,500 each	$22,500.00
		Subtotal	**$7,876,500.00**
	Contingency	20%	$1,575,300
	PED+EDC	11%	$1,039,698
	S&A	7%	$681,947
		Total	**$11,173,445**

5.9 EVALUATION OF FINAL ARRAY OF ALTERNATIVES

5.9.1 System of Accounts

The comparison and evaluation of alternatives involves the consideration of the effects that the plans would have on planning objectives and constraints. The following discussions address the differences and similarities between the future without project conditions and alternatives. The four national accounts are also considered in the comparison and evaluation of alternative plans, as are the associated evaluation criteria.

In the 1970 Flood Control Act, Congress identified four equal national accounts for use in water resources development planning. They are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Policy in the 1970s regarded making contributions to only two of these, NED and EQ, as national objectives. The Federal objective is taken from the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" also known as Principles and Guidelines or P&G.

5.9.1.1 National Economic Development (NED)

The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable Executive orders, and other Federal planning requirements.

"Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. Contributions to NED in clued increases in the net value of those goods and services that are marketed, and also those that may not be marketed" (P&G).

For this project, with the primary outputs being ecosystem restoration, the Environmental Quality (EQ) Account below includes those benefits. Benefits of recreation and flood damage reduction, if any, are accounted for within the NED Account.

Recreation Benefit Analysis

Visitation at the resource would be limited based upon the available parking in the area. Phoenix's design includes several parking lots with a total of 500 spaces. Visitation data maintained by the City for other recreation sites indicates an average number of visitors per vehicle of 2.75. In addition, it is estimated that ten percent of visitors arrive to the site by an alternative mode of transportation (e.g., bicycle, foot traffic and public transportation).

Annual visitation has been estimated for both the winter (October - May) and the summer (June - September) seasons. In addition, visitation has also been broken down by prime time (weekends and holidays) and non-prime time (weekdays). Transfers are expected to be minimal due to the unique recreation opportunities and setting offered at the restoration site. The City expects the primary transfers to be in the categories of education field trips, bird watchers, passive nature watchers, canal joggers, and recreational cyclists. Annual transfers were estimated at ten percent of total visitation. Excluding transfers, annual visitation is estimated at 350,000.

The above visitation projections were also compared to standards established by the National Recreation & Parks Association (NRPA), regarding trail usage and capacity. 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 proposed recreation plan includes approximately 16 miles of multipurpose trails. With baseline visitation projected at 350,000, this equates with a value of about 22,000 users per year per trail mile, which supports that the proposed facilities should be able to accommodate the projected visitation. Further, the proposed facilities should also be able to support likely increases in visitation over time, as the general population growth in the study area will inevitably increase demand and use of the facilities.

Unit Day Point Value Estimates

A panel of Phoenix Parks, Recreation and Library department personnel including Park Managers, Recreation Supervisors, Recreation Coordinators, and Landscape Architects reviewed the recreation plan in light of its location within the planned environmental restoration study area and derived the following point values for the Unit Day Value analysis:

Criteria	Range of Point Values	Assigned Value
Recreation Experience	0-30	24
Availability of Opportunity	0-18	8
Carrying Capacity	0-14	14
Accessibility	0-18	18
Environmental	0-20	12
Total	0-100	76

Recreation experience was rated very high, although most recreation activities could be described as general recreation. This is because of the context within which the recreation takes place. There are very few recreation sites in the market area located in a riparian and wetland environmental setting. This enhances the value of these activities. In addition, non-general recreation and education opportunities are provided, such as interpretive areas and scenic overlooks, birding, etc. The project would be designed to maximize recreational values in the other categories to the extent possible. Please refer to the Economic Appendix (Appendix G), and Recreation Appendix (Appendix L) for additional details.

EGM 06-03 provides ranges for point value to dollar value conversion. The dollar value corresponding with a point value of 76 is $8.254. This point value was applied to projected annual visitation to derive the annual value of the recreation resource. The resulting annual recreation value totals $2,889,000.

Recreation Costs & Benefit/Cost Analysis

Table V-17 details the cost estimates for the proposed recreation plan.

Table V-17: Recreation Plan Expected Annual Costs

First Cost	
Site Preparation	$925,000
Parking Lots (500 Spaces)	$750,000
Entry Roads	$600,000
Sidewalks & Ramps	$240,000
Multi-Use Trails	$282,000
Bridges & Culverts	$75,000
Access Control	$875,000
Security Lighting	$400,000
Signage	$166,000
Picnic/Trail Shelters	$1,205,000
Restroom Facilities	$1,250,000
Utilities	$840,000
Park Furniture	$155,000
Interpretive Guidance Media	$112,500
Subtotal – Construction	**$7,876,500**
Contingency (20%)	$1,575,300
PED/EDC (11%)	$1,039,698
S&A (7%)	$681,947
Total First Cost	**$11,173,445**
Interest During Construction	$573,000
Gross Investment	**$11,746,445**
Annualized Investment Cost	$655,900
OMRR&R	$800,000
Total Annual Cost	**$1,455,900**

Average annual benefits have been estimated at $2,889,000, and average annual costs are estimated at about $1,456,000. Therefore, the proposed recreation plan is economically justified, with net benefits of $1,433,000 and a benefit/cost ratio of 1.98.

5.9.1.2 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 V-18.

Table V-18: Regional Economic Development Account

	No Action	Refine 1	Alt 5A
Employment	No effect	Short-term increase in employment during project construction.	Short-term increase in employment during project construction.
Business and Industry	No effect	Increased recreation and tourist visitation to the area may increase revenues of local businesses.	Increased recreation and tourist visitation to the area may increase revenues of local businesses.
Local Government Finance	No effect	Financing required for construction, $42M. O&M. $980,000/yr $800,000 recreation	Financing required for construction, $60M. O&M. $2,083,000/yr $800,000 recreation.
Growth Inducing Impacts	No effect	No impact on growth. Potential benefit in contribution to neighborhood revitalization.	No impact on growth. Potential benefit in contribution to neighborhood revitalization.

It can safely be assumed that river restoration would contribute significantly to local and regional economic development and revitalization of the neighborhoods adjacent to the river. Land being developed and redeveloped within several miles of the Salt River is taking the potential for a restored river into account. Model homes and developments advertise the restored Rio Salado and the City has a local plan for revitalization and future development upstream of the Rio Salado Oeste study area.

Rio Salado Beyond the Banks

The Rio Salado *Beyond the Banks* area plan is a local policy document for revitalization of the area, which includes approximately 7 square miles between the I-17/I-10 freeways, Broadway Road to the south, 19th Avenue to the west and 32nd Street to the east. City support of private sector investment will be provided through public improvements, financial incentives, technical assistance, and zoning enforcement. Improvements that will increase property values in the area are expected to occur incrementally over time in response to market forces, through private investment, and as a result of City revitalization efforts. As incompatible uses and blight are reduced and new developments, facilities, and amenities are added, the *Beyond the Banks* area will begin to realize its broad potential. Four major areas of emphasis for new development will

help spur area revitalization in general. Estimates of redevelopment that has occurred since the Rio Salado Interim Overlay zoning went into place in January, 2002 are between $325 and $400 million.

Local Property Values

Studies have documented higher property values associated with riparian areas and wetlands. One such study in Tucson, Arizona, documented a 6 percent difference in property value due to proximity to the riparian corridor (Colby and Wishart, 2002). It can be assumed that the change from a degraded floodplain to restored riparian and wetland habitat would have a similar effect on property values in the area.

5.9.1.3 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 could have on significant environmental resources. Table V-19 shows the accounts for each alternative.

Table V-19: Environmental Quality (EQ) Account

	No Action	Refine 1	Alt 5A
AAFCU	580	764	847
Increase in AAFCU	-	184	267
Average Annual Cost ($1,000)	-	$7,553	$12,106
Average Annual Cost/AAFCU ($1,000)	-	$41.05	$45.30
Water Quality	Water quality is expected to decline slightly as the watershed continues to urbanize.	Water quality could decrease temporarily during construction. Best Management Practices would be implemented for mitigation. However, positive impacts over current conditions would occur in the long-term.	Water quality could decrease temporarily during construction. Best Management Practices would be implemented for mitigation. However, positive impacts over current conditions would occur in the long-term.
Air Quality	Existing air quality levels created by business, traffic, and industry would continue. It can be assumed that dust levels would increase with additional dry river bottom disturbed by off road vehicles.	Temporary air quality decrease during construction but would be mitigated through implementation of Best Management Practices. This alternative would have positive long-term impacts when compared to the No Action Alternative.	Temporary air quality decrease during construction but would be mitigated through implementation of Best Management Practices. This alternative would have positive long-term impacts when compared to the No Action Alternative.
Noise	No impacts to noise would occur.	A temporary increase in construction noise would occur but long term conditions would be no more than existing levels.	A temporary increase in construction noise would occur but long term conditions would be no more than existing levels.
Vegetation	Existing native vegetation would decline within the study area.	Restoration of habitat throughout the study area would have a positive effect by restoring native vegetation.	Restoration of habitat throughout the study area would have a positive effect by restoring native vegetation.
Fish and Wildlife	Loss to habitat of fish and wildlife populations due to vegetation changes would occur.	Habitat would improve through the study area and connect upstream and downstream habitats for wildlife movement.	Habitat would improve through the study area and connect upstream and downstream habitats for wildlife movement.

	No Action	Refine 1	Alt 5A
Endangered Species	No impacts to threatened or endangered plant species would occur.	Although no endangered species are known in the study area, habitat restoration could attract them and contribute to positive effects on their habitat.	Although no endangered species are known in the study area, habitat restoration could attract them and contribute to positive effects on their habitat.
Cultural Resources	No impacts on cultural resources.	Potential for impacts to cultural resources is believed to be low. If resources are located, consultation with SHPO would occur.	Potential for impacts to cultural resources is believed to be low. If resources are located, consultation with SHPO would occur.
Aesthetics	Existing aesthetic environment would remain relatively unaffected with continued illegal dumping throughout portions of the study area.	Could be affected during construction, however, many of these areas are not highly visible and affects are short term. Implementation would result in improved views of riparian vegetation.	Could be affected during construction, however, many of these areas are not highly visible and affects are short term. Implementation would result in improved views of riparian vegetation.

5.9.1.4 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 manmade and natural resources. A comparison of the effects that the proposed alternatives would have on OSE resources is shown in Table V-20.

Table V-20: Other Social Effects Account

	No Action	Refine 1	Alt 5A
Life, Health and Safety	No change	Improvement to river environment would improve safety and health in adjacent community.	Improvement to river environment would improve safety and health in adjacent community.
Recreation	Recreation conditions would stay substantially the same. Recreational experiences would also not be enhanced.	Implementation of recreation plan would increase availability and enjoyment of recreation opportunities.	Implementation of recreation plan would increase availability and enjoyment of recreation opportunities.
Community Cohesion	No change	River restoration is preferred over the No Action Alternative and contributes to community cohesion.	River restoration is preferred over the No Action Alternative and contributes to community cohesion.

5.9.2 Associated Evaluation Criteria

The selection of a recommended plan from the alternative plans requires a combination of decision-making factors. As suggested by the U.S. Water Resources Council, 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.

5.9.2.1 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 planning 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. In general, all of the final alternatives are fully formulated and complete. Completeness was a

factor considered in screening of the first set of alternatives. No further measures are needed to allow for the functioning of the final set of alternatives.

5.9.2.2 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 Rio Salado Oeste portion of the Salt River. The No Action Alternative is ineffective in meeting any of the planning objectives. Action alternatives evaluated are all effective to some extent, although some are more effective than others to the extent to which they meet the objectives.

5.9.2.3 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 identifies the plans that have the highest levels of output relative to costs. 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.

5.9.2.4 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. It is assumed that the action alternatives are all acceptable, although this will be assessed further with public review of the draft report.

Table V-21: Associated Evaluation Criteria

Criteria	No Action	Refine 1	Alternative 5A
Completeness	Does not meet objective	Technically feasible, meets restoration objectives, requires less acreage than Alt 5A but also restores less habitat.	Technically feasible, meets restoration objectives, restores the most acreage of priority habitat types.
Effectiveness	Does not meet objective	Restores river channel and provided connectivity but restores less acreage of cottonwood/willow, mesquite and wetlands than Alt 5A.	Restores the river channel and provides connectivity and continuity along river with most acreage of priority habitats restored. Greatest acreage of significant habitat types restored.
Efficiency	Does not meet objective	Provides outputs of 184 AAFCU at a cost of $41,050/AAFCU.	Provides the most output (267 AAFCU) or 45% more than Alt Refine 1 with a 10% increase in cost per unit ($45,300/AAFCU)
Acceptability	Does not meet objective	Non Federal Sponsors have not indicated support for Alt Refine 1.	Supported by Non Federal sponsor, resource agencies, and initial public support was established after the public meeting and Draft Report review June 2006.

5.10 SELECTION OF THE RECOMMENDED PLAN

Upon consideration of the National Objectives and other evaluation criteria Alternative 5A is selected as the NER 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.

That alternative includes restoration of approximately 1,500 acres of riverine habitat throughout the 8-mile study area Approximately 847 AAFCUs would be available with the project, an increase of nearly 47 percent over without-project conditions where there were projected to be 580 AAFCUs. Alternative 5A has an estimated restoration cost of $153,776,850 with an annual cost of $12,367.000 including $2,083,000 Annual O&M.

Restoration features of the alternative include restoration of the river channel to a more natural state by grading and terracing the channel from 19th Avenue to 83rd Avenue; modification of stormwater outfalls to improve water retention; restoration of cottonwood/willow, mesquite, and wetland cover types throught the project area; and the restoration of two old gravel pits to wetland and riparian complexes. The alternative also includes control of invasive species such as saltcedar and Arundo throughout the life of the project . Water supply and distribution for the alternative is to be provided through a combination of 8 mgd of reclaimed effluent from the 23rd Avenue WWTP, and harvesting of storm water.

Table V-22: Acres of Habitat Restored with the Recommended Plan

Habitat	Acres
Cottonwood/Willow	375
Mesquite	417
Open Water	0
Scrub Shrub	52
Wetlands	156
Channel	
Low flow channel	170
In-Channel Wetlands*	34
Riparian scrub	296
*Note that the acreage of in channel wetlands are a part of the 170 acres of low flow channel	

The recreation plan described above is also recommended for implementation. It is consistent with Corps policy on development of recreation at ecosystem restoration projects as outlined in Policy Guidance Letter No. 59, USACE 1998. Major recreation features include multipurpose trails, shelters, signage, shelters, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and 5 smaller access points for walk-in use. Total cost of the recreation plan is $11,173,445. Average annual benefits have been estimated at $2,889,000, and average annual costs are estimated at about $1,456,000. Therefore, the proposed recreation plan is economically justified, with net benefits of $1,433,000 and a benefit/cost ratio of 1.98.

Ecosystem Restoration Significance

As discussed earlier in this report riparian habitat is significant in the Desert 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 recognized 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. The significance of riparian habitat in the Desert Southwest is recognized at various levels. Institutional, public and technical

significance of riparian habitat restoration and that of the Recommended Plan are summarized here.

Executive Order No. 91-6 Protection of Riparian Areas and issued by the Governor of Arizona in 1989 recognizes that "protection and restoration of riparian areas are of critical importance to the state". The order determines a policy statement of the State of Arizona in regards to the protection and restoration of riparian areas.

The Arizona Game and Fish Department Strategic Plan (2001) recognizes riparian habitat as the states richest wildlife habitat and includes focus of conservation on those riparian habitats. It also states that since lowland riparian forest and woodland declined so severely between the 1800 and 1900's that species occupying them comprise more than ½ of the non raptorial birds listed as Wildlife of Special Concern in Arizona.

The U.S. Fish and Wildlife Service describes Southwestern Riparian areas as contributing "significantly to the biological integrity, including biodiversity, of our Nation's waters." It goes on to describe the abundance of breeding birds, as well as its importance as habitat to threatened and endangered species (USFWS, 1993).

The Nature Conservancy in An Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion, lists desert riparian woodland as a very rare although significantly important cover type and describes restoration of riparian systems in the Sonoran Desert as critical. (Marshall et al 2000).

Arizona Partners in Flight Bird Conservation Plan (1999) recommends that maintenance and restoration of riparian deciduous forests should be a top conservation priority in the state. This is due to both the biological significance and the extent to which the habitat has been lost.

Audubon Arizona recognizes the significance of restoration on the Salt River and has entered an agreement with the City of Phoenix to construct the Rio Salado Audubon Center at Central Avenue. This will be an educational conservation center and be adjacent to the constructed Rio Salado project upstream from the Oeste study area.

The references discussed above describe the importance of riparian habitat in Arizona and the region. Restoration of 8 miles of the Salt River in Phoenix goes beyond the footprint of the recommended plan. It also provides a connection between the Rio Salado and Tres Rios projects, when all are combined nearly 18 river miles will be restored. Although significant themselves, once completed the entire reach will be even more so. Restoration will provide a large corridor of restored habitat of extreme importance to breeding and migratory birds and other wildlife that depend on it.

Riparian habitat is recognized in Arizona and the Desert Southwest as being biologically significant, scarce, and threatened due to the losses over the past 100 years. With the recognition of this importance it can be seen that the recommended plan contributes to restoration of a significant ecological resource.

5.11 RISK AND UNCERTAINTY

Uncertainty and variability are inherent in water resources planning and therefore the consideration of risk and uncertainty is important. Situations of risk are conventionally defined as those in which the potential outcomes can be described in reasonably well known probability distributions. In situations of uncertainty, potential outcomes cannot be described in objectively known probability distributions. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. The degree of risk and uncertainty generally differs among various aspects of a project. It also differs over time, because benefits from a particular purpose or costs in a particular category may be relatively certain during one time period and uncertain during another.

5.11.1 Flood Damage Reduction

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 ER 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability and Economics in Flood Damage Reduction Studies (1 March 1996).*

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. Uncertainties in flood damage analysis includes discharge/probability, stage/discharge, geotechnical features, structure elevation and values, and inundation depth/damage.

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-RAS 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.

More detailed discussion of risk and uncertainty in the flood damage analysis and hydrologic and hydraulic data can be found in Appendix A, Hydrology and Hydraulics, and Appendix G, Economic Evaluation.

5.11.2 Ecosystem Restoration

Some risk and uncertainty are assumed in nearly every aspect of a water resources project. The variability of outcome associated with the recommended plan does not fit the definition of risk. That variability is better characterized as uncertainty in that the potential outcomes cannot be described in known probability distributions. 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.

A higher than normal amount of uncertainty exists regarding landscape-scale ecosystem restoration in the arid southwest. This is because the few such projects that have been completed are of recent origin and detailed data is not yet available to assess the outcomes. Given the lack of precedent and scarcity of empirical data regarding restoration of Sonoran riparian systems, there is a degree of uncertainty regarding a number of aspects of the design, construction, and operation of the recommended alternative.
Within planning for the Rio Salado Oeste Project several areas of uncertainty were identified and addressed. Those areas of uncertainty include:

- **Storm Water availability**: In order to account for uncertainty in the volume of runoff at stormwater outfalls, the estimated annual volume of runoff was halved prior to planning the quantity of habitat that could be supported. While observations of existing vegetation at some of the existing outfalls suggest that there is sufficient water to support the proposed restoration, the reduced volume accounts for the uncertainties with rainfall in any given year. Additional water supply to each outfall was also planned for establishment period and as a back-up in severe drought conditions.

- **Trash/Debris unearthed during construction**: As observed in the Rio Salado Project under construction, more trash and debris than previously estimated were unearthed during construction. While a Modified Phase I ESA was performed for this project and

field observations have not identified known areas of extensive trash and debris, 2 percent of the construction cost was added to account for this unknown.

- **River discharges**: In order to reduce the unknown effects of river discharges on restoration features as well as the risk of damages, efforts were made during plan formulation to minimize placement of project features within the 10-year discharge area of inundation. Also, the channel restoration measure in addition to providing for restoration allows conveyance of flood flows and reduced the potential for damages to project features on the terraces.

- **Land use changes**: During project planning, efforts were made to account for any possible land use changes that may affect the project area. The largest area of uncertainty is the duration that existing aggregate operations will be in existence and the potential for new ones to be established prior to implementation. Should conditions change prior to project implementation, it can be assumed that the configuration of restoration features may change with them.

- **Revegetation success**: The success of revegetation measures is vulnerable to some uncertainty. While the proposed actions to restore vegetation have taken place and are in progress in the arid southwest, including immediately upstream of the study area, uncertainties remain. Mortality due to poor stock, disease, insect infestation, herbivore damage, and other unforeseen circumstances contribute to uncertainties. Revegetation techniques assumed with the proposed project features are very similar to those being implemented successfully elsewhere, including Rio Salado immediately upstream. It is assumed that by the time any authorized project is implemented, more will have been learned about the success of that project and any changes necessary would be incorporated at the time of construction. An O&M plan and costs include estimates for vegetation replacement. A Monitoring and Adaptive Management Plan will also be in place and would provide time to monitor success and make any changes to features that require it.

CHAPTER VI
DESCRIPTION OF THE RECOMMENDED PLAN

6.1 THE RECOMMENDED PLAN

Based on the results of the analyses conducted and described in Chapter V above, Alternative 5A has been identified as the recommended NER Plan. Alternative 5A is shown in plates at the end of the report.

6.2 PLAN FEATURES

The Recommended Plan (Alternative 5A) includes restoration of four significant habitat types throughout the project area. These are habitats that are scarce and ecologically significant in the desert southwest, including cottonwood/willow (375 acres), mesquite (417), wetlands including within the river channel (190 acres), and restoration of 8 miles of river channel made up of approximately 500 acres of active channel and riparian scrub. Multiple measures make up the restoration plan, including, water supply and distribution, channel restoration, revegetation, and invasive-species removal.

6.2.1 River Channel Restoration

Restoring the river channel to a more natural state would be accomplished by grading and terracing to help restore an active channel through the entire 8-mile reach. Average depth would be 5 feet, with a width varying from 200 to 400 feet. The channel design passes a 5-year event (~22,000 cfs) with occasional flooding on the terrace 2 to 4 feet depth at 1-7 cfs. An estimated 660,000 c.y. would be removed from the channel to implement this measure. Material removed would be native riverbed material and would be used on site for terracing and construction of other project components, such as reshaping of the two "lakes" within the project area.

Grade Control Structure. Due to a drop in grade downstream of the 35th Avenue Bridge, a grade-control structure is recommended within that vicinity. This structure would be similar to those installed in the upstream Rio Salado Project, and would consist of roller-compacted concrete and grouted stone.

would be less, with approximately 25 velvet mesquite, 5 screwbean mesquite, and 10 understory shrubs per acre.

Riparian Scrub: It is assumed that some portions maintained will remain a more xeric desert scrub but others adjacent to the wetter riparian habitats will develop into more distinctive riparian cover containing species such as Seepwillow, desert broom, or Desert willow. Approximately 296 acres of the active river channel will be riparian scrub.

6.2.4 Wetlands

A total of approximately 156 acres of wetlands would be restored with Alternative 5A. This would include the stormwater wetlands described above, in the vicinity of the "lakes," and within the restored channel. Wetlands could consist of open water, submerged vegetation, or mud flats, all requiring a high water table at or near the surface. Due to the porous soils found in this project area, lining the site would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is 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. Emergent wetlands contain primarily cattails (*Typha domingensis*), tule (*Scirpus acutus*), and sedges (Carex spp.). Because the river will not flow year round, the wetlands would need to be constructed specifically to retain water. In addition to grading and excavation, an impermeable layer would be added to retain water on site.

6.2.5 Lake Restoration

There are existing lake features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. Under Alternative 5A, the proposed measures include significant regrading to restore the lake features into a more natural state coinciding with the floodplain environment. This would include the movement of approximately 3 million c.y. of materials. With the reshaping of the two areas, additional measures described above would be incorporated, including the wetland and riparian habitat restoration that would be carried out within them.

River Channel Habitats: The habitats restored within the active channel will include a combination of dry river bottom, emergent wetland, riparian scrub or desert scrub, depending on the specific site. Total acreage of the active river channel is assumed to be nearly 500 acres comprised of a 170 acre low flow channel, 34 acres of emergent wetland and the remainder riparian scrub.

6.2.2 Stormwater Wetlands

Stormwater outfalls within the project area have been identified and average discharges from them quantified, with an estimated 2,863 ac-ft available for use in restoration. This measure includes the addition of grouted rock channels extending from the banks into the channel from existing pipe outfalls. The grouted rock would extend approximately 100 feet from the existing pipe outfall and would vary from 2 to 4 feet in height. The required grout is approximately thirty percent of the needed rock. Each outfall would require 221 c.y. of rock and 67 c.y. of grout. The outfall sites would require a total of 1989 c.y. of rock and 603 c.y. of grout. Large storm flows would be conveyed to the channel while smaller discharges would be directed into adjacent wetland and riparian habitat areas. Techniques would be site-specific and would include grading or excavation, removal of exotics, and planting of suitable vegetation for the site conditions. Supplemental water would be required via an irrigation source, and structures would be installed to contain high-energy inputs and avoid erosion during storm events. It was assumed that approximatley 28 acres of wetlands would be associated with the outfalls within the study area and that they will improve the water quality.

New Stormwater Outfalls: As the land to the west of 51st Avenue is developed, additional stormwater runoff to the river would be possible. At 75th Avenue, a future storm drain may provide additional source water for project features. However, current drainage regulations require onsite retention of runoff. Changes to local zoning regulations and implementation of stormwater drainage plans for lands nearby the river could provide the benefit of additional project water, increased habitat values, and management of stormwater quality and quantity as the area is devleoped.

6.2.3 Revegetation

Planting of riparian vegetation to restore the various cover types is included in the plan. General locations of the restored habitats are shown on Plates at the end of the report.

Cottonwood/Willow: Cottonwood/willow would be dominated by Fremont's cottonwood (*Populus fremontii*) and Gooding's willow (*Salix gooddingii*). Other understory species would be planted, depending upon individual site conditions, but may include arrowweed (*Pluchea sericea*), elderberry (*Sambucus mexicana*) or burrobush (*Hymenoclea spp.*). The feasibility design includes approximately 60 to 100 trees and 5 shrubs per acre, with a combination of pole and containerized plantings. Hydroseeding of ground cover and additional shrubs is also included in the design.

Mesquite: This habitat would be restored over a potentially large portion of the project area. It would require periodic watering for the first five years after planting, though with less frequency than cottonwood/willow. Watering could possibly be discontinued after five years or when roots are expected to reach groundwater. Mesquite bosques would be dominated by velvet mesquite (*Prosopis velutina*), with scattered screwbean mesquite, and some understory shrubs, such as desert thorn (Lycium spp.), palo verde (*Cercidium floridum*), brittlebush (*Encelia farinose*), and forbs.

Bosque: Mesquite bosques are commonly found 5 to 20 feet above the river channel where water is adequate. They require a water table or semi-saturated soil conditions 10 to 30 feet below the surface elevation, and rely on occasional saturated conditions 1 to 3 feet below the surface. Soil requirements range from fine to gravelly with some rocky areas. The mesquite bosques would be planted with a density of approximately 100 velvet mesquite, 10 screwbean mesquite, and 40 understory shrubs per acre. Understory forbs would also be planted using a seed mix.

Xeric: In locations throughout the study with less water supply, xeric stands of mesquite would be established. It is assumed that mesquite would survive under drier conditions and on higher terraces than mesquite bosques. Planting densities

6.2.6 Invasive Species Management

Invasive species such as saltcedar and Arundo would require removal and management with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. Saltcedar is currently found in stands throughout the study area. Arundo, although not yet a significant problem in Arizona, is a problem in neighboring California and some stands are found within the project area. It was assumed that an approximate 120 acres would require invasive-species control measures prior to restoration.

6.2.7 Water Supply and Distribution

The City of Phoenix developed the water supply and distribution plan for the project. The primary water supply for the Rio Salado Oeste project would be effluent obtained directly from the 23rd Avenue WWTP with supplemental water (if necessary) potentially from several sources. An estimated 8 mgd is available from the 23rd Avenue Plant.

The sustainable water supply and distribution system would consist of the following features:

- 20 mgd pump station
- Supply well
- Monitoring wells
- Electronic flow regulated valves
- Reservoirs
- Pump stations
- Open channel canals
- Irrigation system
- Pressurized distribution piping

A combination of irrigation approaches could be implemented in the project and would be determined in detail during design. These could include temporary drip systems for establishment of vegetation, subsurface liners to create an artificially perched aquifer, and canal or rill (ditch or flood) irrigation, as well as water-harvesting polymer, or polymer-type products, planted with vegetation. The estimated cost of the water supply and distribution for the recommended alternative is $22,037,500.

6.3 PROJECT OUTPUTS

The recommended plan provides a habitat value of 847 AAFCUs, or a net increase of 267 AAFCUs over without-project conditions. This is a 46 percent increase in AAFCUs with project implementation.

In addition, the restoration included in this project would provide an important and significant linkage between the other restoration projects on the river. Restoration of this 8-mile reach would tie together Rio Salado upstream and Tres Rios downstream, providing approximately 21 miles of contiguous Sonoran desert riparian habitat. This type of river-connected riparian and fringe habitat is of an extremely high value due to its rarity. Arid southwest riparian ecosystems are recognized 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.

Table VI-1 Alternative 5A Cost Estimate

Estimate MCACES Cost Estimate ($1,000s FY 06 PL 5 1/8%)	
Construction	$66,343
Contingency (20%)	$13,269
Subtotal	$79,612
PED/EDC (11%)	$8,757
Subtotal	$88,369
S&A (6.5%)	$5,744
Total Construction Cost	$94,113
Real Estate (including 25% contingency)	$55,900
Subtotal	$150,013
Monitoring and Adaptive Management	$3,765
Total First Cost	**$153,776**
IDC	$15,770
Gross Investment	$169,547
Annualized Investment Cost	$9,467
Associated Cost (water supply)	$817
O&M	$2,083
Total Annual Cost	**$12,367**

Notes: *EDC= Engineering During construction*
S&A= Supervision and Administration

6.4 MAINTENANCE CONSIDERATIONS

O&M activities would occur after project construction in order for project features to function as designed. O&M activities are detailed within the cost estimate and would include the activities listed below.

Replacement Costs. Up to 25 percent of vegetation could require replacement following a flood event at some time during the project life.

Invasive Species Control. Annual removal of exotic species was assumed to be necessary. This would include removal of non-native species that threaten to overtake an area and become a monoculture. This wouldn't necessarily include removal of 100 percent of non-natives through the project area.

Stormwater Wetlands. Regrading and excavation was assumed to be necessary once every 10 years. It was assumed that 50 percent of the construction quantity would need to be regraded in this period.

Irrigation System. Maintenance of the irrigation infrastructure, including replacement of infrastructure, would occur annually. Costs were estimated on a per-acre basis for those acres planted to vegetation.

Lakes/Wetlands. The restored wetlands at existing lakes (gravel pits) would require regrading and excavation once every 20 years of up to 1 foot of material over the 40 acres of wetlands.

Channel. The active channel would require regrading up to once every 20 years for up to 50 percent of the estimated construction quantity or 330,000 c.y.

Water Supply. The water supply and distribution system would require periodic maintenance and inspection of pumps and pipelines. Inspection, repair, and replacement would be necessary for the irrigation system and infrastructure. More detailed description of maintenance is included in Appendix J, Design and Cost Estimate.

6.5 RECREATION PLAN

The City of Phoenix developed the recreation plan for the project, which may be found in Appendix L. The plan is consistent with Corps policy on development of recreation at ecosystem restoration projects, as outlined in Policy Guidance Letter No. 59, USACE 1998. Major recreation features include multipurpose trails, shelters, signage, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and five smaller access points for walk-in use. Although an environmental-education center is included in the local plan, it is not a cost-shareable portion of the project and would be a local sponsor cost. Table VI-2 below summarizes the locations and features included in the recreation plan.

Table VI-2 Recreation Plan

Component	Quantity	Unit Cost	Recreation Cost
Site Preparation			
Site Prep to include: clearing, grubbing, and grading	9	Lump Sum	$250,000.00
Vegetative Restoration (Drive in Access)	4	Lump Sum	$600,000.00
Vegetative Restoration (Walk in Access)	5	Lump Sum	$75,000.00
Access and Circulation			
Entry Road w/Turnaround to include: curb, gutter, driveway, & road	4	Lump Sum	$600,000.00
Parking lot	500	$1500/space	$750,000.00
Sidewalks and Ramps	40,000 sf.	$6.00 each	$240,000.00
Multi-Use Trails (24mi * 5280 * 5ft)	47000	$6.00 / sy	$282,000.00
Bridges and Culverts (small) @ Canals, and Localized Drainage Areas	10	$7,500 each	$75,000.00
Protection Access Control			
Access Control Gates (vehicular)	10	$7,500 each	$75,000.00
Access Control Gates (pedestrian)	18	$3,500 each	$63,000.00
Handrails	5,000 l.f.	$50.00 each	$250,000.00
Guardrails	3,000 l.f.	$50.00 each	$150,000.00
Fencing	5,000 l.f.	$30.00 each	$150,000.00
Walls	1,500 l.f.	$125.00 each	$187,500.00
Security lights	100	$4,000 each	$400,000.00
Signage			
Entrance identification signage	8	$15,000 each	$120,000.00
Traffic Control (vehicular)	20	$500 each	$10,000.00
Traffic Control (pedestrian)	27	$500 each	$13,500.00

Instructional/Directional	45	$500 each	$22,500.00
Shelters			
Picnic (large)	5	$60,000 each	$300,000.00
Picnic (small)	5	$25,000 each	$125,000.00
Restroom Facility/Comfort Station	5	$250,000 each	$1,250,000.00
Shelter w/Bulletin Boards	4	$25,000 each	$100,000.00
Trail Shelter w/Railing (large)	9	$40,000 each	$360,000.00
Trail Shelter w/Railing (medium)	4	$30,000 each	$120,000.00
Trail Shelter w/Railing (small)	10	$20,000 each	$200,000.00
Utilities			
Municipal Water Supply and Wastewater Disposal	5	Lump Sum	$500,000.00
Storm Drainage	4	Lump Sum	$80,000.00
Drinking Fountain w/Chiller	12	$5,000 each	$60,000.00
Electical	4	Lump Sum	$200,000.00
Park Furniture			
Benches:	14	$1,500 each	$21,000.00
Off-the-Shelf	40	$800 each	$32,000.00
Recycled/Custom	50	$500 each	$25,000.00
Picnic Tables	40	$1000 each	$40,000.00
Trash Receptacles	75	$500 each	$37,500.00
Interpretive Guidance Media			
Display Boards	50	$600 each	$30,000.00
Interpretive Markers	100	$600 each	$60,000.00
Bulletin Boards	9	$2,500 each	$22,500.00
		Subtotal	**$7,876,500.00**
	Contingency	20%	$1,575,300
	PED+EDC	11%	$1,039,698
	S&A	7%	$681,947
		Total	**$11,173,445**

The recreation plan is estimated at $11,173,445, with Annual O&M of $800,000.

6.6 ASSOCIATED NON-FEDERAL CONSIDERATIONS

The non-Federal sponsor (Sponsor) for the project would be required to purchase all lands, easements, rights-of way and disposal areas (LERRDs) needed for project implementation. Real estate is described in more detail in Appendix H. Approximately 1,500 acres are required for the project and currently estimated at $55,900,000. The estate to implement this project is recommended as fee simple. However, lands owned by Maricopa County are recommended to

be acquired by permanent easement. The estate will be requested in accordance with ER-405-1-12, Chapter 12 Paragraph 12-9 c.

The cost of lands for this project is in excess of 25% of the total project cost. Corps policy pertaining to ecosystem restoration states that "As a target, land value should not exceed 25 percent of total project costs. Projects with land costs exceeding this target level are not likely to be given a high priority for budgetary purposes." (ER 1105-2-100; Section E-30.f).

The Sponsor 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 Sponsor would also be responsible for Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs (estimated at $2,083.000 per year). The sponsor would also be responsible for 50 percent of the cost to implement the selected recreation plan. Annual OMRR&R costs of $800,000 associated with the selected recreation plan would also be the Sponsor's responsibility.

6.7 MONITORING AND ADAPTIVE MANAGEMENT PLAN

The Salt River, although highly modified and controlled, remains a natural river system where changes may occur. While planning for this project has accounted for the possible factors affecting the study area, it is inevitable that uncertainty would remain with the outcome of the recommended plan. Implementation of a monitoring and adaptive management plan would not alleviate all uncertainty, but would provide flexibility to account for changing environmental conditions and new information, as well as measure project success.

The Monitoring and Adaptive Management Plan is an essential element for the overall implementation of the proposed plan. It would provide 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 described in ER 1105-2-100 Planning Guidance Notebook page 3-25 (8) Monitoring and adaptive management:

> "Monitoring may be necessary to determine if the predicted outputs are being achieved and to provide feed back for future projects ... The cost of monitoring included in the total project cost and cost shared with the non-Federal sponsor shall not exceed one percent of the total first cost of ecosystem restoration features. For complex specifically

> authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended. The cost of the adaptive management action, if needed, will be limited to 3 percent of the total project cost excluding monitoring costs."

It was assumed that the Monitoring and Adaptive Management Plan for the recommended plan would be 4 percent of total construction, or $3.75 million over five years. The plan includes cost-shared monitoring and adaptive management actions during the first five years after initial project implementation. After the first five years, monitoring and/or adaptive management would become the responsibility of the local sponsor (City of Phoenix). However, the local sponsor can use this plan to help guide the monitoring efforts and refine the project features such that project goals and objectives are achieved.

It is recommended that the plan, found in Appendix N (Monitoring and Adaptive Management) be reevaluated and updated during PED, taking into account lessons learned from the Rio Salado and Tres Rios Projects in the immediate vicinity, as well as other projects such as Va Shly'ay Akimel further upstream on the Salt River.

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 would provide the maximum NER benefits relative to project costs while achieving the stated project objectives and while meeting the criteria established by the study team and Federal Principles 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 (Public Law 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 related to ecosystem restoration and 50 percent related to recreation. (First costs are all costs to implement the project less O&M costs). The Federal Government's responsibilities are anticipated to be:

1. Design and prepare detailed plans and specifications.

2. Identify the real estate requirements for implementation of the project.

3. Administer contracts for construction and supervision of the project after authorization, funding, and receipt of non-Federal assurances.

4. Conduct all necessary cultural resource investigations and coordinate and implement any necessary preservation or mitigation measures

5. Conduct periodic inspections with the non-Federal sponsor to determine adherence to the post-construction maintenance requirements

7.2.2 Non-Federal Responsibilities

Non-Federal or local responsibilities are anticipated to be:

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

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

    b. Provide, during construction, any additional funds needed to cover the non-Federal share of design costs.

    c. 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.

    d. 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.

e. Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the total project costs allocated to ecosystem restoration and 50 percent of the total project costs allocated to recreation.

2. Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features, without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRRR&R manual and any subsequent amendments thereto

3. 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.

4. Comply with Section 221 of the Flood Control Act of 1970, Public Law 91-611, as amended, 42 U.S.C 1962d-5b. and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, 33 U.S.C. 2213 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.

5. 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.

6. 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.

7. 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.

8. 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.

9. Agree that, as between the Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, 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.

10. Prevent obstructions of, or encroachments on, the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the level of protection it affords, hinder its operation and maintenance, or interfere with its proper function, such as any new developments on project lands or addition of facilities which would degrade the benefits of the project.

11. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended 42 U.S.C 4601-4655, 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.

12. 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)).

13. 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.

14. 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.

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

16. 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.

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

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 or facilities; 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 VII-1 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 $164,950,295.00 at a current Federal discount rate of 5 1/8 percent. Based on the requirements of WRDA 1986, as amended 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.

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 $11,173,000. The cost for all O&M would be the responsibility of the non-Federal sponsor. O&M of the ecosystem restoration is currently estimated at $2,083,000 annually and $800,000 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 $817,000 annually.

Table VII-1: Cost Apportionment Recommended Plan

Item	Federal	Non-Federal	Total
Construction of Ecosystem Restoration Features*	$ 61,173,031	$ 32,939,324.60	$ 94,112,356.00
Monitoring and Adaptive Management	$ 2,446,921.10	$ 1,317,572.90	$ 3,764,494.00
LERRDs**	-	$ 55,900,000.00	$ 55,900,000.00
Total First Cost of Ecosystem Restoration	**$ 63,619,952.50**	**$ 90,156,897.50**	**$ 153,776,850.00**
Cost Share Adjustment***	$ 36,355,000.00	$ (36,335,000.00)	
Total Cost-Shared Costs	$ 99,954,952.50	$ 53,821,897.50	$ 153,776,850.00
Percentage of Total Cost-Shared Amount – Ecosystem Restoration	*65%*	*35%*	
Total Cost-Shared Costs for Recreation	**$ 5,586,722.50**	**$ 5,586,722.50**	**$ 11,173,445.00**
Percentage of Total Cost-Shared Amount – Recreation	*50%*	*50%*	
TOTAL FIRST COSTS	$ 105,541,675.00	$ 59,408,620.00	$ 164,950,295.00

**Construction, S&A, PED/EDC and Contingency, does not include IDC or OMRR&R*
*** Lands, easements, rights of way, relocations, and disposal areas.*
**** Non-Federal cost shared amount exceeds the 35% requirement for ecosystem restoration projects. Adjustment to the first cost amounts result 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

The non-Federal sponsor will prepare the following preliminary financial analysis.

1 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.

2 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.

3 Investigate the means for raising additional non-Federal financial resources including, but not limited to, special assessment districts.

4 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 (NEPA)

NEPA ensures public involvement and notification of a proposed project. An initial public meeting was held on September 13, 2001, and a final public meeting was held on May 18, 2006. Multiple public workshops, information sessions, and meetings were also held as part of the scoping process. State and agency review of the Final EIS will be completed and a Record of Decision will be prepared.

7.6.2 Endangered Species Act

Endangered Species Act, Section 7 informal consultation was completed with concurrence letter dated August 7, 2006 received from the USFWS. The Biological Assessment (see EIS) found that the project may affect but not adversely affect bald eagle, Southwest willow flycatcher, and Yuma clapper rail.

7.6.3 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act Report provided by the USFWS supports the proposed restoration project and listed four recommendations to pursue in project implementation. These include the following:

1. Focus significant attention on securing a permanent and sufficient source of water, perhaps through a combination of effluent, groundwater, and storm water.

2. Maximize opportunities to restore a mosaic of heterogeneous vegetative cover types that maximizes structural habitat complexity.

3. Ensure that site-specific microhabitat conditions would be conducive to establishment and growth of native riparian plants, especially cottonwood, willow, and mesquite.

4. Encourage the non-Federal sponsor to evaluate Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans.

The first two recommendations have been implemented during formulation and evaluation of restoration alternatives. During project design site specific microhabitat conditions will be revisited and evaluated to ensure conditions are conducive to native riparian plants. The Corps will encourage and participate in evaluation of Safe Harbor Agreements, Candidate Conservation Agreements, or Habitat Conservation Plans as necessary during PED and Construction.

7.6.4 Clean Water Act, Section 404(b)(1)

Pursuant to sect 404 of the Clean Water Act, 33 U.S.C. 1251 et seq, the Corps regulates the discharge of fill materials into waters of the United States. Where, as here, the discharge is

part of a Federal construction project that Congress authorizes the Corps to perform, the Corps does not issue itself a permit, but rather evaluates the impacts of the discharge utilizing the section 404(b)(1) guidelines and includes the evaluation in the environmental impact statement (EIS) for the project. The EIS for this project contains a 404(b)(1) analysis as Appendix A to the EIS. Although no section 404 permit is required for Corps construction activities, the non-Federal sponsor may be required to obtain a Section 404 permit for discharges of material associated with post construction operation and maintenance activities, unless granted a 404(r) exemption.

The recommended plan would result in discharge of fill material into waters of the United States during the period of construction. Pursuant to section 404 of the Clean Water Act, 33 U.S.C. 1251 et seq, the Corps regulates the discharge of fill materials into waters of the United States. Where, as here, the discharge is part of a Federal construction project that Congress authorizes the Corps to perform, the Corps does not issue itself a permit, but rather evaluates the impacts of the discharge utilizing the Section 404(b)(1) guidelines and includes the evaluation in the environmental impact statement (EIS) for the project.

The recommended plan may result in discharges associated with O&M activities. A Section 404(b)(1) evaluation has been prepared to address practicable alternatives, and can be found in the accompanying EIS. Based on this analysis, the feasibility report recommends that the project receive a 404(r) exemption for the construction period when Congress authorizes the project. Discharges into waters of the U.S. for future OMRR&R activities by the non-federal sponsor would require separate authorization pursuant to the Clean Water Act.

7.6.5 National Historic Preservation Act

Archeological investigations have been conducted as described in Sections 4.2.8.4 and 4.2.8.5 of this report. A letter was sent to the Arizona State Historic Preservation Officer (SHPO) on July 6, 2005 with our determinations in accordance with 36 CFR 800.4(d). We received a letter of response dated August 10, 2005. This letter concurred with the APE as described in Section 4.4.5 above. The SHPO requested a written report of the survey conducted by Corps personnel. A Memorandum of Record (MFR) was completed describing the survey conducted in March

2004. Correspondence may all be found within the attached EIS. The Rio Salado Oeste project is in compliance with Section 106 of the National Historic Preservation Act, Public Law 89-665, as amended, 16 U.S.C. 470a, and its implementing regulations found at 36 C.F.R. Part 800.

Unanticipated Discovery: Pursuant to Section 106 of the National Historic Preservation Act, Public Law 89-665, as amended, 16 U.S.C. 470a, and its implementing regulations found at 36 C.F.R 800.12(2), any discoveries of either human remains or archeological deposits during construction activities shall result in the following process:

- Corps of Engineers Archeology Staff shall be notified of discovery.
- Corps Archeology Staff shall determine if discovered cultural matter is an isolated find, or consists of a deposit of some extent. If needed, hand excavations shall be conducted to determine if the deposit is of sufficient content and integrity to be eligibly for listing on the National Register of Historic Places.
- The Corps shall determine eligibility, and effect in consultation with the State Historic Preservation Officer pursuant to 36 CFR 800.

7.7 SPONSORSHIP AGREEMENTS

Prior to the start of construction, the non-Federal sponsor would be required to enter into an agreement with the Federal Government that it would comply with Section 221 of the Flood Control Act of 1970, Public Law 91-611, as amended U.S.C. 1962d-5b, and the Water Resources Development Act of 1986 , Public Law 99-662, as amended 33 U.S. 2201 et seq.

7.8 PROCEDURES FOR IMPLEMENTATION

Future actions necessary for authorization and construction of the Recommended Plan are summarized as follow:

1. The Draft and Final Feasibility Report/Environmental Impact Statement will be reviewed by the Headquarters of USACE, Washington, D.C, City of Phoenix, EPA, and the public.
2. The Chief of Engineers will seek formal review and comments by the Governor of the State of Arizona and interested Federal agencies.

3. Following State and Agency review, the report will be sent to the Assistant Secretary of the Army for Civil Works.

4. Upon approval of the Assistant Secretary, the report will be forwarded to the Office of Management and Budget to obtain the relationship of the project to programs of the President.

5. The final report of the Chief of Engineers will then be forwarded by the Assistant Secretary of the Army for Civil Works to Congress.

6. Congressional review of the feasibility report and possible authorization of the project would follow.

7. 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.

8. Following receipt of funds, preconstruction engineering and design would be initiated and surveys and detailed engineering designs would be accomplished.

9. Following Congressional authorization of the project, plans and specifications would be accomplished by the District Engineer.

10. Subsequent to appropriation of construction funds by Congress, but prior to construction, formal assurances of local cooperation would be required from non-Federal interests.

11. 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 ecosystem restoration measures, and problems they addressed, in general were obtained through coordination with the local sponsor and with other various local and regional public agencies, community groups, resource conservation groups and the public. These coordination efforts consisted of public meetings held during the reconnaissance and feasibility phases, through the maintenance of points of contact that any interested party could discuss matters, and a distribution list where notices of public meetings was distributed. Announcement of public meetings was made in local media providing the date, time, place and subject matter.

8.2 DIVISION OF PLAN RESPONSIBILITIES

The City of Phoenix has expressed willingness in continuing to be a non-Federal sponsor for project implementation. They 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 project is presented as Figure VIII-1. There is currently a significant interest in providing ecosystem restoration solutions with recreation opportunities on the Rio Salado Oeste reach of the Salt River.

City of Phoenix
OFFICE OF THE CITY MANAGER

April 21, 2006

Colonel Alex Dornstauder
United States Army Corps of Engineers
915 Wilshire Boulevard, Suite 14P00
Los Angeles, California 90017

Re: Letter of Support for the Rio Salado Oeste Recommended Plan, Salt River Ecosystem Restoration Feasibility Study

Dear Colonel Dornstauder:

The City of Phoenix, as the local sponsor, supports the recommended plan contained in the Rio Salado Oeste Ecosystem Restoration Feasibility Report, for the Salt River between 19th Avenue and 83rd Avenue through Phoenix.

This restoration plan is consistent with the overall vision and goals the city has for restoration of the Salt River. We are prepared to move forward with the Army Corps to the next level of design and construction. This includes the sponsor's commitment to secure our financial share for preconstruction engineering and design costs once the project receives Congressional authorization.

We thank the Army Corps for their commitment and involvement in constructing the upstream Rio Salado environment restoration project. The successful grand opening of Rio Salado for our residents and all of its visitors on November 5, 2005 was a great beginning in making the riverbed an asset for our community and a natural resource. We look forward to working with the Army Corps to extend the improvements downstream by making Rio Salado Oeste a reality.

Sincerely,

Karen Williams

Karen Williams
Rio Salado Project Director
City Manager's Office

200 West Washington Street, 12th Floor • Phoenix, Arizona 85003 • 602-262-6941 • FAX: 602-261-8327
Recycled Paper

Figure 0-1 City of Phoenix Support Letter

8.3 SUMMARY OF STUDY MANAGEMENT, COORDINATION, PUBLIC VIEWS AND COMMENTS

The study team was made up of a multi-disciplinary group that consisted of several functional elements of the Corps and the non-Federal sponsor. The study team included study and project managers, engineers, hydrologic and hydraulic engineers, groundwater specialists, environmental specialists, cost estimators, designers, appraisers, economists, materials, geotechnical specialists, real estate specialists, and landscape architects.

Formal and informal coordination occurred with a variety of Federal, State, and local agencies in addition to the public involvement described above. The Draft Environmental Impact Statement was distributed to local, State, and Federal Agencies and Tribal Governments for review and comment. Representatives from USFWS and AGFD participated in development of the functional assessment model and its application. The USFWS, AGFD, and FCDMC also participated in development of alternatives and their design. USFWS has provided a Coordination Act Report for this study, which can be found in the attached Final EIS. Further information pertaining to public meetings as well as public comments is also found in the EIS.

Letters from the US EPA, US Department of the Interior, Yavapai Prescott Indian Tribe, and Arizona Game and Fish Department were all supportive of the restoration project. Additional letters of support were received from Audubon Arizona, Phoenix Community Alliance, Valley Forward, Phoenix Planning Commission, Phoenix Parks and Recreation Board, members of the Phoenix City Council and former members of the Rio Salado Advisory Committee. All correspondence and comments on the report are found in the attached Environmental Impact Statement.

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CHAPTER IX

RECOMMENDATIONS

I recommend that the plan described herein for ecosystem restoration and recreation, be authorized for implementation as a Federal project. The total first cost of the project is currently estimated at $164,950,295 under October 2006 prices. The Federal share is currently estimated at $105,541,675.

I recommend that the 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.

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 required items of local cooperation identified in Chapter VII which the non-Federal sponsor must agree to prior to project implementation.

The plans presented herein are recommended with such modifications 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 before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Alex C. Dornstauder
Colonel, US Army
District Engineer

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CHAPTER X
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PLATES

Plate 1: Alternative 1 No Action

Plate 2: Alternative 2

Plate 3: Alternative 4

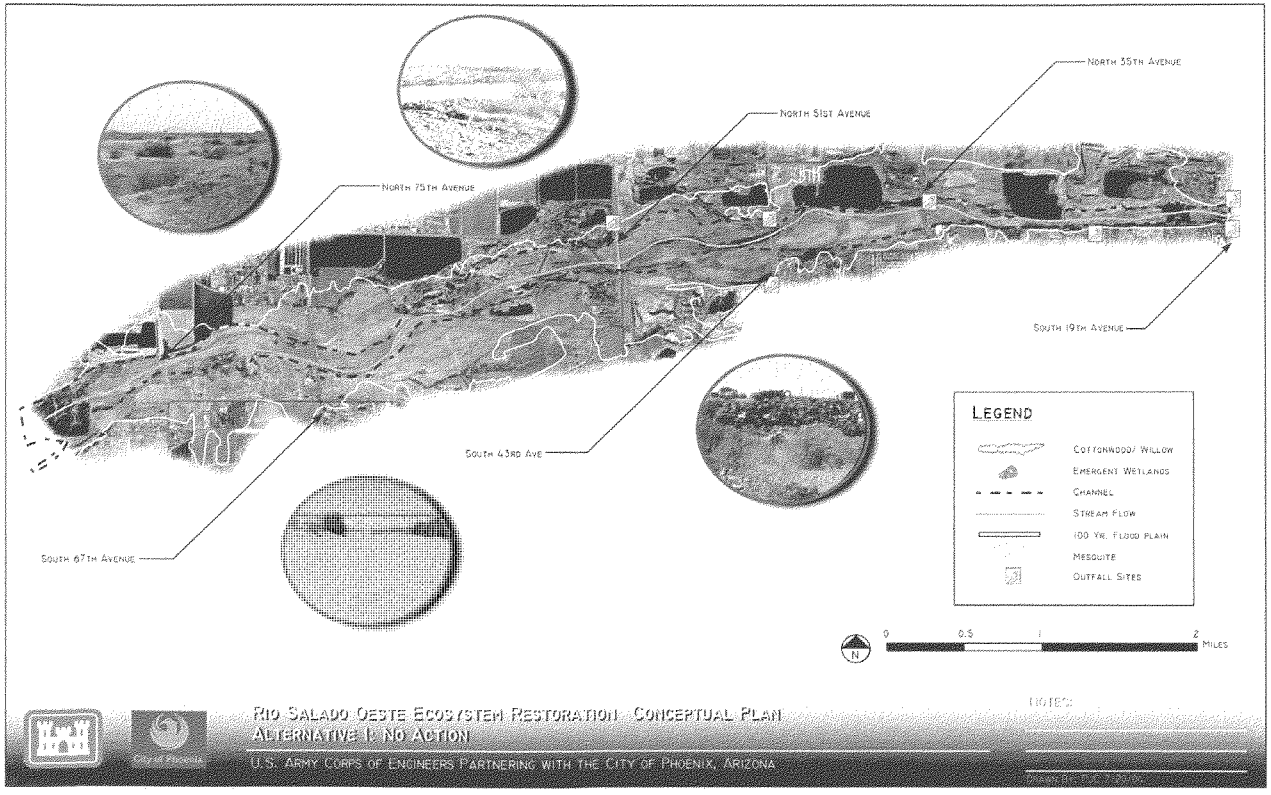
Plate 4: Alternative 5

Plate 5: Alternative 5A

Plate 6: Alternative 5B

Plate 7: (Recommended Plan)

Alternative 1: No Action



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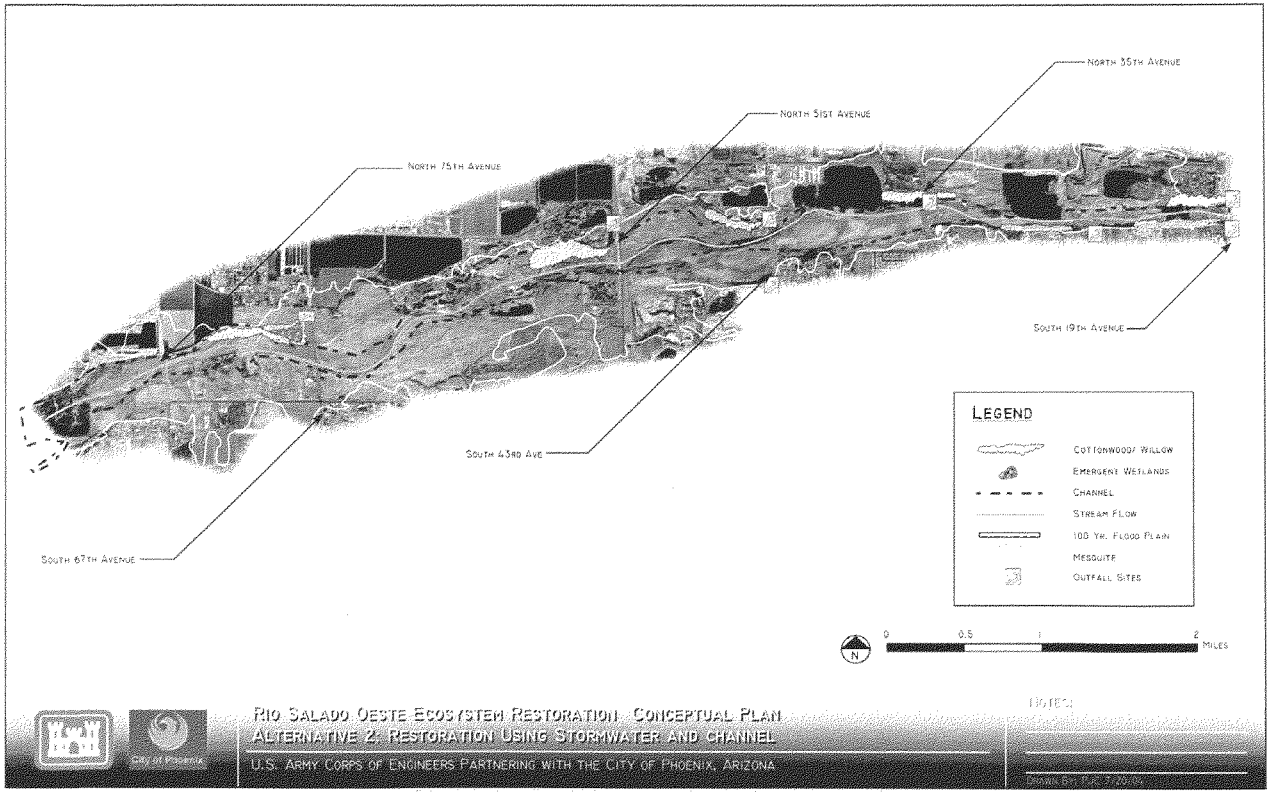

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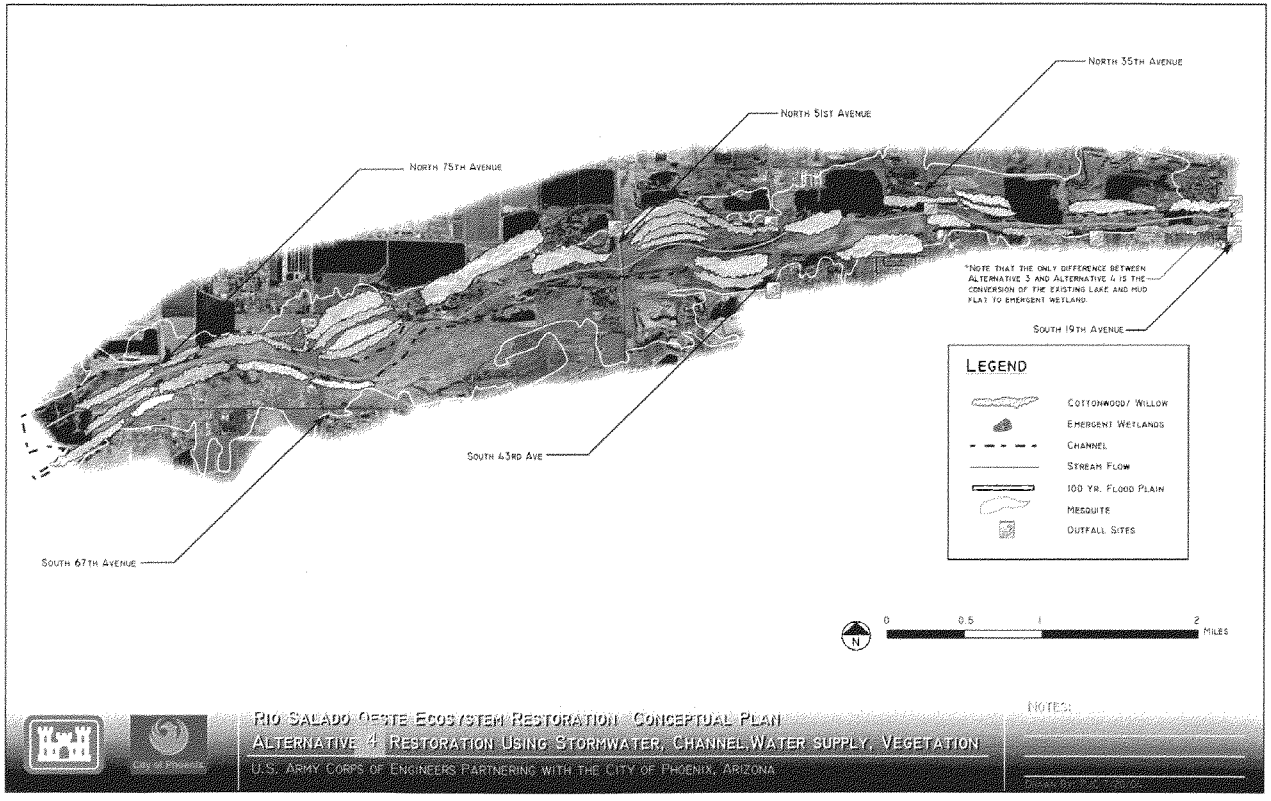

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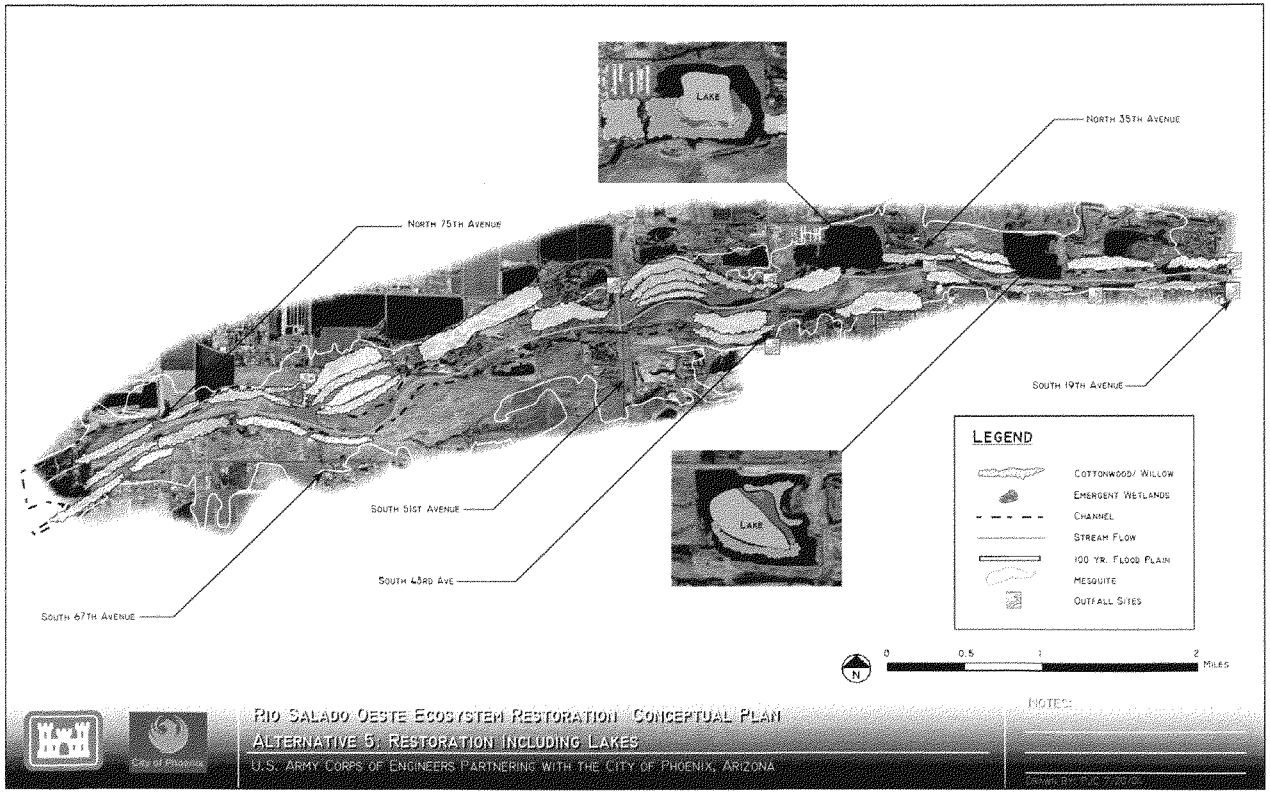
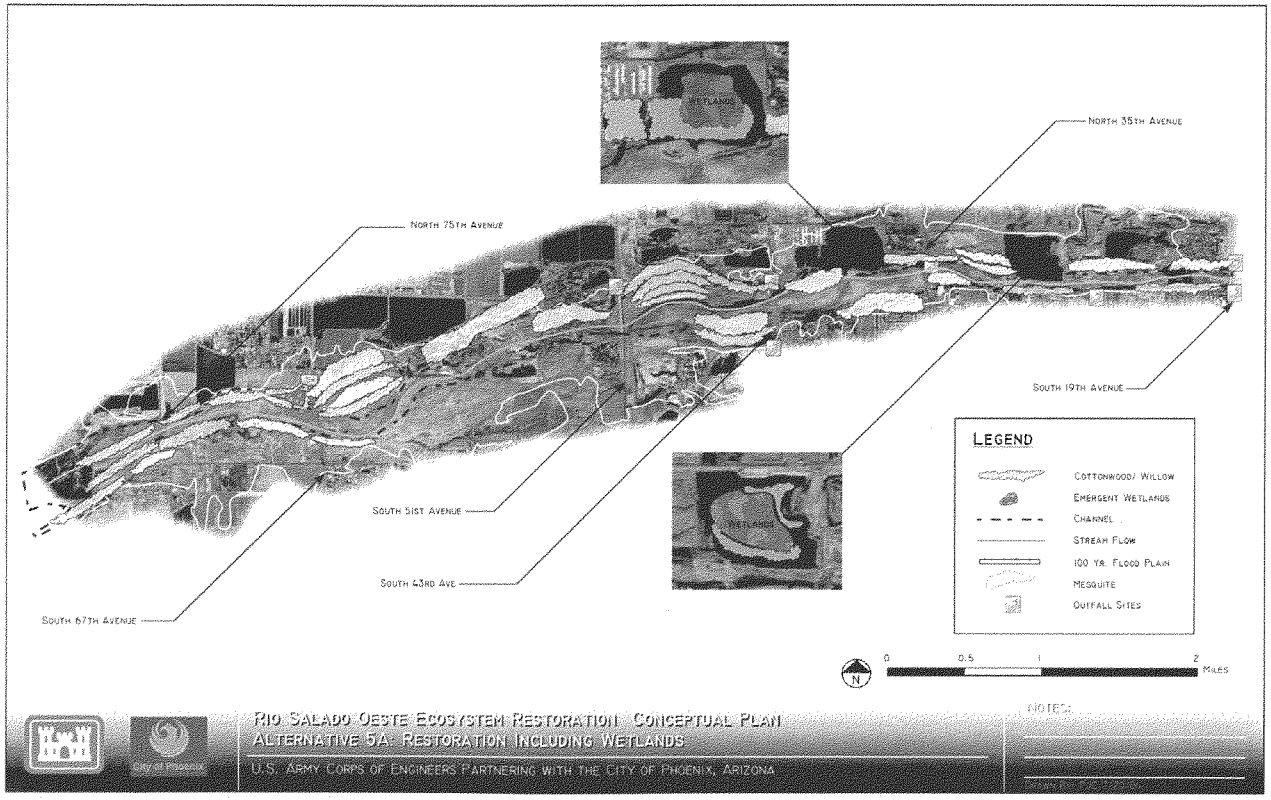
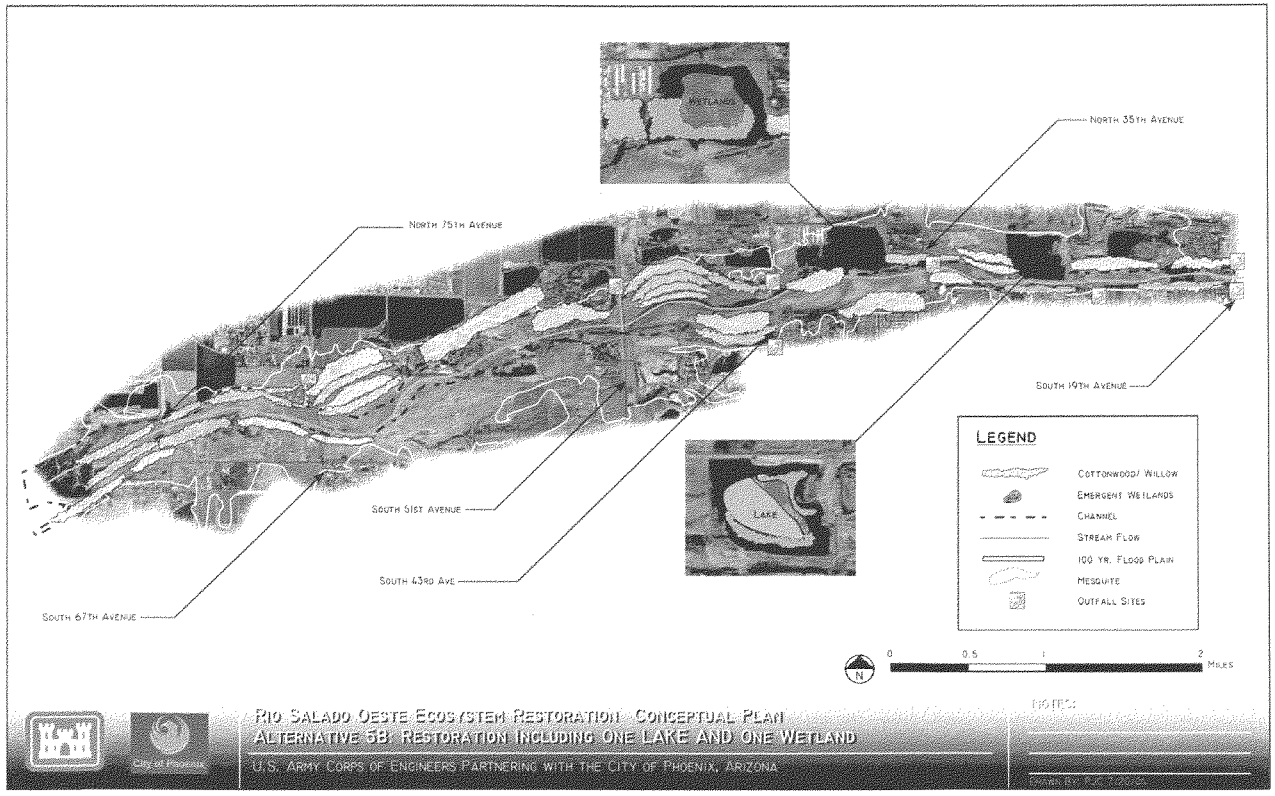


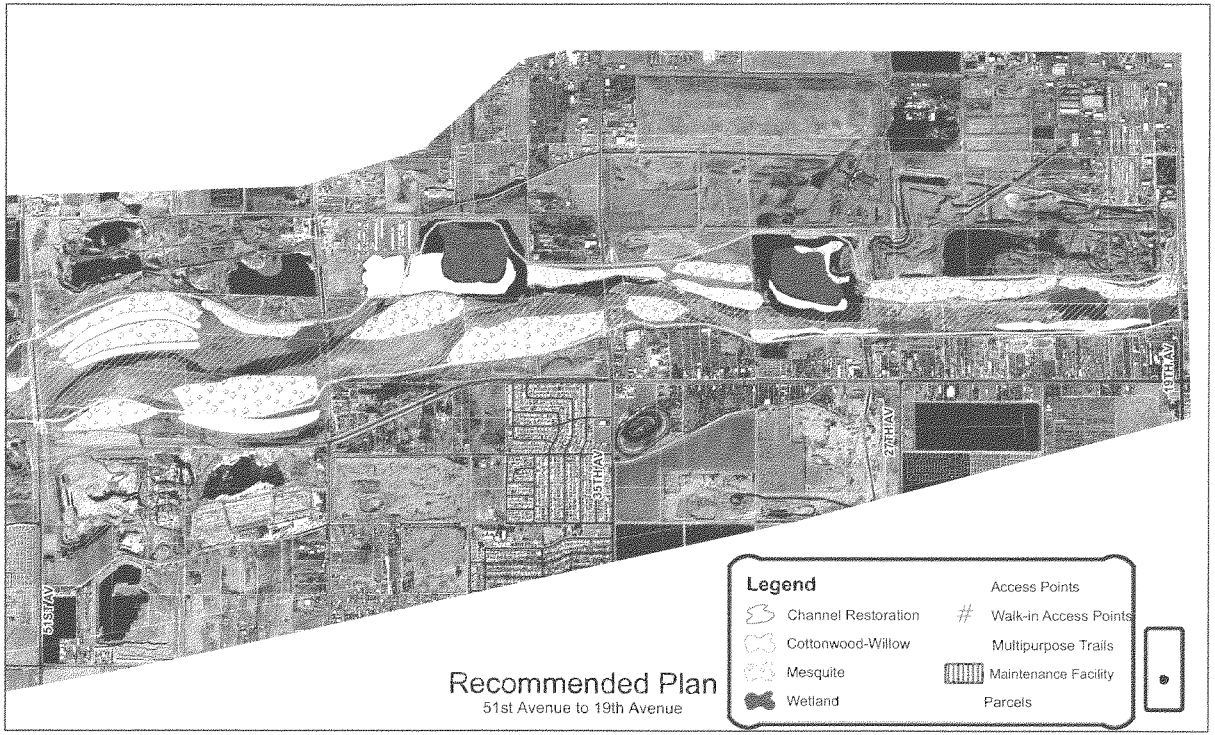
Alternative 5A



Alternative 5B

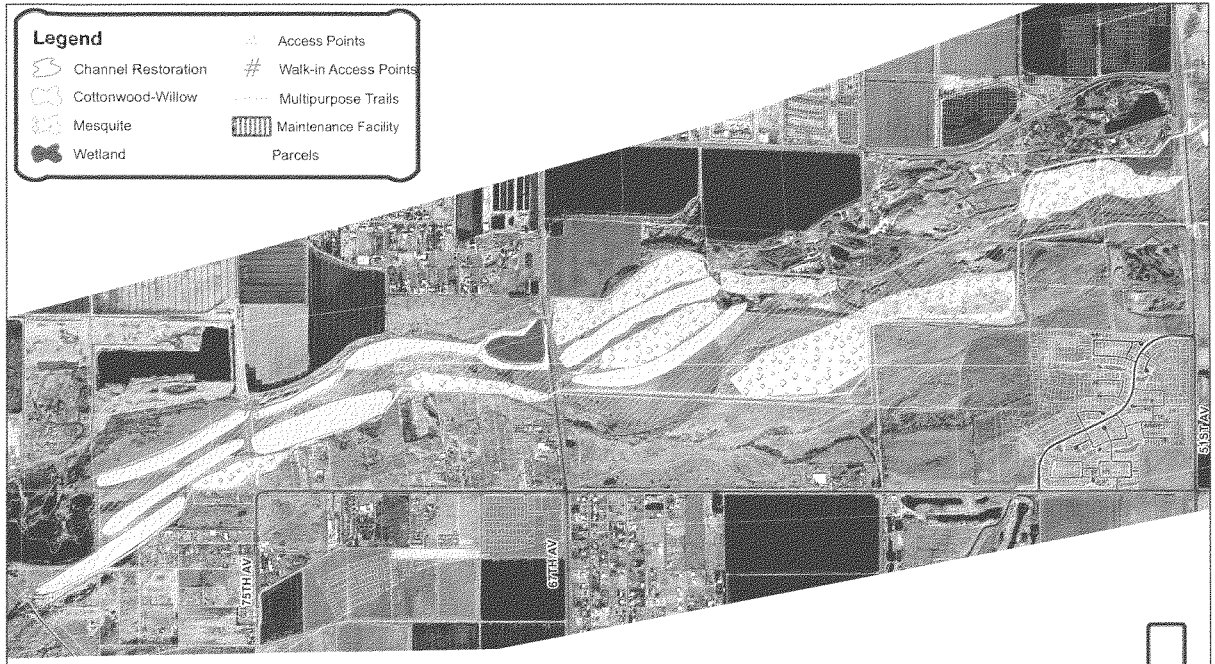


Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Recommended Plan
51st Avenue to 19th Avenue

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Recommended Plan
83rd Avenue to 51st Avenue

US Army Corps of Engineers
Los Angeles District
South Pacific Division

Rio Salado Oeste
Final Environmental Impact Statement

Salt River-Phoenix, Arizona

Prepared by:

U.S. Army Corps of Engineers, Los Angeles District
Arizona Nevada Area Office
3636 North Central Avenue, Suite 740
Phoenix, AZ 85012-1936

September 2006

Proposed Action:	Ecosystem restoration along an eight mile reach of the Salt River
Type of Statement:	Final Environmental Impact Statement (FEIS)
Lead Agency:	U.S. Army Corps of Engineers, Los Angeles District
Cooperating Agency:	City of Phoenix
For Further Information:	Scott K. Estergard U.S. Army Corps of Engineers, Los Angeles District Arizona-Nevada Area Office, Planning Section C 3636 N. Central Ave., Suite 900, Phoenix, AZ. 85012-1939 (602)640-2003, X-242, Scott.K.Estergard@usace.army.mil

Abstract: This final environmental impact statement (FEIS) analyzes the potential environmental impacts associated with the proposed Rio Salado Oeste project on the Salt River in Maricopa County, Arizona. The primary purpose of the proposed action is ecosystem restoration. The responsible federal lead agency is the Department of the Army, U.S. Army Corps of Engineers, Los Angeles District. The City of Phoenix is the non-federal sponsor.

The study area for the project consists of an eight mile reach of the Salt River and adjacent lands in and near southwestern Phoenix, Maricopa County, Arizona. More specifically, the study area consists of the Salt River corridor from 19th Avenue downstream (west) to 83rd Avenue, between Lower Buckeye Road and Baseline Road. This study area is three miles wide and encompasses approximately 23.5 square miles.

This document addresses the No-Action Alternative, the Recommended Plan, and four additional alternative plans developed to restore and improve native vegetation and wildlife habitat values in the project area. The recommended plan would entail earth moving, planting of vegetation and irrigation installation to facilitate restoration of 1,466 acres of riparian habitats along the Salt River. Restored habitats would consist of 170 acres of river channel (including 34 acres of in-channel wetland), 375 acres of cottonwood/willow forest, 417 acres of mesquite, 156 acres of other wetlands, 296 acres of riparian scrub and 52 acres of scrub shrub.

Additional benefits would include recreational opportunities, general improvements in aesthetic quality, and a slight reduction in the potential for flood damage. Each alternative 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 (NEPA) and other applicable laws, regulations, and policies, and have been conducted in coordination with the City of Phoenix, the Gila River Indian Community, 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.

A 45-day comment period on the Rio Salado Oeste, Draft Environmental Impact Statement (EIS) began with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register on May 12, 2006. A public hearing to discuss and receive comments on the Draft EIS was held at the Travis L Williams Family Services Community Center in Phoenix, Arizona on the evening of May 18, 2006. All comments received during the comment period were considered in the preparation of the Final EIS. Comments received during the public hearing or in writing, along with responses, may be found in Appendix E of the Final EIS. Unless otherwise requested, copies of the Final EIS will be provided on CD-ROM.

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 alternatives for the Rio Salado Oeste ecosystem restoration project. The study area is geographically located in the City of Phoenix, which lies within Maricopa County, Arizona. The study area is approximately eight miles long extending from 19th Avenue on the east downstream to 83rd Avenue on the west, and from Lower Buckeye Road on the north to Baseline Road on the south. The study area is approximately three miles wide and comprises approximately 23.5 square miles. While this is a large study area extending beyond the riverbanks, any implementation of project features would be associated with the river floodplain in an area referred to as the project implementation area. The project implementation area extends from 19th Avenue on the east to 83rd Avenue on the west, and is the area within the 100-year floodplain of the Salt River. The project implementation area averages two-thirds of a mile in width, and consists of approximately 3,315 acres. The study area lies between two other U.S. Army Corps of Engineers ecosystem restoration projects; Rio Salado Phoenix upstream and Tres Rios downstream.

Information referred to in this FEIS, as well as in the accompanying Feasibility Report titled *Rio Salado Oeste Interim Feasibility Report, Salt River – Phoenix, Arizona* (hereafter variously referred to as main report, feasibility report and main feasibility report) and its appendices, is incorporated by reference.

The FEIS provides a description of restoration alternatives and 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 action alternatives that have been determined to be the most feasible. Alternative 5A has been identified as the recommended plan based on its achievement of project objectives and for its level of attainment 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 proposed action is to restore degraded riparian ecosystem structure, function and dynamic processes to a more self-sustaining, diverse, and functional condition. Flood damage reduction was evaluated as an additional project purpose, but could not be economically justified. However, incidental flood damage reduction benefits would likely be obtained from an ecosystem restoration project. Potential additional benefits in the project area would include the following: passive recreation; improved water quality, air quality and aesthetics, and; noise reduction.

Specific planning objectives reflect the problems and opportunities for desired positive changes along the Rio Salado Oeste reach of the Salt River. The established objectives were: to restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish, and wildlife species; to reduce flood damages to infrastructure and structures, and; to improve passive recreation and environmental-education opportunities.

Alternative plans were developed during the feasibility study to meet the specified problems and opportunities and planning objective and constraints. The alternatives were then ranked based on completeness, effectiveness, efficiency, and acceptability and twelve were selected for further review. To narrow the array further, the study team determined the most significant criteria to use in comparing alternatives. These were:

- Cottonwood/willow is an important and scarce cover type in Arizona and the Southwest. The study team, including the U.S. Fish and Wildlife Service (USFWS) and Arizona Game and Fish Department (AGFD), decided that cottonwood/willow cover type was the highest priority for restoration, followed by mesquite and wetlands. Due to the significance and scarcity of cottonwood/willow, alternatives not including this cover type were eliminated from further consideration.

- Since the watershed is developed, tributaries to the river have been replaced by stormwater outfalls. These stormwater outfalls provide opportunities for restoration and for potential water harvesting. These outfalls also provide an inexpensive opportunity to direct additional water to the project area and associated restoration features. The stormwater measure is a necessary component of any alternative because of the restoration opportunities and potential water source. Therefore, alternatives not including that individual component were eliminated from further consideration.

- Channel restoration is an important project component for various reasons. It provides a connection to other projects, is a potential means of water distribution, is important for the ecosystem, and contributes to reducing flooding potential. Therefore, alternatives not including that component were not considered.

Applying these criteria to the array of alternatives narrowed the list to five alternatives, plus the No-action Alternative. The remaining five alternatives all include channel modification to maximize stormwater retention for habitat use. Alternative 4 includes active restoration of cottonwood and mesquite and emergent habitat, as well as active management to control invasives. Alternative 5 includes all of the above, plus the development of two existing gravel pits into lakes. Alternative 5A, the Recommended Plan, was similar to Alternative 5, except that it proposed filling the pits to restore them to emergent wetland and riparian areas. Finally, Alternative 5B combines Alternatives 5 and 5A to develop one gravel pit into a lake and the other pit into an emergent wetland/riparian area. Table ES-1 summarizes this information below, and quantitatively shows expected restored acres for each cover type.

Alternative 5A is the recommended plan. It would restore 375 acres of cottonwood/willow, 417 acres of mesquite, 190 acres of wetlands (including 34 acres of in-channel wetlands), 156 acres of other wetlands, 296 acres of riparian scrub, and 52 acres of scrub-shrub habitat. In addition to restoration, the proposed alternative includes incidental flood damage reduction, incidental noise

reduction, incidental air quality benefits, incidental water quality benefits, incidental aesthetic improvements and passive recreation.

Incidental flood damage reduction benefits would include a slightly lowered water-surface elevation, the creation of attenuation within the channel, reduced surface roughness, a reduction in the erosion potential, and a reduction in sedimentation issues. In addition, there would be reduced potential for head-cutting west of the 35th Avenue bridge where a grade control structure would be constructed. This grade control structure would also reduce potential damages to the bridge. Restored vegetation would help attenuate noise and PM-10 emissions, thus providing incidental benefits of noise reduction and improved air quality. The increase in wetlands provides for filtration and attenuation of stormwater pollutants, thus providing incidental water quality benefits. Improvements to the quality of vegetative habitats and new recreation features would improve the aesthetic quality of the project implementation area. Major features of the recreation component include multipurpose trails, shelters, signage, utilities, park furniture, and interpretive media.

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) activities have also been identified for the project and have been evaluated in this FEIS. These activities include maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features, annual invasive species control, channel and wetland regrading and excavation and periodic removal of sediment, surface reshaping, or replanting of project features damaged by flood events.

ES 2.2 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

The public scoping process was initially conducted on September 13, 2001, between the City of Phoenix and Corps of Engineers' staff. Continuing meetings were also held with the Rio Salado and Tres Rios Advisory committees to seek stakeholder and agency input. Meetings have been held throughout the planning process to gain further public input into the screening of alternatives. Major areas of concern included technical considerations based upon the specifics of the study, vector control, flood damage reduction, and opportunities for recreation.

A 45-day comment period on the Rio Salado Oeste, Draft Environmental Impact Statement (EIS) began with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register on May 12, 2006. Appendix E, Draft EIS Public Hearing, Comments and Responses, contains all of the tribal, agency, public and other comments. The majority of the comments were issued in support of the project. Those that included any other comments were comments which suggested clarification or editorial changes. This project has wide support and no areas of controversy were brought to our attention.

While not considered unresolved issues, future coordination with other agencies may occur in the following areas upon project authorization from Congress:

- The Corps has determined that this project as proposed is consistent with the Section 404(b)(1) guidelines (Appendix A) and is in compliance with the Clean Water Act. Upon authorization by Congress, the Corps will recommend an exemption from the

requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act.

- Upon authorization from Congress to proceed with our recommended alternative, further evaluations of cultural resources in the project area may need to be conducted in accordance with Section 106 of the National Historic Preservation Act (NHPA). If resources were determined to be National Register of Historic Places (NRHP)-eligible and avoidance is not feasible, further mitigation measures would be detailed in a Memorandum of Agreement (MOA) between all necessary parties, including the State Historic Preservation Officer (SHPO), the City of Phoenix and the tribes. These measures 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 would stop until a qualified archaeologist can evaluate the finds and determine whether further investigation is necessary. All necessary parties would be notified if buried cultural resources are encountered.

- The USFWS sent a concurrence letter dated August 7, 2006. The Section 7 consultation letter concurs that the proposed action may affect, but is not likely to adversely affect the species of concern. A copy of this letter can be found in Appendix B. Reinitiation of consultation will only be 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 and 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 reasonably certain to occur.

It is expected that these issues would be resolved during the preliminary engineering design phase of the project after the Final EIS has been published.

Table ES-1: Array of Alternatives and Associated Habitat Acres Restored

Alternative	Channel[1]			Cottonwood/ Willow	Mesquite	Open Water	Scrub-Shrub[2]	Other Wetlands	TOTALS
	Low-Flow Channel	In-Channel Wetlands[3]	Riparian Scrub						
2. Stormwater and Channel	170	17	125	66	43	0	305	28	737
4. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent	170	34	165	348	409	0	63	33	1188
5. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent, Lake	170	34	296	375	417	40	92	76	1466
5A. Wetland/riparian restoration in lieu of permanent open water and lakes	170	34	296	375	417	0	52	156	1466
5B. Hybrid of 5 & 5A with one gravel pit restored to a lake and the other a wetland/ riparian complex	170	34	296	375	417	20	52	136	1466

[1] River channel consists of low flow, wetland or riparian scrub.
[2] Scrub shrub acres are dispersed among and between the other restored cover types within the floodplain.
[3] Alternative 2 assumes that 10% of the low-flow channel would consist of wetlands; the remaining alternatives assume that 20% of the low-flow channel would consist of wetlands.

ES 2.3 SUMMARY OF POTENTIAL ENVIRONMENTAL EFFECTS

Each of the alternatives has been analyzed to determine the environmental effects that would result should that alternative be implemented. Mitigation measures have been developed to avoid, minimize, or reduce the effects of any substantial adverse impacts. A cumulative impact analysis has also been prepared for each resource area. Table ES-2 provides a summary of the adverse impacts and mitigation measures for each resource area by alternative. Chapter 4 of this Statement includes more detailed information on potential impacts, beneficial or otherwise. Chapter 8 of the FEIS provides more detailed information on the mitigation measures.

Based on the Hydrogeomorphic Model (HGM, see Section 2.5.1) and Incremental Cost Analysis (ICA, see Section 2.5.2 and 2.5.3), Alternative 5A was determined to be the environmentally preferable alternative. Alternative 5A is also the locally preferred plan of the non-federal sponsor.

Table ES-2. Potential Adverse Effects Environmental Impact Summary Matrix

Environmental Element	*Alternative 2*	*Alternative 4*	*Alternative 5*	*Alternative 5A*	*Alternative 5B*	*No-Action*
4.1 GEOLOGY AND TOPOGRAPHY						
Impact: Minor Geomorphologic Changes in River Channel						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	Significant
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	Significant
4.2 HYDROLOGY AND WATER RESOURCES						
Impact: Changes in 100-year Water Surface Elevations						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Impact: Potential Changes in Groundwater Depths						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
4.3 WATER QUALITY*						
Impact: Temporary Adverse Effects on Water Quality during Project Construction						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement Mitigation Measure (MM) WQ-1	Implement Mitigation Measure WQ-1	Implement Mitigation Measure WQ-1	Implement Mitigation Measure WQ-1	Implement Mitigation Measure WQ-1	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< 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	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM WQ-2	Implement MM WQ-2	Implement MM WQ-2	Implement MM WQ-2	Implement MM WQ-2	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Potential Adverse Effects on Water Quality Associated with Effluent						
Level of Significance	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No mitigation

*** Mitigation Measures are described in Chapter 8 of the EIS.**

Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Impact: Potential Adverse Effects on Groundwater Quality associated with Introduction of Effluent Water Source						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
4.4 BIOLOGICAL RESOURCES*						
Impact: Short-Term Decrease in Vegetation due to Construction						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM BR-1 & BR-2	Implement MM BR-1 & BR-2	Implement MM BR-1 & BR-2	Implement MM BR-1 & BR-2	Implement MM BR-1 & BR-2	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Long-Term Decrease in Vegetation						
Level of Significance	N/A	N/A	N/A	N/A	N/A	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	Significant
Impact: Short-Term Decrease in Fish & Wildlife Populations due to Construction and OMRR&R Activities						
Level of Significance	< Significant	< Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM BR-3	Implement MM BR-3	Implement MM BR-3 & BR-7	Implement MM BR-3 & BR-7	Implement MM BR-3 & BR-7	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Long-Term Decrease in Fish & Wildlife Populations						
Level of Significance	N/A	N/A	N/A	N/A	N/A	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	Significant
Impact: Potential Adverse Effects of Recreation to Wildlife and Vegetation						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
Impact: Short-Term Decrease in Potential for Special Status Species due to Construction and OMRR&R Activites						

*** Mitigation Measures are described in Chapter 8 of the EIS.**

Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM BR-4, BR-5 & BR-6	Implement MM BR-4, BR-5 & BR-6	Implement MM BR-4, BR-5 & BR-6	Implement MM BR-4, BR-5 & BR-6	Implement MM BR-4, BR-5 & BR-6	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Long-Term Decrease in Potential for Special Status Species						
Level of Significance	N/A	N/A	N/A	N/A	N/A	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	Significant
4.5 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	< Significant
Mitigation Measure(s)	Implement MM C-1	Implement MM C-1	Implement MM C-1	Implement MM C-1	Implement MM C-1	No Mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
4.6 AESTHETIC RESOURCES						
Impact: Potential Short-Term Adverse Aesthetic Effects Due to Construction						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Potential Long-Term Adverse Aesthetic Effects						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	No Impact
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant
4.7 AIR QUALITY*						
Impact: Generation of Construction-Related and Tailpipe Emissions (CO, VOC, $N0_X$)						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Generation of Construction-Related and Operational Fugitive Dust (PM-10) Emissions						
Level of Significance	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	N/A

*** Mitigation Measures are described in Chapter 8 of the EIS.**

Mitigation Measure(s)	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	Implement MM AQ-1	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Determination of Conformity						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Potential Adverse Effects on Air Quality due to Recreational Use						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM AQ-2	Implement MM AQ-2	Implement MM AQ-2	Implement MM AQ-2	Implement MM AQ-2	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
4.8 NOISE						
Impact: Short-Term Effects to Ambient Noise Conditions due to Construction and OMRR&R Activities						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Long-Term Effects to Ambient Noise Conditions						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
4.9 SOCIAL AND ECONOMIC RESOURCES						
Impact: Detectable Increases or Decreases to Population, Housing, Employment or Income due to the Project						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Effects on Environmental Justice						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
4.10 TRANSPORTATION*						

*** Mitigation Measures are described in Chapter 8 of the EIS.**

Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM T-1	Implement MM T-1	Implement MM T-1	Implement MM T-1	Implement MM T-1	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Potential Damage to Roadway Surfaces during Project Construction						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM T-2	Implement MM T-2	Implement MM T-2	Implement MM T-2	Implement MM T-2	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Generation of Additional Vehicle Trips by Recreationists						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
4.11 LAND USE						
Impact: Temporary Adverse Effects on Land Use During Project Construction						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Compatibility with Land Use and Planning Policies of Local Government Jurisdictions						
Level of Significance	Compatible	Compatible	Compatible	Compatible	Compatible	Not Compatible
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation
Residual Significance	Meets Goals	Meets Goals	Meets Goals	Meets Goals	Meets Goals	Not Compatible
4.12 RECREATION						
Impact: Temporary Adverse Effects on Recreation During Project Construction						
Level of Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Mitigation Measure(s)	No Mitigation	No Mitigation	No Mitigation	No Mitigation	No Mitigation	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
4.13 PUBLIC HEALTH AND SAFETY*						
Impact: Temporary Construction-Related Water Quality Impacts						

*** Mitigation Measures are described in Chapter 8 of the EIS.**

Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM PHS-1	Implement MM PHS-1	Implement MM PHS-1	Implement MM PHS-1	Implement MM PHS-1	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Temporary Construction and OMRR&R-Related Area Safety Issues						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	N/A
Mitigation Measure(s)	Implement MM PHS-2	Implement MM PHS-2	Implement MM PHS-2	Implement MM PHS-2	Implement MM PHS-2	N/A
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	N/A
Impact: Potential for Increases in Vector Control						
Level of Significance	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	Potentially Significant	< Significant
Mitigation Measure(s)	Implement MM PHS-3	Implement MM PHS-3	Implement MM PHS-3	Implement MM PHS-3	Implement MM PHS-3	No Mitigation
Residual Significance	< Significant	< Significant	< Significant	< Significant	< Significant	< Significant

*** Mitigation Measures are described in Chapter 8 of the EIS.**

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CHAPTER 1
PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 INTRODUCTION

The Salt River (*Rio Salado* in Spanish) is a major tributary to the Gila River. It originates in eastern Arizona and flows westward to its confluence with Gila River, west of downtown Phoenix. Prior to agricultural development and urbanization of the Phoenix metropolitan area, the Salt River was a perennial stream fed by snowmelt from mountains in eastern Arizona. Early in the 20th century, major modifications to the river system occurred as part of the Salt River Project (SRP). Several dams were placed along the river allowing diversions of water for agricultural and urban uses. Sand and gravel mining operations and other activities induced additional changes to the river channel and hydrology. As water diversions increased, the groundwater table lowered, separating riparian communities on the surface from a principal water source. Groundwater depletion, coupled with damming of the river by the SRP, caused perennial flow in the Salt River to cease. These changes in hydrological conditions caused the natural riparian ecosystem to decline. Only small, isolated fragments of former habitat remain. Changes in hydrology have also allowed salt cedar, an invasive non-native plant species with minimal habitat value, to become established in the region. Presently, the study area consists of a highly disturbed riverbed with minimal existent native vegetation.

1.2 PURPOSE AND NEED

The purpose of the proposed action is to restore degraded ecosystem structure, function and dynamic processes to a more natural condition. Indicators of success would include the presence of a variety of native plants and animals, and the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species. There is a need to restore the area in such a manner that the function and desired outputs can naturally evolve with a minimum of continuing human intervention. Potential benefits include increasing wildlife habitat, improving water and air quality, improving the aesthetic quality, reducing ambient noise levels, providing incidental flood damage reduction, and offering passive recreational opportunities.

Further, flood damage reduction and water supply projects within the Gila River watershed have resulted in substantial alteration of the hydrological regime. This alteration, increased agricultural development and urbanization of Phoenix, has resulted in substantial alteration of native cottonwood/willow, mesquite bosque, freshwater marsh and willow woodland desirable habitat types. Without restoration, habitat values in the Rio Salado Oeste reach of the Salt River are expected to further decline within the next 50 years. This would decrease the overall habitat value for federally listed Threatened and Endangered species, as well as Wildlife of Special Concern to the Arizona Game and Fish Department (AGFD). These species include the Yuma clapper rail and southwestern willow flycatcher.

This project is needed to provide an ecological connection between other riparian restoration projects on-going along the Salt River. Without this connection we will see a spread of invasive

non-native plants into those restored ecological areas up stream and down stream of this proposed action due to the high level of disturbance within the proposed reach. Also, there is substantial need for additional recreational areas within Phoenix. While recreation is not a major goal of this project, restoration of the area may provide passive recreational benefits.

1.3 STUDY SCOPE

The Rio Salado Oeste Feasibility Study is being conducted by the U.S. Army Corps of Engineers (Corps, Los Angeles District, and the City of Phoenix, in cooperation with the Flood Control District of Maricopa County (FCDMC). The purpose of this study is to identify whether or not it is feasible to implement a project along the Salt River in Phoenix. This study will identify ecosystem restoration, flood damage reduction and recreation alternatives that are technically feasible, economically practicable, and sound with respect to environmental considerations, and that are publicly acceptable. The City of Phoenix, as the non-federal sponsor for the project, supports the proposed project purpose to restore and improve native vegetation and wildlife habitat values in the project area.

1.4 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

The EIS contains the following major elements that are required under the Council on Environmental Quality (CEQ) NEPA Regulations:

- Coversheet, which includes a list of the responsible agencies, the title of the proposed action and its location, the name, address, and telephone number of the person at the agency who can supply further information, the statement's current designation, a one paragraph abstract, and the date by which comments must be received.

- Executive Summary, which stresses the major conclusions, areas of controversy, and the issues to be resolved.

- Chapter 1. Purpose and Need. This chapter also includes an overview of the elements necessary for the U.S. Army Corps of Engineers' participation in the planning of Rio Salado Oeste.

- Chapter 2. Alternatives Including the Proposed Action. This section explores and evaluates all reasonable alternatives, selected and eliminated, in a way that allows reviewers to evaluate their comparative merits. It includes reasonable alternatives not within the Corps' jurisdiction, includes the alternative of No-Action, identifies the Corps' recommended plan, and includes appropriate mitigation measures.

- Chapter 3. Affected Environment. This section includes relevant data and analyses used to determine affects the alternatives would have on the environment.

- Chapter 4. Environmental Consequences. The section includes environmental impacts of the alternatives, including the No-Action alternative. It includes discussions related to mitigation; however mitigation is further discussed in Chapter 8. The remaining requirements of the NEPA Regulations were broken out into separate chapters.

- Chapter 5. Cumulative Impacts. This section describes possible beneficial, adverse, and unavoidable significant cumulative impacts within the Rio Salado Oeste Cumulative Impact Zone.

- Chapter 6. Irreversible or Irretrievable Commitments of Resources and Unavoidable Significant Impacts. This section articulates damages to the environment that cannot be reversed, even after the life of a project and resources that are lost for a long period of time.

- Chapter 7. Environmental Compliance. This section discusses the major state and federal environmental laws potentially applicable to the project.

- Chapter 8. Mitigation Measures. This section describes mitigation measures as applicable for each of the 13 affected resource categories.

- Chapter 9. Public Involvement. This section discusses scoping, the public involvement process to date, and agency coordination completed by the Corps.

- A List of Preparers is provided in Chapter 10.

- References cited in the text are listed in Chapter 11.

- A List of Agencies, Organizations, and persons to whom copies of the statement are sent is provided in Chapter 12.

- An Index.

- Appendices: Appendix A - Clean Water Act Section 404(b)(1) Compliance Evaluation, Appendix B – Biological Resources Appendix, Appendix C – Cultural Resources Appendix, Appendix D – Air Quality Assumptions Used to Generate Air Emission Estimates for the Rio Salado Oeste Project and Appendix E – Draft EIS Public Hearing, Comments and Responses

The EIS focuses on major issue areas including:

- Geology and topography,
- Hydrology and water resources,
- Water quality,
- Biological resources,
- Cultural resources,

- Aesthetic resources,
- Air quality,
- Noise,
- Social and economic resources (including environmental justice),
- Transportation,
- Land use,
- Recreation, and
- Public health and safety.

1.5 SUMMARY OF PROPOSED AUTHORIZATIONS

The study was conducted under two separate authorities provided by Congress.

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

  "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."

- The second and most recent authority is provided by House Resolution 2425 (HR 2425), dated May 17, 1994, 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."

1.6 STUDY AREA AND PROJECT LOCATION

The study area for the project consists of an eight mile reach of the Salt River and adjacent lands in and near southwestern Phoenix, Maricopa County, Arizona (see Figure 1-1). More specifically, the study area consists of the Salt River corridor from 19th Avenue downstream (west) to 83rd Avenue, between Lower Buckeye Road and Baseline Road. This study area is three miles wide and encompasses approximately 23.5 square miles. The study area lies between two other U.S. Army Corps of Engineers ecosystem restoration projects; Rio Salado Phoenix upstream and Tres Rios downstream.

While this is a large study area extending beyond the riverbanks, any implementation of project features would be associated with the river floodplain. For the purpose of alternative formulation, the project implementation area was defined as the area within one mile of the centerline of the Salt River from 19th Avenue to 83rd Avenue (Figure 1.6-3). With the formulation of alternatives now complete, the project implementation area has been reduced to encompass only the area within the 100-year floodplain of the Salt River. The project implementation area is, on average, approximately two-thirds of a mile wide and consists of approximately 3,315 acres. Figure 1.6-3 displays the study area and project implementation areas.

1.7 PREVIOUS STUDIES

The Salt River has been extensively utilized for irrigation since prehistoric times. In the 1800s, settlers reestablished many historical irrigation canals. Since then, the Phoenix metropolitan area has established itself around the river. The Salt River has presented many opportunities and challenges, and has been studied extensively.

Various agencies and engineering consulting firms have conducted or published over 50 studies and reports on the Salt River since 1980. The topics of the reports or studies include water resources, flood damage reduction, recreation and urban development, and environmental assessment. Two of these studies supported implementation of water resources projects immediately upstream and downstream of the Rio Salado Oeste reach Figure 1.7-1. These studies are as follows:

- In April 1998, the Corps completed the feasibility report and EIS for the Rio Salado Salt River, Arizona project. The report identified plans that would provide environmental restoration benefits and serve the public interest to this upstream reach of the Salt River. The project is currently in the final year of construction.

- In April 2000, the Corps completed a feasibility report and EIS for the Tres Rios, Arizona Project. The study examined a portion of the Salt River and Gila River from 83rd Avenue downstream to the Agua Fria River, and selected a plan that includes environmental restoration and flood damage reduction components. The project is currently in the design phase.

Other previous studies can be found in Chapter 3 of the feasibility report. The findings in these reports and the chronology of change within the Salt River corridor are important and essential in describing the changes over time and in outlining the importance of this project.

1.8 PLANNING OBJECTIVES

This study has specific planning objectives that provided the focus for the formulation of alternatives. The study objectives reflect the problems and opportunities for desired positive changes along the Rio Salado Oeste reach, and are as follows:

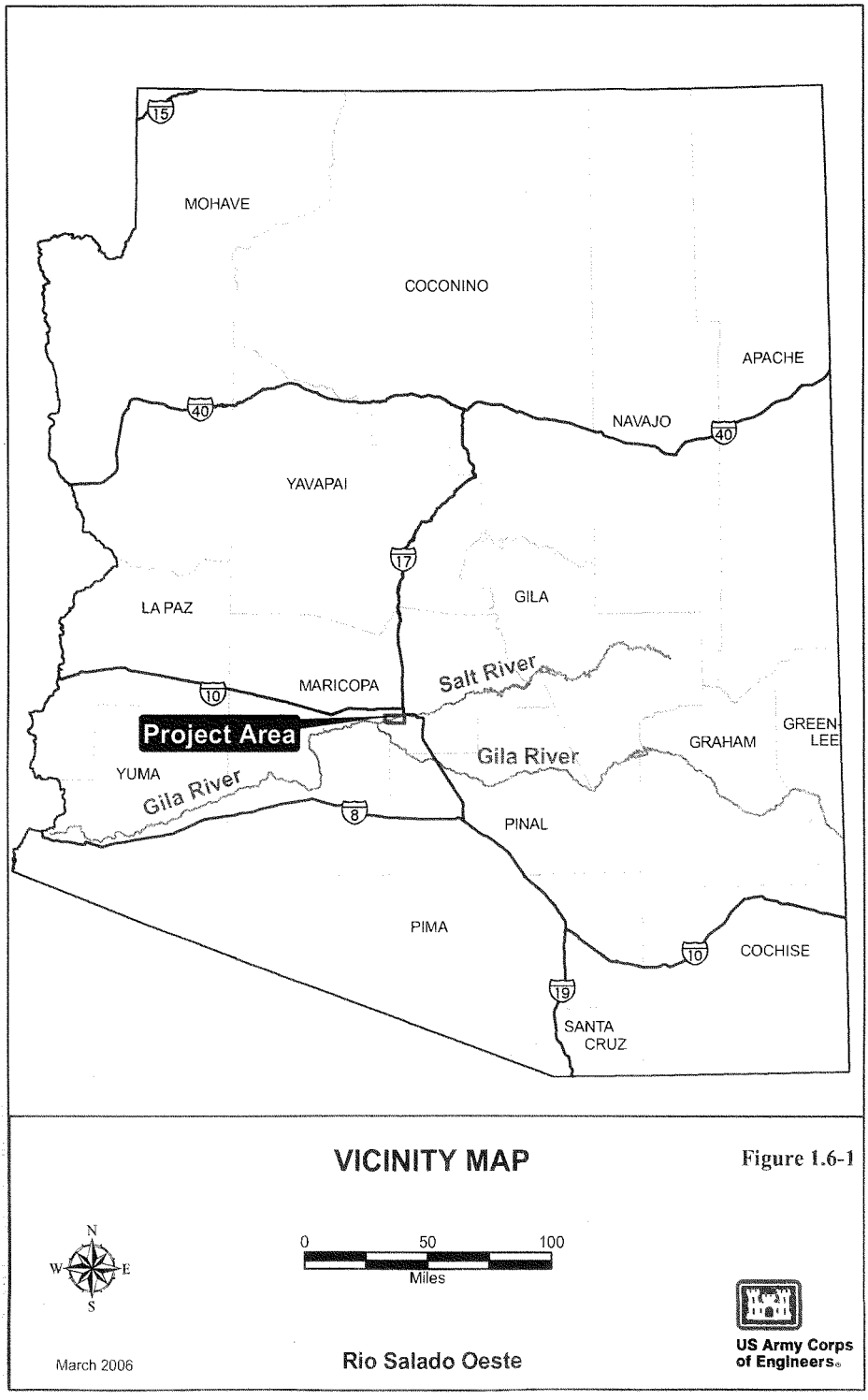
- restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish, and wildlife species;

- reduce flood damages to infrastructure and structures, and;

- improve passive recreation and environmental-education opportunities.

1.9 PUBLIC INVOLVEMENT

Information regarding public and interagency involvement during the initial scoping for Rio Salado Oeste can be found in Chapter 9 of this Statement. The National Environmental Policy Act (NEPA) ensures public involvement and notification of a proposed project. The release of this document on Friday, May 12, 2006 coincided with a public hearing on May 18, 2006. The outcomes of this meeting can be found in Appendix E of this report.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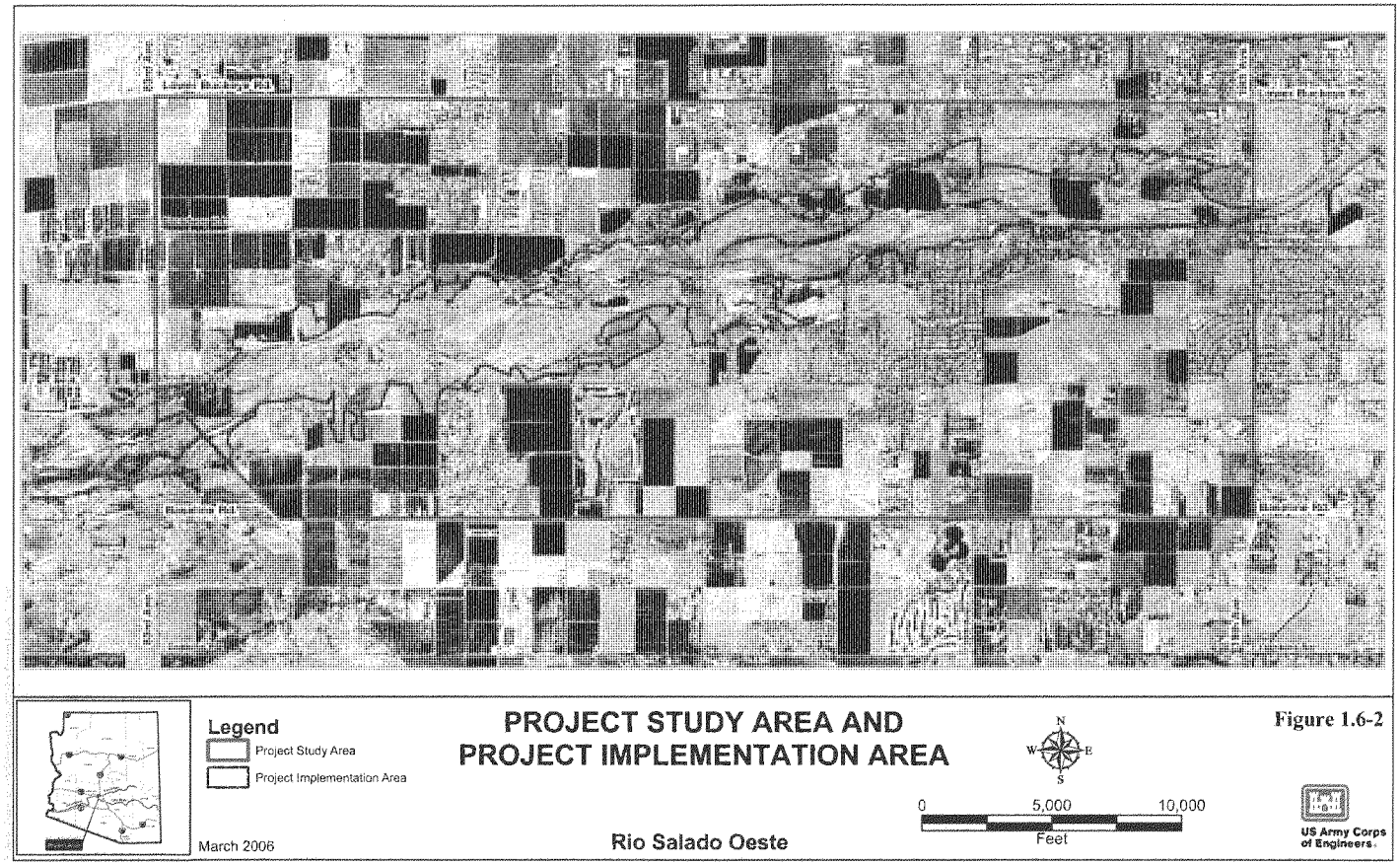
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CHAPTER 2
ALTERNATIVES

The purpose of this section is to provide a comprehensive description of alternatives for the Rio Salado Oeste Feasibility Study, including alternatives outside the Corps' jurisdiction, abandoned alternatives, the no-action alternative and identification of the proposed alternative. Chapter 5 of the Main Feasibility Report discusses the alternatives, their development and screening in further detail and should be referred to for additional information.

This section provides:

- an overview of the alternative formulation and screening process conducted for the Rio Salado Oeste Feasibility Study;
- 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;
- a recreation plan that could be implemented with any of the alternatives selected for evaluation.

2.1 INTRODUCTION

This Environmental Impact Statement is part of the U.S. Army Corps of Engineers and City of Phoenix and planning effort to restore degraded ecosystem structure, function and dynamic processes to a more natural condition. There is a need to restore the area in such a manner that the function and desired outputs can naturally evolve with a minimum of continuing human intervention. The alternatives would have to achieve the project purpose while complying with Corps federal planning objectives and the more specific objectives set during the Rio Salado Oeste planning effort.

In Section 209 of the Flood Control Act of 1970, Pub, L. No. 91-611, 42 U.S.C. 1962-2, Congress identified four general objectives to be included in federally financed water resource projects. These objectives are: enhancing regional economic development, the quality of the total environment, including its protection and improvement, the well-being of the people of the United States, and the national economic development. These four objectives remain important considerations of water resource projects and address long-term impacts, defined in such a manner that each proposed plan can be easily compared to the no action plan and other alternatives. However, ecosystem restoration projects focus on a fifth objective, the National Ecosystem Restoration (NER) objective. That objective is to contribute to the Nation's ecosystems through restoration, with contributions measured by changes in the amounts and values of habitat.

The more specific objectives for Rio Salado Oeste were developed through coordination with local and regional agencies, public involvement, site assessments, interpretation of prior studies and reports, and review of existing water projects. The planning objectives reflect the problems and opportunities, represent desired positive changes along the Rio Salado Oeste reach and provide focus for the formulation of alternatives. These objectives are to: restore native riparian, wetland, and floodplain habitat and manage undesirable plant, fish and wildlife species; reduce flood damages to infrastructure and structures, and; improve passive recreation and environmental recreation and environmental-education opportunities.

2.2 REASONABLE ALTERNATIVES NOT WITHIN CORPS' JURIDICTION

There are several alternatives that do not fall within the programs, missions and authorities of the U.S. Army Corps of Engineers (Corps). These alternatives would meet the project purpose of restoring the degraded ecosystem structure, function and dynamic processes to a more natural condition. One such alternative would be to negotiate substantial releases of stored water from the dams operated by the Salt River Project to restore perennial flows into the Salt River. Reintroducing perennial flow would have the potential to re-establish riparian habitats, which could incidentally help restore dynamic channel processes to a more natural condition. In order to implement this alternative, supplemental water sources for the metropolitan areas in Maricopa County would need to be developed.

A second alternative could involve the City of Phoenix Parks & Recreation Department coupling with a volunteer-based community group, such as the Phoenix Parks and Conservation Foundation or the Boy Scouts of America, to restore portions of the Rio Salado Oeste project area. The City of Phoenix had major success with volunteer contribution to the Rio Salado Phoenix project in the planting of the "Thousand Tree Forest." Volunteer projects could eventually provide smaller-scale restoration of riparian habitats, which could incidentally help to restore other functions and dynamic processes to a more natural condition.

2.3 FORMULATION AND SCREENING OF ALTERNATIVES

2.3.1 THE SIX-STEP PLANNING PROCESS

The Corps' six-step planning process is used to formulate, 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 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.
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 for the alternative identification and evaluation process.
6. The plan with the greatest net benefits is selected for recommendation if at least one plan demonstrating federal interest exists.

2.3.2 DEVELOPMENT OF ALTERNATIVE PLANS

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.

The study team combined these measures to form the first array of twenty preliminary alternative plans. Table 2.3-1 lists the preliminary alternatives considered for implementing ecosystem restoration. Development of those alternatives assumes that restoration is dependent both on water supply and control of invasive species. Also, implementation of the City of Phoenix recreation plan is assumed for all but the No-Action alternative.

These preliminary alternatives were evaluated using three screening criteria: completeness – the extent to which a given alternative provides and accounts for all necessary investments or other actions to ensure realization of the planned effects; effectiveness – the extent to which an alternative alleviates the specified problem and achieves the specified opportunities, and; induction of flood damages – alternatives that install significant vegetation to the floodplain but neither include channel restoration nor restrict the location of that vegetation could raise water surface elevations and should be avoided. Alternatives that did not meet the three criteria were dropped from further evaluation. These alternatives are shown in the table below with grey shading.

Table 2.3-1. Preliminary Screening of Possible Alternatives

#	Description	Complete	Effective	Flooding
1	No Action	-	0	Y
7	Water Supply	-	0	Y
8	Water Supply, Invasive Control	-	0	Y
2	Invasive Control	-	0	N
3	Channel Restoration	-	1	N
4	Channel Restoration, Invasive Control	-	1	N
9	Water Supply, Channel Restoration	-	1	N
10	Water Supply, Channel Restoration, Invasive Control	-	1	N
11	Water Supply, Channel Restoration, Emergent, Invasive Control	-	1	N
12	Water Supply, Channel Restoration, Mesquite	+	2	N
13	Water Supply, Channel Restoration, Mesquite, Emergent, Invasive	+	2	N
14	Water Supply, Cottonwood, Channel Restoration, Invasive	+	2	N
15	Water Supply, Cottonwood, Channel Restoration, Emergent, Invasive	+	2	N
5	Storm Water	+	3	N
6	Storm Water, Channel Restoration	+	3	N
16	Water Supply, Cottonwood, Channel Restoration, Mesquite, Invasive	+	3	N
17	Water Supply, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
18	Water Supply, Storm Water, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
19	Water Supply, Lake, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N
20	Water Supply, Lake, Storm Water, Cottonwood, Channel Restoration, Mesquite, Emergent, Invasive	+	3	N

Note: Effectiveness: Numbers designate number of habitat cover types that would be restored by that alternative. For example the number 2 indicates that 2 habitat types would be restored.
+ or – indicate if that alternative meets the subject criteria as described.

Applying the three screening criteria to the preliminary alternatives reduced the number of alternatives from 20 to 12. In order to obtain a smaller number of alternatives that were more easily comparable and that more precisely met the project objectives, the study team screened the second array of alternatives with more specific criteria. The four criteria eliminated alternatives that did not include: creating cottonwood/willow habitat, harvesting water from stormwater outfalls for restoration and restoring the channel. The results are shown in Table 2.3-2, below. Again, alternatives that did not meet the criteria and were dropped from further evaluation are shown in grey.

Table 2.3-2. Second Array of 12 Alternatives

#	Preliminary Alternatives	Reason Dropped
1	No-Action	
2	Stormwater	No channel restoration included.
3	Stormwater, Channel	
4	Water Supply, Channel, Mesquite	Does not include cottonwood/willow
5	Water Supply, Channel, Mesquite, Emergent, Invasive	Does not include cottonwood/willow
6	Water Supply, Cottonwood, Channel, Invasive	Does not include stormwater
7	Water Supply, Cottonwood, Channel, Emergent, Invasive	Does not include stormwater, similar to alternative 8
8	Water Supply, Cottonwood, Channel, Mesquite, Invasive, added Stormwater	
9	Water Supply, Cottonwood, Channel, Mesquite, Emergent, Invasive	Does not include stormwater, similar to alternative 10
10	Water Supply, Stormwater, Cottonwood, Channel, Mesquite, Emergent, Invasive	
11	Water Supply, Lake, Cottonwood, Channel, Mesquite, Emergent, Invasive	Does not include stormwater, with inclusion of it same as alternative 12.
12	Water Supply, Lake, Stormwater, Cottonwood, Channel, Mesquite, Emergent, Invasive	

Applying these three criteria produced an array of four alternatives, plus the No-Action alternative. Upon further evaluation, alternatives eight and ten (from the table above) were too similar to one another to be evaluated separately and, thus, were combined into the final array Alternative 4. Alternative 12, above (Alternative 5 in the final array), includes restoring both sand/gravel pits into open water lakes. The study team realized that this alternative could be broken down into different levels of sand/gravel pit restoration. One level would restore the two pits into riparian complexes instead of lakes (Alternative 5A) and the other alternative would restore one pit to an open water lake and one to a riparian complex (Alternative 5B). Thus, the five alternatives, plus the No-Action alternative, originated.

2.4 DESCRIPTION OF THE PROJECT ALTERNATIVES

This section begins by discussing the measures that are common to multiple alternatives. The five action alternatives are then discussed in detail including the acres of each habitat type that would be restored by each.

2.4.1 MEASURES COMBINED TO FORM CONSTRUCTION ALTERNATIVES

The following measures were used in various combinations for the five construction alternatives (Alternatives 2, 4, 5, 5A and 5B, see Table 2.5-1).

2.4.1.1 Provide Water Supply

Project water is a constraint and a limiting factor across all alternatives. The project area can be split into two reaches based on water supply: (1) 19th to 51st Avenues where effluent and stormwater are primary sources and (2) 51st to 83rd Avenues where groundwater is more likely to be shallow enough to support vegetation after it is established. Water supply and distribution has been evaluated and planned by the City of Phoenix and is described in more detail within Appendix J, *Design and Cost Estimate*, of the feasibility report.

Effluent: Effluent from the 23rd Avenue wastewater treatment plant (WWTP) is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. Use of this water would require construction of a means to deliver effluent to the project from the 23rd Avenue Wastewater Treatment Plant (WWTP).

Stormwater: Stormwater outfalls within the project area have been identified and possible discharges from them quantified. This includes eight different outfalls from which an estimated average of 2,863 ac-ft was estimated to discharge based upon a 7-inch annual rainfall. Additional future outfalls may be implemented by the county at 51st Avenue (south) and 75th Avenue (north). While not a reliable, constant source of project water, there are opportunities for future use of this water with proper design at the outfall locations. Various types of habitat are currently being supported by stormwater runoff. Design of a restoration plan would include site-specific measures maximizing use of that runoff. Table 2.4-1, below, provides a summary of the eight stormwater outfalls potential for restoration.

Table 2.4-1. Summary of Stormwater Outfalls with Recommended Restoration Potential

Location	Restoration
19th Avenue NW	Mesquite Bosque/Palo Verde
19th Avenue SW	Wetland and Riparian Corridor
27th Avenue SE	Wetlands and Riparian
35th Avenue NW	Cottonwood/willow
43rd Avenue N	Wetland/Cottonwood-Willow
43rd Avenue S	Wetland
51st Avenue NW	Wetland/Mesquite
67th Avenue	Wetland/Cottonwood-Willow

Groundwater: Depth to groundwater through the project area varies from an average of 20 to 60 feet. In general, the depth to groundwater decreases to the west end of the study area where dewatering is required at 91st Avenue. In an analysis of Arizon Department of Water Resources well data and interpolation of surface water in gravel pits, there appears to be a zone of shallow (20-feet deep) groundwater between 51st and 19th Avenues in the river channel. This is likely due to excavation and is known to fluctuate as much as 20 feet annually (Rinker Materials Observation). Groundwater is being pumped in the vicinity of 23rd Avenue for sand and gravel mining where it contributes to the large lake near 27th Avenue. It was also assumed that the lake in the vicinity of 37th Avenue was excavated to groundwater depth; however, observations in 2004 appear to indicate that the level has dropped significantly and that the elevations in the lake appear to be influenced more by effluent discharge.

Supply Well: A supplemental well providing up to 1.85 mgd from the Upper Alluvial Unit is part of the proposed system. This would provide redundancy in the event that there is a prolonged outage and effluent becomes unavailable for a period of time.

2.4.1.2 Provide Water Distribution

A water distribution system is needed to deliver water from the sources described above through the study area to locations where native vegetation is being reestablished.

Flood Irrigation: Flood irrigation may be accomplished through a series of canals or channels delivering water to revegetation sites. Distribution within the revegetation sites may be through a braided network of channels. Effluent and pumped groundwater may be utilized for flood irrigation.

Drip Irrigation: This would be a temporary drip irrigation system consisting of small diameter pipes and drip emitters. Pumping would be required as a portion of this system. Drip irrigation works best with groundwater. Effluent water tends to clog the system and requires high maintenance.

Stormwater Harvesting: This measure is similar to creating a perched aquifer by providing water to a location with a below-grade low permeable layer. Although this could be accomplished with any water source and proper site-specific soil conditions, it appears that at several of the stormwater outfalls, similar conditions already exist. At constructed wetlands or ponds, a design option may include features that allow or encourage subsurface recharge to percolate down gradient and provide moist conditions, thereby irrigating adjacent vegetation.

2.4.1.3 Revegetation

2.4.1.3.1 Cottonwood/Willow

Due to groundwater depth, cottonwood/willow habitat could only be restored in proximity to existing or future surface water. This habitat would require a constant water source for the life of the project unless it can be verified that groundwater would be available within six to seven feet of the surface, in which case surface water would only be required for the first five years. Cottonwood/willow habitat would also require richer soils than some other habitat types. Generally, cottonwoods occur at a greater distance from surface water than willows. Willows require more moisture at the surface for optimal growth. Cottonwood/willow would be dominated by Fremont's cottonwood (*Populus fremontii*) and Gooding's willow (*Salix gooddingii*). Other understory species would be planted, depending upon individual site conditions, but could include *Baccarus spp*, arrowweed (*Pluchea sericea*), elderberry (*Sambucus mexicana*), burrobush (*Hymenoclea spp.*), and possibly ash. Two planting options are being considered for establishment of cottonwood/willow. It is assumed that a combination of techniques would be utilized with specific planting techniques to be determined during project design.

Plant Poles: Plant poles are dormant pole cuttings harvested from living woody plants and planted vertically into the substrate. Poles need to be three to 4.5 inches in diameter and at least six to eight feet long. Unless planted in saturated soils or near stable groundwater, temporary irrigation would be required. Pole plantings of cottonwood and willow have shown high rates of success with this technique. Plant materials should be available nearby, and may even be obtained from the other Salt River projects.

Plant Containers: Nursery grown potted containers would be planted on site. One gallon containers have shown the greatest success rates (80+ percent) at Lower Las Vegas Wash, Nevada. They are also the least expensive container plants available. Plantings would require a source of irrigation, at least temporarily.

2.4.1.3.2 Mesquite

This habitat would potentially be restored over a large portion of the project area. It would require periodic watering for the first five years after planting, although with less frequency than cottonwood/willow. Watering could possibly be discontinued after five years or when roots are expected to reach groundwater. Mesquite bosques would be dominated by velvet mesquite (*Prosopis velutina*), with scattered screwbean mesquite (*Prosopsis pubescens*), and some understory shrubs, such as desert thorn (*Lycium spp.*), palo verde (*Cercidium floridum*), brittlebush (*Encelia farinose*), and *forbs*.

Bosque: Mesquite bosques are commonly found five to 20 feet above the river channel where water is adequate. They require a water table, or semi-saturated soil conditions ten to 30 feet below the surface elevation and rely on occasional saturated conditions one to three feet below the surface. Soil requirements range from fine to gravelly, with some rocky areas. The mesquite bosques would be planted with a density of approximately

100 velvet mesquite, ten screwbean mesquite, and 40 understory shrubs per acre. Understory forbes would also be planted using a seed mix.

Xeric: In locations throughout the study with less water available, xeric stands of mesquite would be established. It is assumed that mesquite would survive under drier conditions and on higher terraces than mesquite bosque. Planting densities would be lower, with approximately 25 velvet mesquite, five screwbean mesquite, and ten understory shrubs per acre.

2.4.1.3.3 Riparian Scrub Shrub

The project implementation area already contains a substantial acreage of scrub shrub habitat. Although portions of this cover type would be converted to the other riparian habitats, other areas would be maintained as scrub shrub. This cover type provides a connection between other habitat types, and contributes to the important mosaic of vegetative cover types that maximizes structural habitat complexity. It is assumed that some portions maintained would remain a more xeric desert scrub, but others adjacent to the wetter riparian habitats would develop into more distinctive riparian cover containing species such as Seepwillow, desert broom, or Desert willow. Estimated acreages for both scrub shrub and riparian scrub are included in the acreages provided in Table 3.4-1. It is estimated that if the active river channel is approximately 500 acres, between 25 and 60 percent would be occupied by riparian scrub in the with-project conditions, depending on water supply.

2.4.1.3.4 Wetlands

Wetlands can consist of open water, submerged vegetation, or mud flats, all requiring a high water table at or near the surface. Due to the porous soils found in the project area, an impervious lining would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is 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.

Stormwater Wetland: Stormwater wetland restoration would take place at individual stormwater outfalls. Techniques would be site-specific and would include grading or excavation, removal of exotics, and planting of suitable vegetation for the site conditions. Supplemental water would be required via an irrigation source, and structures would be installed to contain high-energy inputs and avoid erosion during storm events.

Emergent Wetland: Emergent wetlands contain primarily cattails (*Typha domingensis*), tule (*Scirpus acutus*), and sedges (*Carex spp.*). Because the river would not flow year round, the wetlands would need to be constructed specifically to retain water. In addition to grading and excavation, an impermeable layer would be added to retain water on site.

2.4.1.3.5 Lake Restoration

There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to better utilize the existing water and improve the functionality of these features. The existing banks would need to be reshaped for public safety and restoration. Potential substrate modification may be required to reduce the annual fluctuation in the lake levels. In addition, aeration would need to be considered to retain water quality.

Grading: Banks would be reshaped to create "irregular random terraces" (variable in length, width and depth below the water surface) that would become submerged to different depths to provide more diversity in the littoral zone. The littoral zone is the nearshore area where sunlight penetrates all the way to the sediment and allows aquatic plants to grow. The irregularity and randomness of the terraces provides more opportunities for the establishment of submerged, floating, and emergent vegetation and a more diverse and natural shoreline habitat. The random terracing would provide different thermo strata for aquatic organisms, potentially improving mixing and maintaining a less stratified body of water, making it less susceptible to turnover (reducing oxygen levels). These terraces or shelves may be exposed periodically, functioning as emergent wetlands or mud flats during seasonal fluctuations in the lake level. The terraces, when exposed, provide an opportunity for voluntary native vegetation to become established. When these areas are again submerged, some of this vegetation would persist. Vegetation unable to survive the wetter conditions would contribute to the organic content of the benthic zone. The productivity of the benthic zone is largely dependent on the organic content of the sediment and amount of physical structure.

Substrate: It would be necessary to modify the substrate of existing bodies of water within the study area to implement restoration at the lakes. This may include the addition of impermeable materials to both maintain water elevations and grow vegetation. There are various alternatives for lake bottoms that improve the benthic zone productivity. There are tradeoffs in productivity, refuge availability, diversity, and food production associated with the various lake bottom characteristics. A sandy substrate contains relatively small amounts of organic matter for organisms and provides limited protection from predation. Higher plant growth is limited and sparse in sandy sediment; the sand is unstable and nutrient deficient. A rocky bottom has a high diversity of potential habitats offering protection (refuge) from predators, substrate for attached algae, and pockets of organic "ooze." A flat, mucky bottom offers abundant food for benthic organisms; however, there is less protection and the diversity of structural habitats may be reduced unless higher plants colonize the lake bottom.

2.4.1.3.6 Invasive Species Management

Invasive Species Removal/Control: It would be necessary to remove and manage invasive species such as salt cedar and *Arundo* with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. Salt cedar is currently found in stands throughout the study area. Arundo, though not yet a significant problem in

Arizona, is a problem in neighboring California. A stand of Arundo can be found on the south side of the river near a stormwater outfall at 43rd Avenue.

2.4.1.3.7 River Channel Restoration

Project implementation would restore approximately eight miles of river channel to a more natural state based on hydraulics and geomorphology. This work would be conducted along the entire length of the Salt River from 19th Avenue west to 83rd Avenue. The restoration would be accomplished by grading and terracing to help recreate an active channel through the entire reach. Average depth of grading is assumed to be five feet, with a width varying from 200 to 400 feet. The average width of the river channel, including adjacent river terrace, throughout the study area would be approximately 500 feet. The channel design passes a five-year event (~22,000 cfs) with occasional flooding on the terrace two to four feet in depth flowing at approximately 1-7 ft/s. Due to a drop in the channel downstream of the 35th Avenue Bridge, a grade control structure is recommended in that vicinity. At this time, erosion and scour do not appear to be a concern with project features or infrastructure. However, should it appear in future analysis that it is a concern, appropriate protection would be included. An estimated 660,000 cubic yards of material would be removed from the channel to implement this measure. Material removed would be native riverbed material, and would utilized on site for terracing and construction of other project components, such as lake restoration.

> **River Channel Habitats**: The river channel itself can include different habitat cover types depending on site specific conditions. These may include dry river bottom, emergent wetland, riparian scrub or desert scrub. The team assumed that after construction, a low flow channel similar to that in the Rio Salado Project area and the existing channel in the reach near 43rd Avenue, would become established. The total acreage of this low flow channel through the project reach was assumed to be 170 acres. It was projected that between 10-20% of that would become vegetated with emergent wetlands. The remainder of the channel would vegetate with either riparian scrub or desert scrub depending on conditions within this active channel.

2.4.1.3.8 Operation, Maintenance, Repair, Replacement and Rehabilitation

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) activities 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 OMRR&R 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 2 would require the least amount of OMRR&R, while Alternatives 5, 5A and 5B would require the greatest amount of OMRR&R because they restore the largest amounts of acres.

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, 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;
- spraying larvicides such as *Bacillus thuringiensis israeliensis* and *Bacillus sphaericus* at a frequency of every two to four 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 five 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 non-federal sponsor (City of Phoenix). Appendix N of the Feasibility Report contains a Monitoring and Adaptive Management Plan prepared by the Corps for this project.

Sediment Removal

During high flows, 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).

For features within the floodplain, regrading and excavation was assumed to be needed once every ten years. It was assumed that for the stormwater outfalls, 50 percent of the construction quantity would need to be regraded in this period. The restored wetlands at existing lakes (gravel pits) would require regrading and excavation once every 20 years of up to one foot of material over the wetlands. The active channel would require regrading up to once every 20 years for up to 50 percent of the estimated construction quantity, or 330,000 cubic yards.

2.4.2 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. Opportunities for incidental flood damage reduction, noise reduction, water and air quality improvements, aesthetic resource benefits and passive recreation also would not be realized. Although it is possible that local agencies would implement limited improvements, restoration efforts would not occur on the scale of the proposed project. The existing and future without-project conditions are discussed later in this document. Acres of habitat associated with each action alternative are displayed in Table 2-3 below.

2.4.3 ALTERNATIVE 2

This alternative includes the modification of existing stormwater outfall areas to improve retention and water spreading as well as increase the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th to 83rd Avenues. No additional water source is included in this alternative other than temporary irrigation to establish vegetation.

Table 2-4.1 of Section 2.4.1.1 above lists the locations of each stormwater outfall and the amount of habitat acreage that could be supported by the water available at each site. The acreage of habitat that could be supported was based on utilizing one-half of the estimated water supply currently found at each site. It was assumed that when stormwater wetland is combined with cottonwood/willow riparian, the wetland would utilize one-third of the potential supply, with the cottonwood/willow utilizing the remainder.

The 170 acres of restored channel are based upon an active channel varying in width from 200-400 feet. A grade control structure is included in this measure due to an elevation drop in the vicinity of the 35th Avenue Bridge. It was assumed that approximately 10 percent of the channel would naturally regenerate emergent wetlands much like the upstream Rio Salado Phoenix reach low flow channel.

Table 2.4-2. Acres of habitat associated with each action alternative

Alternative	Channel[1]			Cottonwood/ Willow	Mesquite	Open Water	Scrub-Shrub[2]	Other Wetlands	TOTALS
	Low-Flow Channel	In-Channel Wetlands[3]	Riparian Scrub						
2. Stormwater and Channel	170	17	125	66	43	0	305	28	737
4. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent	170	34	165	348	409	0	63	33	1188
5. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent, Lake	170	34	296	375	417	40	92	76	1466
5A. Wetland/riparian restoration in lieu of permanent open water and lakes	170	34	296	375	417	0	52	156	1466
5B. Hybrid of 5 & 5A with one gravel pit restored to a lake and the other a wetland/ riparian complex	170	34	296	375	417	20	52	136	1466

[1] River channel consists of low flow, wetland or riparian scrub.
[2] Scrub shrub acres are dispersed among and between the other restored cover types within the floodplain.
[3] Alternative 2 assumes that 10% of the low-flow channel would consist of wetlands; the remaining alternatives assume that 20% of the low-flow channel would consist of wetlands.

2.4.4 ALTERNATIVE 4

The major components of this alternative include stormwater, channel restoration, water supply, cottonwood, mesquite, invasive control, emergent wetlands.

Stormwater and Channel: This alternative includes the stormwater wetlands and channel restoration measures described in Alternative 2. It was assumed that with implementation of this alternative, however, that 20 percent of the channel would regenerate to emergent wetland vegetation due to additional water supply.

Water Supply: Effluent from the 23rd Avenue WWTP is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. This would require construction of a means to deliver effluent to the project from the 23rd Avenue WWTP. Distribution of water would be through a combination of flood and drip irrigation. The water supply plan is described in detail in Appendix J of the Feasibility Report.

Revegetation: This alternative would restore cottonwood/willow riparian stands adjacent to water sources and low terraces throughout the study area, mesquite would also be restored with this alternative. Total acreages of each cover type are shown in the Table 2.5-1 above.

Invasive Control: It would be necessary to remove and manage invasive species such as salt cedar and Arundo with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. There is roughly 110 acres throughout the study area where invasive species are of concern.

2.4.5 ALTERNATIVE 5

The major components of this alternative include stormwater, channel restoration, water supply, cottonwood, mesquite, invasive control, emergent wetlands and lake.

Stormwater and Channel: This alternative includes the stormwater wetlands and channel restoration measures described in Alternative 2.

Water Supply: Effluent from the 23rd Avenue WWTP is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. This would require construction of a means to deliver effluent to the project from the 23rd Avenue plant. Distribution of water would be through a combination of flood and drip irrigation. The water supply plan is described in detail within Appendix J of the Feasibility Report.

Revegetation: This alternative would restore cottonwood/willow riparian stands adjacent to water sources and low terraces throughout the study area. Mesquite would also be restored with this alternative. Total acreages of each cover type are shown in the Table 2.5-1, above.

Invasive Control: It would be necessary to remove and manage invasive species such as salt cedar and *Arundo* with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. There is roughly 110 acres throughout the study area where invasive species are of concern.

Lake: There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to better utilize the existing water and improve the functionality of these features. The existing banks would need to be reshaped for public safety and restoration. Potential substrate modification may be required to reduce the annual fluctuation in the lake levels. In addition, aeration would need to be considered to retain water quality.

Alternative 5 inclues approximatley 5.4 million cubic yards of regrading to implement the lake restoration measure. An additional 212,000 cubic yards are included for lining material to reduce infiltration and maintain open water.

2.4.6 ALTERNATIVE 5A (RECOMMENDED PLAN)

The major components of this alternative include stormwater, channel restoration, water supply, cottonwood, mesquite, invasive control, emergent wetlands and lake.

Stormwater and Channel: This alternative includes the stormwater wetlands and channel restoration measures described in Alternative 2.

Water Supply: Effluent from the 23rd Avenue WWTP is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. This would require construction of a means to deliver effluent to the project from the 23rd Avenue Plant. Distribution of water would be through a combination of flood and drip irrigation. The water supply plan is described in detail within Appendix J of the Feasibility Report.

Revegetation: This alternative would restore cottonwood/willow riparian stands adjacent to water sources and low terraces throughout the study area, Mesquite would also be restored with this alternative. Total acreages of each cover type are shown in the table above.

Invasive Control: It would be necessary to remove and manage invasive species such as salt cedar and Arundo with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. There is roughly 110 acres throughout the study area where invasive species are of concern.

Lake: In lieu of lake restoration inluding permanent open water, this alternative includes regrading to existing gravel pits to restore them to the floodplain and installs emergent wetlands and riparian vegetation. Regrading of the gravel pits requires moving approximately 3.2 million cubic yards of material and installation of fine materials to support wetland/riparian vegetation.

2.4.7 ALTERNATIVE 5B

The major components of this alternative include stormwater, channel restoration, water supply, cottonwood, mesquite, invasive control, emergent wetlands and lake.

Stormwater and Channel: This alternative includes the stormwater wetlands and channel restoration measures described in Alternative 2.

Water Supply: Effluent from the 23rd Avenue WWTP is the primary source of water available for the restoration project. The City of Phoenix estimates that approximately 8 mgd (8,964 ac-ft) is available to the project. This would require construction of a means to deliver effluent to the project from the 23rd Avenue Plant. Distribution of water would be through a combination of flood and drip irrigation. The water supply plan is described in detail within Appendix J of the Feasibility Report.

Revegetation: This alternative would restore cottonwood/willow riparian stands adjacent to water sources and low terraces throughout the study area mesquite would also be restored with this alternative. Total acreages of each cover type are shown in the table above.

Invasive Control: It would be necessary to remove and manage invasive species such as salt cedar and Arundo with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project. There is roughly 110 acres throughout the study area where invasive species are of concern.

Lake: With this alternative the lake restoration is a variation of alternatives 5 and 5A with one gravel pit converted to a lake and the other a wetland riparian complex.

2.4.8 WATER DEMAND

Available sources for the project include effluent and harvested stormwater. Approximately 8 mgd (8,961 ac-ft/yr) of effluent would be made available from the 23rd Avenue WWTP. Stormwater runoff within the project area was also calculated based upon average monthly rainfall in Phoenix, and approximately 2,900 ac-ft can be expected to run off into the project area from the approximately eight adjacent outfalls. Water demand for individual alternatives is summarized in the table below, with more detail included in Appendix B of the Feasibility Report, Water Budget Report and Interior Drainage Report.

Table 2.4-3. Water Demand for Alternative Plans

Alternative	Water Demand (ac-ft)	Water Demand (mgd)
Alternative 2	1,583	1.41
Alternative 4	4,701	4.20
Alternative 5	7,752	6.92
Alternative 5A	9,293	8.30
Alternative 5B	9,234	8.24

2.5 CHOOSING THE PREFERRED ALTERNATIVE

Cost-Effectiveness (CE) and Incremental Cost Analyses (ICAs) were performed on the above alternatives. CE 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 lower 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 increases in cost relative to output.

In addition to the five project alternatives, four additional alternatives were evaluated during policy review to assure that the Cost Effectiveness and Incremental Cost Analysis provided an evaluation of alternatives covering a full range of both output and cost. These added alternatives contain the same project measures but are smaller combinations of the project alternatives described in detail in the EIS. These alternatives include:

Partial: This alternative restores only the portion of Salt River from 19th to 35th Avenues without any restoration of existing gravel pit lake. It includes capture of storm water from only 4 outfalls. Approximately 270 acres are required for this alternative and restored areas include 15 acres of emergent wetlands, 30 acres of cottonwood-willow, 30 acres of mesquite, and 75 acres of riparian scrub. In addition the low flow channel would encompass approximately 48 acres.

Refine 1: This alternative includes restoration of the river channel from 19th to 83rd Avenues, modification of existing storm water outfalls and restoration of associated habitats and restoration of the two existing gravel pit lakes. Approximately 1024 acres are required to implement this alternative. Acres restored with this alternative include: cottonwood-willow 210, mesquite 56, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 2: This refinement restores the river from 19th to 83rd Avenues and includes the same features as Alternative 5A but is scaled back to restore much less cottonwood-willow and mesquite habitats. Approximately 1300 acres are required to implement this alternative. Acres restored include: cottonwood-willow 204, mesquite 110, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 3: This refinement also restores the river from 19th to 83rd Avenues without restoration of the gravel pit lakes and less acreage of cottonwood-willow and mesquite. Approximately 1130 acres are required to implement this alternative. Acres restored include: cottonwood-

willow 169, mesquite 102, wetlands 92, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

2.5.1 HYDROGEOMORPHIC MODEL (HGM)

The HGM analysis provides quantitative estimates of projected hydrogeomorphic changes over the period of analysis for the alternatives, and also provides a means of comparing the hydrogeomporhic changes of the different alternatives, including the No-Action alternative. HGM benefits are expressed as Functional Capacity Units (FCUs). Members of the HGM team develop Functional Capacity Indices, which are the indices within the ecosystem that can be quantified to present a range of how the ecosystem is functioning and how it would function with different alternatives. Indices include such functions as: floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance. These FCIs can then be multiplied by acreages to derive Functional Capacity Units, or the unit that provides a means of assessing the gains or losses in functional value for a single target year of interest. For all alternatives, a baseline condition of 580 FCUs is used. The FCUs are averaged over the period of analysis for the project (51 years for this study) to determine Average Annual FCUs (AAFCUs) for each alternative. This analysis includes the AAFCUs for each of the alternatives for purposes of comparison. The detailed HGM analysis is included as Appendix I of the Feasibility Report.

2.5.2 COST-EFFECTIVE ALTERNATIVES

An alternative is cost effective if it provides greater AAFCU output for the same or lesser cost than another alternative. Table 2.3-1 shows the cost effective alternatives.

Table 2.5-1. Cost-Effective Alternatives

Alternative	AAFCU	AA Cost*	AAC/AAFCU*
2	51	$2,443	$47.73
4	165	$8,022	$48.55
5A	267	$12,334	$46.15
Partial	33	$1,684	$49.34
Refine 1	184	$7,553	$41.05
Refine 2	187	$8,309	$44.52
Refine 3	87	$5,678	$65.41

*Dollar figures are in thousands.

2.5.3 INCREMENTALLY EFFECTIVE ALTERNATIVES

Incremental cost analysis goes beyond cost effective analysis to identify "Best Buy" plans. Best Buy plans are those that have the lowest incremental average annual cost (AAC) per incremental increase in output. As can be seen below, Alternative Refine 1 provides 184 AAFCU and Alternative 5A provides 267. The AAC/AAFCU for Alternative 5A is about ten percent higher than Alternative Refine 1, and the incremental AAC per incremental AAFCU is about 33 percent higher than Alternative Refine 1. However, Alternative 5A provides 83 AAFCUs more than Alternative Refine 1, representing an increase in output of over 45 percent. .

Table 2.5-2. Incrementally Cost-Effective Alternatives

Alternative	AAFCU	AA Cost*	Cost/AAFCU*	Incremental Cost/Incremental AAFCU*
Refine 1	184	$7,553	$41.05	$41.0
5A	267	$12,106	$45.34	$54.7

* Dollar figures are in thousands.

Based on the HGM and ICA analyses, Alternative 5A is NER plan. It is cost effective and provides the highest environmental outputs.

2.6 RECREATION AND ENVIRONMENTAL EDUCATION

2.6.1 INTRODUCTION

The Rio Salado Oeste Project provides a unique opportunity to enhance natural resource-based recreation and environmental education. The restoration of the dry Salt River channel would bring a riparian open space feature to the rapidly expanding Laveen and Estrella Planning Areas. Rio Salado Oeste would provide a habitat and recreational connection to the desert riparian habitat corridor created by the Rio Salado and Tres Rios Projects. By connecting the eight mile gap between the two projects, Rio Salado Oeste would enhance the unique recreation and education opportunities for residents and out-of-town visitors.

Alternative formulation for the project focused on the ecosystem restoration itself. The associated recreation plan has been developed by the City of Phoenix. The recreation plan was added to the restoration plans after the ecosystem restoration alternatives were completed in compliance with Corps' policies on recreation development at ecosystem restoration projects. Recreation features are ancillary to the ecosystem restoration, do not degrade the restoration value but take advantage of the recreational and educational opportunities provided, and follow the checklist of cost shareable recreation features. The Corps and the City of Phoenix would cost-share the recreation plan as allowed by Corps' policies. The conceptual recreation plan is shown in Figure 2.6-1.

2.6.2 VISITATION ESTIMATES

Drawing on a population base of over two million in the Valley, it is estimated that visitation to the Rio Salado Oeste Project would exceed 350,000 annually (Table 2.6-1). Primary use times for this unique resource would coincide with the "visitor season" between October and May when temperatures are moderate.

Table 2.6-1. Rio Salado Oeste Recreation Plan Baseline Visitation Estimate

	Days	Turnover/Day	Visits
Winter (Oct-May)	243		
Prime Time	78	1.50	160,875
Non-Prime Time	165	.50	113,438
Winter Total			274,313
Summer (Jun -Sep)	122		
Prime Time	36	1.00	49,500
Non-Prime Time	86	0.25	29,563
Summer Total			79,063
Grand Total (by vehicle)			353,376
Add - Arrive by Alternative Mode (10%)			35,338
Total Visitation			388,714
Less Transfers (10%)			38,871
Baseline Visitation for Benefit Analysis (rounded)			350,000
Note: Based upon parking capacity for 500 spaces. Average of 2.75 Persons/Vehicle			

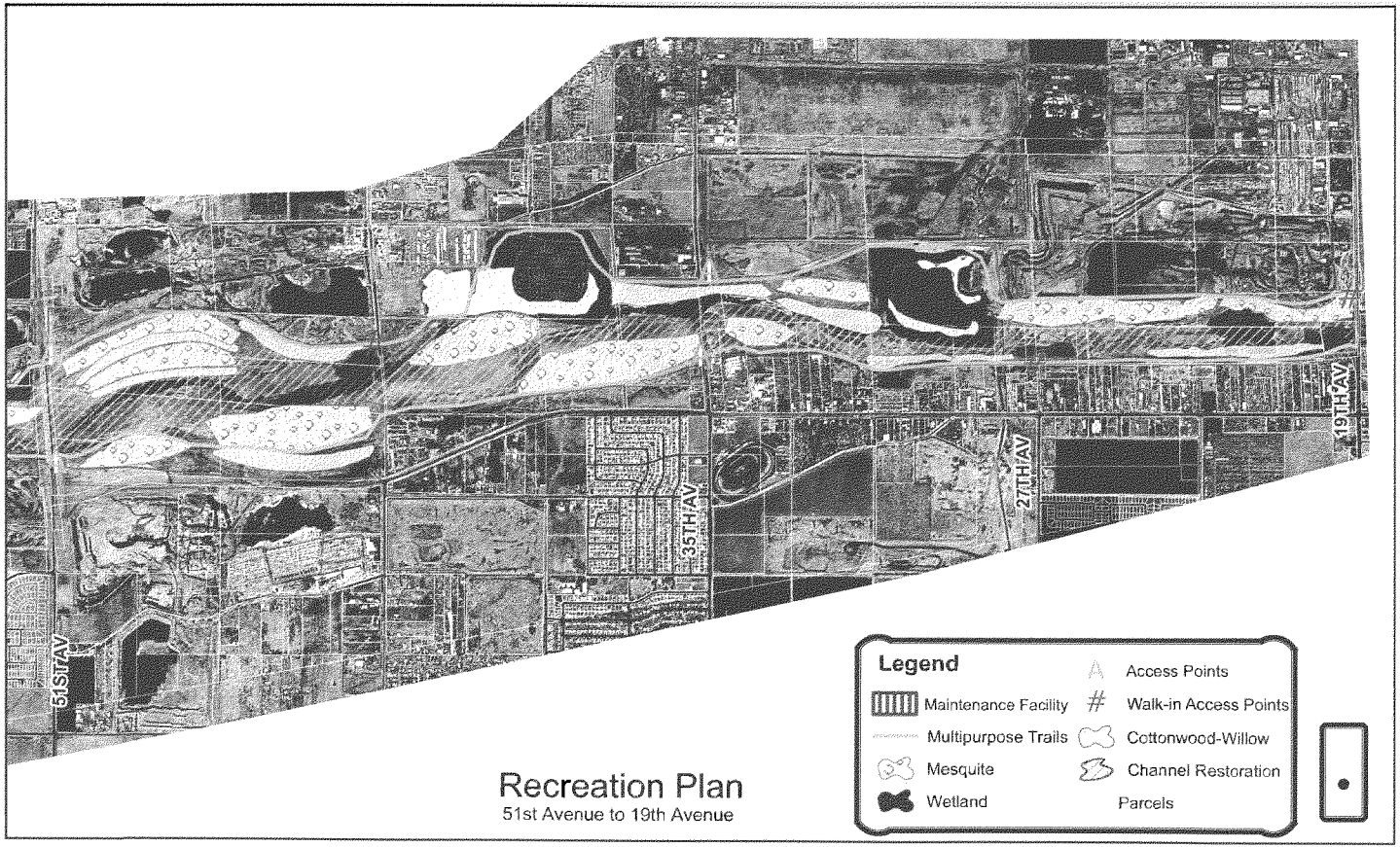
2.6.3 RECREATION PLAN FEATURES

The City of Phoenix developed the recreation plan for the project, which may be found in Appendix L of the Feasibility Report. This recreation plan would be implemented for all five action alternatives. Major recreation features include multipurpose trails, shelters, signage, shelters, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and five smaller access points for walk-in use. Additionally, nine minor points for walk-in access from adjacent neighborhoods would be completed. Table 2.6-2 below includes the recreation features. Figure 2.6-1 depicts the conceptual Rio Salado Oeste Recreation Plan.

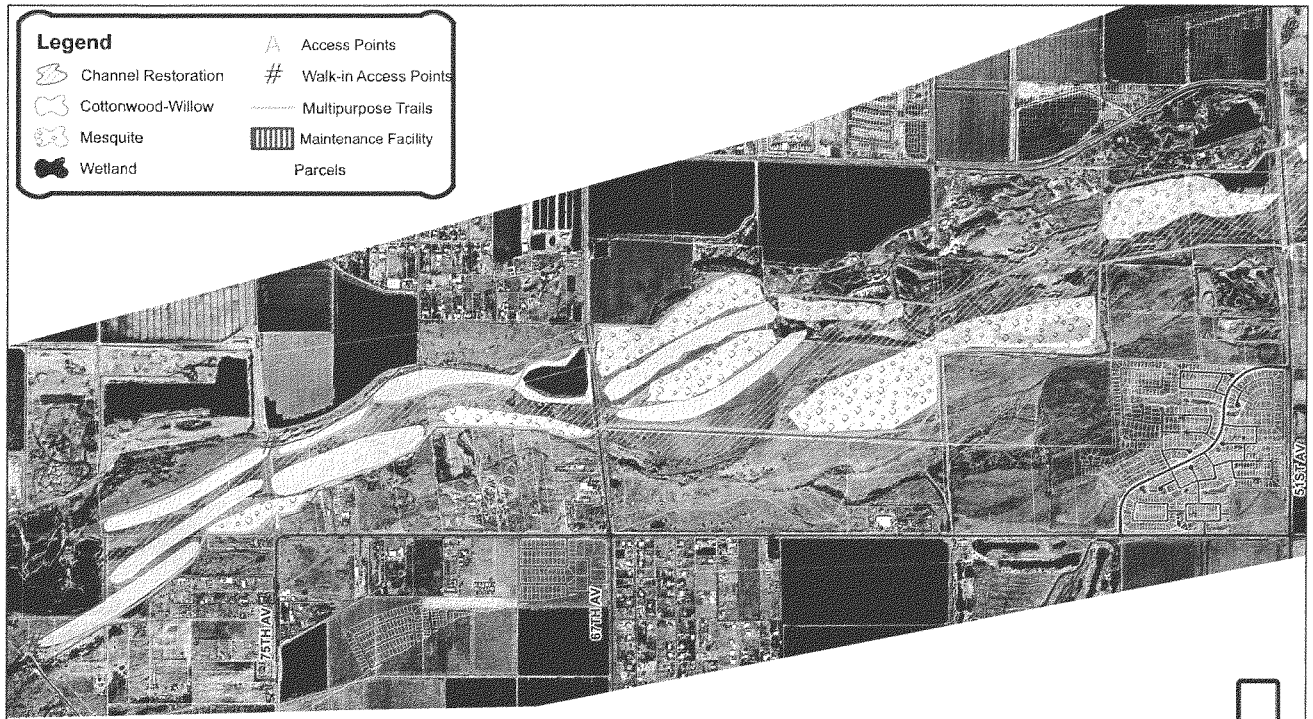
Table 2.6-2. Rio Salado Oeste Recreation Plan Components

Component	Quantity	Unit Cost	Recreation Cost
Site Preparation			
Site Prep to include: clearing, grubbing, and grading	9	Lump Sum	$250,000.00
Vegetative Restoration (Drive in Access)	4	Lump Sum	$600,000.00
Vegetative Restoration (Walk in Access)	5	Lump Sum	$75,000.00
Access and Circulation			
Entry Road w/Turnaround to include: curb, gutter, driveway, & road	4	Lump Sum	$600,000.00
Parking lot	500	$1500/space	$750,000.00
Sidewalks and Ramps	40,000 sf.	$6.00 each	$240,000.00
Multi-Use Trails (24mi * 5280 * 5ft)	47000	$6.00 / sy	$282,000.00
Bridges and Culverts (small) @ Canals, and Localized Drainage Areas	10	$7,500 each	$75,000.00
Protection Access Control			
Access Control Gates (vehicular)	10	$7,500 each	$75,000.00
Access Control Gates (pedestrian)	18	$3,500 each	$63,000.00
Handrails	5,000 l.f.	$50.00 each	$250,000.00
Guardrails	3,000 l.f.	$50.00 each	$150,000.00
Fencing	5,000 l.f.	$30.00 each	$150,000.00
Walls	1,500 l.f.	$125.00 each	$187,500.00
Security lights	100	$4,000 each	$400,000.00
Signage			
Entrance identification signage	8	$15,000 each	$120,000.00
Traffic Control (vehicular)	20	$500 each	$10,000.00
Traffic Control (pedestrian)	27	$500 each	$13,500.00
Instructional/Directional	45	$500 each	$22,500.00
Shelters			
Picnic (large)	5	$60,000 each	$300,000.00
Picnic (small)	5	$25,000 each	$125,000.00
Restroom Facility/Comfort Station	5	$250,000 each	$1,250,000.00
Shelter w/Bulletin Boards	4	$25,000 each	$100,000.00
Trail Shelter w/Railing (large)	9	$40,000 each	$360,000.00
Trail Shelter w/Railing (medium)	4	$30,000 each	$120,000.00
Trail Shelter w/Railing (small)	10	$20,000 each	$200,000.00
Utilities			
Municipal Water Supply and Wastewater Disposal	5	Lump Sum	$500,000.00

Storm Drainage	4	Lump Sum	$80,000.00
Drinking Fountain w/Chiller	12	$5,000 each	$60,000.00
Electical	4	Lump Sum	$200,000.00
Park Furniture			
Benches:	14	$1,500 each	$21,000.00
Off-the-Shelf	40	$800 each	$32,000.00
Recycled/Custom	50	$500 each	$25,000.00
Picnic Tables	40	$1000 each	$40,000.00
Trash Receptacles	75	$500 each	$37,500.00
Interpretive Guidance Media			
Display Boards	50	$600 each	$30,000.00
Interpretive Markers	100	$600 each	$60,000.00
Bulletin Boards	9	$2,500 each	$22,500.00
		Subtotal	**$7,876,500.00**
	Contingency	20%	$1,575,300
	PED+EDC	11%	$1,039,698
	S&A	7%	$681,947
		Total	**$11,173,445**


51ST AV
35TH AV
27TH AV
19TH AV
Legend
Maintenance Facility
Multipurpose Trails
Mesquite
Wetland
Access Points
Walk-in Access Points
Cottonwood-Willow
Channel Restoration
Parcels
Recreation Plan
51st Avenue to 19th Avenue

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Recreation Plan
83rd Avenue to 51st Avenue

CHAPTER 3
AFFECTED ENVIRONMENT

The Rio Salado Oeste study area consists of an eight mile reach of the Salt River and adjacent lands in and near southwestern Phoenix, Maricopa County, Arizona. More specifically, the study area consists of the Salt River corridor from 19th Avenue downstream (west) to 83rd Avenue, between Lower Buckeye Road and Baseline Road. This study area is three miles wide and encompasses approximately 23.5 square miles. The much smaller project implementation area consists of the 100-year floodplain of the Salt River within the overall study area (Figure 1.6-2). The project implementation area averages two-thirds of a mile in width, and consists of approximately 3,315 acres.

The regulations at 40 CFR 1502.15 require that an environmental impact statement (EIS) by prepared to describe the environment of the area to be affected by the alternative actions being considered. The area affected by the proposed action is defined as the Salt River between 19th Avenue and 83rd Avenue (Rio Salado Oeste reach). This chapter provides a description of the existing and future without-project conditions for a 50-year period of analysis within the study area. The future without-project conditions serve as the baseline for determining the nature and magnitude of environmental impacts of the proposed action and alternatives (refer to the Feasibility Report for information on the period of analysis).

A variety of resources exist in the study area that may or may not be significantly impacted by the proposed restoration project. This chapter describes the baseline environmental conditions for 13 resources categories:

- Topography and Geology
- Hydrology and Water Resources
- Water Quality
- Biological Resources
- Cultural Resources
- Aesthetic Resources
- Air Quality
- Noise
- Social and Economic Resources
- Transportation
- Land Use
- Recreation
- Public Health and Safety

The scope of the descriptions provided to characterize each resource is guided by the scope of the proposed action as it relates to a particular resource category, which generally defines a region of influence for each resource category. The region of influence consists of the geographic area in which the proposed action is expected to have a direct or indirect effect on the resource.

3.1 GEOLOGY AND TOPOGRAPHY

This section describes the topography and geographic conditions of the Rio Salado Oeste study area. This section is based on the geotechnical analysis in the *Rio Salado, Salt River, Arizona: Feasibility Report and Environmental Impact Statement* (U.S. Army Corps of Engineers, 1998).

3.1.1 REGIONAL GEOLOGY AND TOPOGRAPHY

The study area is located in the eastern portion of Maricopa County. It is located just north of the southern City Limits of Phoenix, and north of South Mountain. The terrain varies from hills and rock outcrops, south of the study area, to alluvium within the river floodplain. Slope angles in the study area range from 0–2% (Maricopa County, 1992). The project area is in the Phoenix basin of the Salt River Valley. The Phoenix metropolitan 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. 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 rock. From the end of the Pliocene until recent (Holocene) time, the basins, including the Salt River Valley, filled with unconsolidated and occasional semiconsolidated sediment eroded from the ranges. The thickest accumulations of valley alluvium formed during the early to middle Quaternary period. 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 unconformable 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. These 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. Total thickness of alluvial materials ranges from nearly nothing along the mountain fronts, to nearly 10,000 feet under the valley interior. 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, valley fills have been eroded as the river formed terraces during its evolution.

3.1.2 LOCAL GEOLOGY AND TOPOGRAPHY

The Rio Salado Oeste study area extends east and west along the Salt River. The river 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 predominant surface materials within the study area consist of Quaternary-age river sediments, deposited as alluvium, and terraces, 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. 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 overlie thick Tertiary sedimentary and volcanic rocks beneath the basin. They interface with Tertiary rocks along mountain ranges and inselbergs. The very thick Precambrian basement complex underlies basin terrace and alluvium at maximum depths greater than 3,300 feet.

3.1.3 SOILS

Two major soil associations are found within the study area. Within, and immediately adjacent to, the river is the Carrizo-Brios Association, with the Gilman-Estrella-Avondale Association to the south. The Carrizo-Brios Association is characterized by deep, excessively drained soils and nearly level to gently sloping, gravelly sandy loams and sandy loams in stream channels on low-stream terraces. The Gilman-Estrella-Avondale Association is characterized by deep, well-drained soils and nearly level loams and clay loams on valley plains and low stream terraces (Maricopa County, 1992).

3.1.4 RIVER TOPOGRAPHY

The Salt River is characterized by scour-and-fill events, floods and channel shifts. The river was once characterized by meandering flows throughout the river system. Recent urban development in the region has changed the Salt River from a meandering channel to a straight channel with high banks in several reaches. In the central portion of the study area is a large groundwater retention/recharge basin.

The Salt River channel has shifted within the floodplain several times from the 1880s to the present, at times meandering on the north side of the floodplain and on the south side during other times. Channel shifts have distributed alluvial material across the entire width of the floodplain. 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 side bars, mid-channel bars, point bars and overbank deposits. Many of these deposits have recently been disturbed by intensive sand and gravel mining. Mining activity alters later transportation events by removing and compacting material, thereby reducing the amount of sediment transported and loosening other sediments. Sand pits serve as depositional traps for fine sediments.

Sediment transported, in a scour-and-fill setting, will tend to move in waves or pulses, rather than at a constant rate over time. Large amounts of sediment are periodically moved downstream during flow events. Flood flows 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; however, there is also movement of sediment as washload 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. The amount of sediment moved in lesser events is small when compared with the amount of material moved during a flood.

3.1.5 GRADIENT

The general gradient of Salt River, between Granite Reef Dam and the confluence with Gila River, is about 0.0021 feet of vertical drop per 1,000 feet 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.

3.1.6 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 Main Street Fault, in the northwest corner of the state, and Verde Fault, approximately 56 miles north of the Rio Salado Oeste 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 ten feet of normal displacement, causing rockfalls in the project study area. In 1974, events were located northeast of the study area, with recorded Richter Scale magnitudes of 2.5 to 3.0. A 2.1 was recorded in North Central Arizona, approximately 13 miles southwest of Kaibab on 9 August 2005, well outside the area of detection for Rio Salado Oeste.

3.1.7 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 are near Luke Air Force Base, west of the study area, where one to three feet of subsidence has been measured and exhibits the shape of a two-mile-diameter "bowl" depression. Earth fissures and subsidence are both produced by groundwater 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.

3.1.8 REGULATORY SETTING

Topography and geological resources and issues related to geotechnical hazards are primarily under local jurisdiction. 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 structures meet minimum safety standards. Building codes in each jurisdiction establish standards for construction depending on soil conditions, slopes and potential for ground movement and faulting.

3.2 HYDROLOGY AND WATER RESOURCES

The following discussion characterizes the hydrology and water quality conditions of Rio Salado Oeste. The information presented below is based primarily on the following reports:

- Rio Salado, Salt River, Arizona - Draft Feasibility Report and Draft Environmental Impact Statement (U.S. Army Corps of Engineers, 1997), and;

- Tres Rios Feasibility Study, Salt River, Arizona (U.S. Army Corps of Engineers, 2000)

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. Hydrologic investigations and water quality studies have been conducted for the feasibility study and are included in the main Feasibility Report.

3.2.1 REGIONAL HYDROLOGY AND SURFACE WATER RESOURCES

3.2.1.1 Background

The Salt River drains 14,500 square miles of mountainous desert terrain in central and eastern Arizona and is the largest tributary to 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 confluence 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 Phoenix Sky Harbor Airport. The Phoenix metropolitan area is near the center of the Gila River Basin and lies within the West Salt River Valley Subbasin of the Phoenix Active Management Area (Arizona Department of Water Resources, 1994). After its confluence with the Salt River, the Gila River continues westward and joins the Colorado River near Yuma, Arizona.

Most of the City of Phoenix, including the Rio Salado Oeste project implementation area, lies within the West Salt River Valley Subbasin. Annual average rainfall in the West Salt River Valley Subbasin is approximately eight inches (Table 3.7-1). 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 typically develop from the flow of subtropical air masses from the Gulf of Mexico and the tropical eastern North Pacific. Regional storms from the Pacific Ocean generate gentle, widespread showers during December thru mid-March. Summers are hot, with daily temperatures exceeding 100° F from mid-June through August. During the summer, mean daily temperatures 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.

3.2.1.2 Dam System

During the 20th century, the Phoenix area changed from a mainly agricultural region to a mainly 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 river use 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. See table 3.2-1 for a listing of the dams on the Salt, Verde, and Agua Fria and Gila Rivers.

The Salt River Project (SRP) operates six storage dams on the Salt and Verde Rivers and one diversion dam just east of the City of Mesa. Granite Reef Diversion Dam (Granite Reef) does not have any storage capacity. The purpose of this facility is to divert water released from the reservoirs 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 supply the Phoenix Metropolitan Area with water for agricultural and municipal and industrial (M&I) use. Stored water is allocated based on water rights associated with the land in the SRP service area.

All Salt River dams have hydrogenation capacity. Safety of Dams modifications (completed in 1996) to Theodore Roosevelt Dam include a zone for flood control. The total space for water-supply storage behind these dams is 2,025,798 acre-feet (ac-ft) including the cities' new conservation storage, with an additional 556,196 ac-ft for flood damage reduction at Roosevelt Dam. The Roosevelt Reservoir is the largest reservoir of the SRP reservoir system. It stores runoff from about 5,800 square miles of the Salt River watershed.

Downstream of the Stewart Mountain Dam, the Verde River discharges into the Salt River. The drainage area of the Verde River is about 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 Salt River), which provide an additional 287,403 ac-ft of storage. New Waddell Dam is located on Agua Fria River northwest of Phoenix and downstream of the study area.

Table 3.2-1. Major Dams and Reservoirs in the Gila River Basin

Dam	River	Reservoir	Date of Origin	Storage (acre-feet)
Waddell	Agua Fria	Lake Pleasant	1927, mods 1994	812,100
Bartlett	Verde	Bartlett Lake	1939	178,186
Horseshoe	Verde	Horseshoe Lake	1949, mods 1951, 1995	109,217
Stewart Mountain	Salt	Saguaro Lake	1930	69,765
Mormon Flat	Salt	Canyon Lake	1938	57,852
Horse Mesa	Salt	Apache Lake	1927, mods 1992	248,138
Roosevelt	Salt	Roosevelt Lake	1911, mods 1996	1,653,043
Coolidge	Gila	San Carlos Lake	1928, mods 1994	1,222,000
Painted Rock	Gila	Painted Rock Lake	1959	2,500,000
Source: SRP, 2006				

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 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 the Granite Reef Diversion Dam. During normal times, SRP releases water from the reservoirs to meet water needs in the Valley. When the reservoirs approach full capacity, a point which SRP is always fully aware, releases above the water order may b

initiated. Water released in excess of the water order typically flows over or around Granite Reef Dam and flows into the normally dry Salt River channel. The actual amount is dependent upon numerous variables including: available storage space, forecasts, downstream impacts and constraints, and desired future storage levels. The Granite Reef Diversion Dam is located about three 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 Salt River), and the South Canal (for the area south of Salt River). The canal system generally follows the topographic contour of the Phoenix metropolitan area in order to provide gravity flow delivery of water to agricultural, municipal and industrial users. There are no releases during climatically drier years, as occurred between 1942 and 1964. Except for stormwater runoff, groundwater emergence and effluent, the Salt River is dry during those times.

Before 1938, an average of 413,000 ac-ft/year of water flowed through the 28-mile stretch of the Salt River between where McClintock Road crosses the Salt and the confluence of the Salt with the Gila and Agua Fria Rivers (U.S. Army Corps of Engineers, 1997). The estimated pre-development, average annual discharge for the Salt-Verde drainage basin was about 1,250,000 ac-ft and had a median of about 950,000 afy (U.S. Geological Survey, 1991). Since 1965, the 28-mile stretch of the River 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 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 the Granite Reef Diversion Dam, the flow is typically sustained for several days or more and of a significant magnitude. Since 1965, there have been about two releases per year. These releases 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 five-day average flow rate of 15,000 cfs, and a ten-day average flow rate of 10,000 cfs (U.S. Army Corps of Engineers, 2000).

Little data exists 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 the Salt River streamflow infiltrated and recharged groundwater upstream from Indian Bend Wash near Scottsdale. Groundwater discharged to the channel provided 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. Flows were lowest in June, averaging only 6% of the mean high flows in February. Data for 1965 through 1993 show flows below Granite Reef Dam 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, in light of the length of periods without flow in a river that was perennial under natural conditions.

3.2.1.3 Flood Hazards

During periods of high spill water releases from the dams, flood damage may occur in the Phoenix metropolitan area. This happened in the 1970s and early 1980s. Spill water releases exceeded 100,000 cfs in the Salt River below Granite Reef in 1978, 1980, 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 3.2-1 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 one mile, depending on the location. Significant problems related to flooding within the study area include large flood flows 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 mean peak annual discharge on the Salt River 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 one fourth of the years. Before 1938, flows exceeded 10,000 cfs in two thirds of the years. Prior to damming, a peak annual discharge greater than 100,000 cfs occurred in only one year on record, while two such flows have occurred in the past 16 years. Cycles of the climatic regime and man-made alterations to the watershed surface have resulted in grater occurrences of extreme high flows in the latter period. Table 3.2-2, shows estimated flow values for variable frequency and duration flows within the Salt River channel near immediately upstream of the study area (U.S. Army Corps of Engineers, 1997). The peak 100-year flood flow is 166,000 cfs.

Table 3.2-2. Inundation-Duration Frequency 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	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]

[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 cfs is exceeded for 53 days during this event. Results are based upon simulation of Balanced Hydrographs.
Source: U.S. Army Corps of Engineers, 1997

3.2.1.4 Local Hydrologic Characteristics

The study area is located downstream of several other planned restoration projects, including the first phases of the Rio Salado Project located between upstream and downstream of the Tempe Town Lakes Project. The approximately 2-mile upstream section of the study area is surrounded by highly urbanized land-use areas. The lower five miles of the study area flow through a mix of residential and agricultural land-use areas with occasional commercial/industrial developments.

Numerous urban drainage channels are located in the study area. They discharge local stormwater runoff to the Salt River channel By way of eight different outfalls. Together, the outfalls discharge 2,863 ac-ft/year of stormwater during an average year of precipitation. Additional future outfalls may be implemented by the county at 51st Avenue (south) and 75th Avenue (north). While not a reliable constant source of project water, there are opportunities for future use of this water with proper design at the outfall locations. Currently, various forms of habitat are being supported by stormwater runoff and design of a restoration plan would include site-specific measures maximizing the use of that runoff.

3.2.2 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 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).

Groundwater is regulated by the Arizona Department of Water Resources (ADWR). The groundwater basin underlying lower Salt River Valley is located within 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), 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 units are: (1) Lower Alluvial Unit (LAU), (2) Middle Alluvial Unit (MAU) and (3) 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 subflow 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 through the project area varies from an average of 20 to 60 feet. In general, the depth to groundwater decreases to the west end of the study area where dewatering is required at 91st Avenue. In an analysis of ADWR well data and interpolation of surface water in gravel pits, there appears to be a zone of shallow (20-feet deep) groundwater between 51st and 19th Avenues in the river channel. This is likely due to excavation and is known to fluctuate as much as 20 feet annually (Rinker Materials Observation). Groundwater is being pumped in the vicinity of 23rd Avenue for sand and gravel mining where it contributes to the large lake near 27th Avenue. It was also assumed that the lake in the vicinity of 37th Avenue was excavated to groundwater depth, although observations in 2004 appear to indicate that the level has dropped significantly and that the elevations in the lake appear to be influenced by effluent discharge. Figure 3.3-1 shows the depth to groundwater along the Salt River between 19th Avenue and 83rd Avenue.

3.3 WATER QUALITY

3.3.1 CONTAMINANTS

Surface water and groundwater contaminants include naturally occurring and artificial (manmade) 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 six categories: pesticides, metals, nutrients, ions, microorganisms and radiological substances. In addition to these six categories, Volatile Organic Compounds (VOCs) may be present in groundwater, but not surface water (Table 3.3-1). Similar quality issues exist for all water sources in the lower Salt River; contamination by VOCs and various metals, ions, nutrients, and herbicides. While VOCs often exceed drinking water standards in groundwater, they do not exceed standards for irrigation or wildlife uses.

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. CAP water and 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.

Salt River flows maintain high amounts of mineral content and total dissolved solid (TDS). When flood flows do occur, they commonly violate quality standards for fecal coliform bacteria. 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. The Verde water tends to lower the overall TDS content in flows downstream of their confluence. The quality of water would be sufficient to support native fish species; however elimination of the base flows does not allow it.

Table 3.3-1. 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 Dichloroethylene (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			

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 Assurance Revolving Fund (WQARF) sites. They 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 landfills, and leaking underground storage tanks (LUSTs). 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 & Stokes, 2000). While VOC levels often exceed standards for drinking water, they generally meet standards for irrigation or wildlife uses. Metals as contaminants are not as extensively distributed as VOCs. Possible sources of metal contamination include landfills, mines, metal finishing and natural origins. The surface waters of both the Salt and Gila Rivers exceed the maximum allowable limit for mercury. Mercury contamination is commonly associated with mining operations and effluent-dominated waters, such as the Salt River below the 91st Avenue WWTP, located downstream from the study area. When water quality standards are exceeded, it frequently appears to be linked to the remobilization of contaminated sediments during higher-than-normal flows. Although metals appeared in some Salt River Project groundwater wells, 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. Nitrates ranged from 2 to 172 milligrams per liter (mg/l) in SRP-operated wells throughout the valley in 1989 (Jones & Stokes, 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 Salt River, between Phoenix and Glendale, exceeds EPA's Maximum Contaminant Level drinking water-quality standard of 45 mg/l for nitrate (USGS and ADEQ, 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 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 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 pose 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/l. TDS concentrations are generally lower in the surface waters of the Salt and Verde Rivers and averaged 552 mg/l and 282 mg/l, 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/l in 1900, 2,490 mg/l in 1912, 2,900 mg/l 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 Salt and Verde Rivers ranged between 100 and 900 mg/l at lower flows and between 200 and 500 mg/l 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 the Flood Control District Maricopa County (FCDMC), have conducted specialized studies of contaminants in urban stormwater runoff in Maricopa County (USGS, 1995a; USGS, 1995b). Based on data collected from 1993 through 1994, stormwater could degrade water quality with oil and grease, pesticides, dissolved trace metals, and ammonia (USGS, 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 (USGS, 1995b). 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 percent 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 (USGS, 1994). When compared with other municipalities, contaminant loading in Phoenix, from residential, commercial and industrial drainage basins ranked fourth, second and third lowest, respectively.

3.3.2 POTENTIAL WATER QUALITY STRESSORS

The Water Quality Technical Committee (WQTC), for the first phases of the adjacent Tres Rios Project, identified categories of stressors that could affect the quality of the surface waters and groundwater in the Salt River Valley (Tres Rios River Management Steering Committee–Water Quality Technical Committee, 1998). These stressors are described below.

3.3.2.1 Flood flows

Flood flows are the releases from upstream dams. The flows vary in quantity from minor flows in the channel to the projected 100-year flood flows. The minor flows are the result of controlled releases, while the major floods are caused by uncontrolled releases. Flood flows transport substantial amounts of sediment that originate from tributary flows entering the Salt and Gila Rivers from upstream portions of the river channels and erosion in the study area. Substantial scouring of the Salt River channel occurs during flood flows and is partially related to levee

maintenance activities, channelization projects and removal of material for gravel mining operations (USGS, 1995c). Flood flows 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 & Stokes, 2000).

The flood flows 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 to downstream areas. There is very little information available on the chemical constituents in flood flows.

3.3.2.2 Stormwater Runoff

Stormwater enters the Salt River at numerous locations in the study area and has the potential to degrade the surface quality of water in the system. 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. 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 of the compliance requirements of the Arizona National Pollutant Discharge Elimination System (NPDES) permit program, typically referred to as the AZPDES permits, which 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. Detailed description of surface water quality within the study area can be found in Appendices B and D of the Feasibility Report.

There are many areas where stormwater is not collected in a drainage system and 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 land use of the runoff area.

The City of Phoenix, as part of their citywide Stormwater Management Program (SWMP) for the Municipal Separate Storm Sewer System (MS4), conducts annual monitoring and reporting of selected locations throughout the system. The most recent annual report for the MS4 is for the year ending June 30, 2005. This includes monitoring of storm sewer outfalls located at Elwood Street and the Salt River (SR03), the south bank of the Salt River at 27th Avenue (SR30), at 67th Avenue and the Salt River (SR49), and at an in-stream monitoring location on the Salt River at 51st Avenue. Monitoring data indicate that on the Salt River conventional pollutant concentrations have decreased with time and trace metals and nutrients have remained fairly constant. It can be assumed that with the continuation of the SWMP and best management practices, the stormwater quality would remain fairly consistent if not improve over time.

3.3.2.3 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 can also originate from equipment yards. In most cases, agricultural runoff from fields and equipment yards is collected in adjacent irrigation drainage canals and discharged to river channels. In some locations where the farm fields are near river channels, the stormwater runoff can flow directly into river channels. Agricultural stormwater runoff from fields can contain large amounts of sediment because plowing and cultivation break up the soil surface and make soils 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 agricultural drainage, but have not eliminated it.

3.3.2.4 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, 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 from 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.

3.3.2.5 Wastewater Treatment Plant Direct Discharge

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, including the 23rd Avenue WWTP operated by the City of Phoenix. Reclaimed water produced by this plant is reused by Roosevelt Irrigation District (RID) for irrigation water. When RID is using the reclaimed water, there is no flow discharged to Salt River. RID diversions are seasonal, following the demand for irrigation water. During winter, the reclaimed water from the WWTP is discharged into Salt River. The discharge percolates into the riverbed, but as the discharge season progresses, the flow extends downstream. When hydrologic conditions permit, the flow from the 23rd Avenue WWTP can continue downstream beyond the study area.

3.3.3 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.

3.3.3.1 Agency Jurisdiction

Several governmental agencies have administrative interests in the lower Salt and lower Gila Rivers. Upstream dams were built and/or operated by the USBR, U.S. Bureau of Indian Affairs (BIA), SRP, and the U.S. Army Corps of Engineers (Corps). The Corps built and now operates a major flood control structure (Painted Rock Dam) downstream of the study area. The entire study area for this report is located in Maricopa County. The Flood Control District of Maricopa County (FCDMC) is the primary entity providing for flood protection. These agencies and their jurisdictions are described below.

3.3.3.1.1 U.S. Army Corps of Engineers (Corps)

Since its original legislative mandate in 1927 for flood-related work in the United States, the Corps has acquired significant responsibility for flood damage reduction 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.

3.3.3.1.2 U.S. Bureau of Reclamation (USBR)

The 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.

3.3.3.1.3 Salt River Project (SRP)

Until the mid-20th century, the SRP was primarily a water storage and delivery agency for agricultural users. After World War II, 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 two 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 six major dams and the Granite Reef Diversion Dam upstream of the

metropolitan area on the Salt and Verde Rivers. SRP also operates the C.C. Cragin Dam (formerly Blue Ridge Dam) on the Little Colorado River. Water will be pumped from there to provide water to communities on the Salt River watershed. Therefore, SRP must be included 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.

3.3.3.1.4 Flood Control District of Maricopa County (FCDMC)

FCDMC is a primary agency involved with the management of the lower Salt River and portions of the Gila River. Although Maricopa County had undertaken some flood damage reduction 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. FCDMC builds various flood control structures, often in cooperation with other agencies, such as Arizona Department of Transportation (ADOT) and NRCS. In addition, 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 (NFIP), administered by 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 FCDMC. In exercising its responsibilities, FCDMC has completed 32 projects and structures within Maricopa County, including vegetation clearing projects, levee construction, bank stabilization and channel improvements.

3.3.3.2 Water Quality Regulations

3.3.3.2.1 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 (CWA) and administered by the Corps of Engineers. Under the act, the state must issue or waive Section 401 water quality certification before a project can receive Section 404 authorization. Water quality certification requires the evaluation of water quality considerations associated with dredging or placement of fill materials into waters of the United States. An evaluation of the potential effects of each action alternative on water quality has been included as the 404(b)(1) Compliance Evaluation (Appendix A).

Section 404(r) of the Clean Water Act waives the requirement to obtain either the State water quality certificate or the 404 permit, provided that the discharge is part of a federal construction project authorized by Congress, and if the following conditions are met: (1) information on the effects of such discharge of dredged or fill material into waters of the United States, including the application of the Section 404(b)(1) Guidelines, are included in the Environmental Impact Statement (EIS) on the proposed project, and; 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. The Corps has determined that this project as proposed is consistent with the Section 404(b)(1) guidelines (Appendix A) and is in compliance with the Clean Water Act. Upon authorization by Congress, the Corps will recommend an exemption from the

requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act.

The Section 404(r) exemption does not extend to the OMRR&R responsibilities of the non-federal sponsor. The sponsor may be required to obtain a Section 404 permit for discharges of dredge and fill material that are not considered part of the five year adaptive management plan. The Regulatory Branch would determine what type of permit (if any) is needed for these activities. The Corps would assist the non-federal sponsor with preparation of any permit application that may be needed.

The EPA requires states to identify and establish beneficial uses and water quality objectives for surface and groundwater resources. 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 waterbody under Title 18, and ADEQ regulates effluent discharges within this reach on a site-specific basis.

Section 303(d) of the Clean Water Act 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 Phoenix Sky Harbor Airport to the confluence with the Gila River (ADEQ, 1998). TMDLs for these constituents are proposed to be developed before 2007.

3.3.3.2.2 National Pollutant Discharge Elimination System Discharge Permits

Established by Section 402 of the Clean Water Act, the National Pollution Discharge Elimination System (NPDES) is the primary federal program that regulates point-source discharges to waters of the United States. The NPDES program is administered by the EPA Region 9 office in San Francisco, California. In 1992, EPA promulgated rules for a General Construction Storm Water Permit under NPDES which requires property owners to file a notice of intent to discharge stormwater runoff to U.S. waters from land disturbances of more than one acre. The permit generally requires dischargers to eliminate non-stormwater discharges to stormwater systems, develop and implement a Stormwater Pollution Prevention Plan (SWPPP), and perform inspections of stormwater pollution prevention measures. EPA transferred NPDES permitting authority to the Arizona Department of Environmental Quality (ADEQ) on December 30, 2002. ADEQ currently operates the program and issues AZPDES permits for water pollution. Grading that would occur as part of this project would be more than one acre and, therefore, would require a SWPPP.

However, on August 22, 2005, the 9th U.S. Circuit Court of Appeals vacated EPA's approval of the AZPDES permit program. *Defenders of Wildlife, et al. v. EPA, et al.*, No. 03-71439, 2005 WL 2001100. On September 9, 2005, EPA sent a letter to the ADEQ Water Quality Division stating that unless and until the court's mandate is issued, Arizona's authorization to issue NPDES (AZPDES) permits and implement the program remains in effect.

3.3.3.2.3 Safe Drinking Water Act

Water quality standards for drinking water are established and regulated by the federal Safe Drinking Water Act of 1986. Maximum contaminant levels, which apply to metals and other toxic compounds in drinking water, are subject to revision. Additional compounds may be added. The Arizona Safe Drinking Water Program is administered by ADEQ, except for Underground Injection Control permits. These are still issued by EPA Region 9.

3.4 BIOLOGICAL RESOURCES

This section contains a summary of biological resources occurring in, or potentially occurring in, the Rio Salado Oeste study area. Information was derived from published and unpublished reports, Jones & Stokes' file information, and information obtained incidental to other activities in the study area. For the purpose of this biological resources discussion, the project study area consists of the eight mile long section of the Salt River between 19th Avenue and 83rd Avenue. The study area extends one mile to either side of the center of the river channel, for a total width of two miles. Ten federally- and/or state-listed wildlife species have the potential to occur in the study area and are evaluated in this study.

3.4.1 GENERAL STUDY AREA SETTING

Historically, the study area supported significant biological resources including extensive riparian and marsh habitats and included a rather diverse native fishery which has been extirpated below Granite Reef Dam. Most of these fish species are now federally listed throughout minimal sites in the State of Arizona. 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 man-made 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 3.4-1 summarizes the mapped cover types and subtypes in the project study area. This section also includes a description of the important biological communities that occur in the project study area, including characteristics of the vegetation and wildlife in each. The general location of these cover types is shown in Figure 3.4-1.

3.4.2 COVER TYPE DESCRIPTIONS

3.4.2.1 Agricultural Lands

3.4.2.1.1 Vegetation

Agricultural lands are common in the study area, occupying 26% of the total area. Generally, agricultural uses include crops such as cotton, small grains, and assorted vegetables. At the time of the field survey, large areas were being prepared for the year's crops and were dominated by bare soil.

3.4.2.1.2 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 agronomic crops such as alfalfa and small grains. The abundance of small mammals using these edge habitats attracts 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, various ground-feeding granivorous sparrows and finches will forage in agricultural fields.

Table 3.4-1. Cover Types Present Within the Rio Salado Oeste Project Study Area

Major Cover Type	Subtype	Description	Extent in Acres	Percentage of Project Study Area
Agricultural Lands	Grains	Croplands used for wheat production	273.1	3%
	Alfalfa	Croplands used for hay production	493.7	5%
	Fallow/Ruderal Field	Plowed fields not used for at least a year.	157.9	2%
	Unclassified Agriculture	Plowed and unplanted at the time of the survey.	1,687.9	16%
Cottonwood-willow Forest	Young cottonwood/willow forest	Dominated by native trees, generally less than 10 years old with salt cedar in the understory.	3.3	<1%
	Mature cottonwood/willow forest	Dominated by native trees, generally more than 10 years old with salt cedar in the understory.	7.2	<1%
	Salt cedar/ cottonwood-willow forest	Dominated by salt cedar with scattered native species.	120.7	1%
Ditch/Canal	None	Aqueducts and major ditches	12.4	<1%
Low Flow Channel	None	Low flow channels in the active channel	32.6	<1%
Mesquite Woodland	None	Dominated by mesquite and other small shrubs	10.4	<1%
Open Water	Small ponds	Ponds not associated with gravel operations	3.6	<1%
	Oxidation ponds	Ponds associated with 91st Avenue WWTP	134.3	1%
	Sand/gravel operation ponds	Permanent ponds associated with active sand/gravel operations	240.2	2%
Parks and Recreation Areas	None	Golf courses and parks	133.3	1%
River Bottom	None	Unvegetated river bottom covered mostly with cobbles.	50.0	<1%
Scrub-Shrublands	None	Dominated by burrobush, rabbitbush, quailbush, and saltbush	1,263.1	12%
Sand-Gravel Operations	None	Operations within the active channel	1,179.9	11%
Upland Buffer Zone	None	Newly established shrubs and scrub dominated by a mixture of native and non-native shrubs	489.2	5%
Urban	None	Residential, industrial, or transportation	3,534.7	34%
Ruderal	None	Disturbed areas not associated with agricultural clearing, mostly weedy herbaceous species.	639.4	6%

3.4.2.2 Cottonwood-Willow Forest

3.4.2.2.1 Vegetation

Cottonwood-willow forest 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. The availability of water in the study area is mainly regulated by upstream irrigation diversion dams. Because of the modification of the Salt River system, groundwater elevations have been lowered and have contributed to the decline in cottonwood and willow species. These same conditions have also favored the establishment and dominance of salt cedar. 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. An example of cottonwood/willow habitat can be found near the City of Phoenix 91st Avenue Wastewater Treatment Plant (WWTP).

Only one percent of the total study area acreage consists of cottonwood/willow habitat. In terms of basal area and density, Fremont's cottonwood, Goodding's willow and salt cedar are the dominant canopy species in these habitats. 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 salt cedar.

For the purpose of this report, riparian habitat was separated into three subtypes; young cottonwood/willow forest, mature cottonwood/willow forest, and salt cedar-cottonwood/willow forest based on differences in species dominance and stand age within each subtype. All subtypes support varying combinations of cottonwoods, willows and salt cedar in the canopy.

The most common riparian habitat in the project study area is salt cedar-cottonwood/willow subtype. The salt cedar-cottonwood/willow subtype in the project study area is dominated by dense stands of salt cedar with scattered cottonwoods or willows in the canopy. Salt cedar has been labeled an "extreme" phreatophyte because of its ability to tap and exploit deep water tables (Duncan et al., 1993). Salt cedar 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 salt cedar with a competitive advantage over native plants, such as willows and cottonwoods (Duncan et al., 1993). In contrast to the salt cedar/ cottonwood/willow subtype, the young cottonwood/willow forest subtype is characterized by small native trees and shrubs generally less than ten years old, and the mature cottonwood/willow forest subtype is characterized by larger native trees and shrubs generally

more than ten years old. Common understory associates in these types include salt cedar, desert broom, marsh fleabane and desert willow.

3.4.2.2.2 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 provides a variety of food sources and microclimate conditions for wildlife. 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.

Although salt cedar has displaced large amounts of riparian and other vegetation along the Salt River, the remaining native riparian habitat still provides high wildlife value, especially for resident and migratory birds. Great blue herons, great egrets, western yellow-billed cuckoos, and black-crowned night-herons also roost in the cottonwood/willow vegetation and forage in nearby habitats.

An active rookery with approximately 25 double-crested cormorants, 30 great blue herons, 25 great egrets, and five snowy egrets was observed at one section of salt cedar-cottonwood/willow habitat in the Rio Salado Oeste study area (Kiewet Materials gravel operations site) during the March 6, 2002 field reconnaissance.

The cottonwood/willow habitats are especially important for resident and migratory 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, willow 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 area are the cactus mouse, deer mouse, and western harvest mouse. White-throated woodrat, 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 the area include the tree lizard, earless lizard, sideblotched 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 salt cedar trees in the vicinity (CH2M HILL et al., 1997).

Many native wildlife species, especially riparian-dependent or riparian/marsh-dependent birds (e.g., willow flycatchers and the western yellow-billed cuckoo [both 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.

3.4.2.3 Ditch/Canal

3.4.2.3.1 Vegetation

Ditches and canals are uncommon in the project study area, occupying less than one percent of the total area. These features are characterized by open, perennially flowing water and typically lack any vegetation.

3.4.2.3.2 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 serves as movement 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. Belted kingfishers and black phoebes were observed foraging in the vicinity of the larger aqueducts during the site reconnaissance.

3.4.2.4 Low Flow Channels

3.4.2.4.1 Vegetation

Low flow channels in the Salt River have been almost entirely eliminated, occurring in less than one percent of the project study area downstream of the 23rd Avenue WWTP. These features are characterized by either seasonal or perennial open water and are generally unvegetated. Vegetation, when present, consists of scattered patches of Bermuda grass, salt heliotrope and sedges.

3.4.2.4.2 Wildlife

Due to extensive disturbance from sand and gravel mining, and the lack of perennial flow, low flow channels are uncommon in the study area. The low flow channel that does exist within the Salt River is supported primarily by effluent discharged from the 23rd Avenue WWTP. Depending on the water needs of the Roosevelt Irrigation District, the volume of effluent varies from nothing to nearly 50 mgd on a generally annual cycle. The wide fluctuations in water availability and lack of cover (vegetation) limits the suitability of the low flow channel for wildlife. Despite these limitations, the low flow channel provides feeding opportunities for wading birds and some mammals, and can serve as suitable habitats for amphibian larvae (tadpoles) during dry conditions.

3.4.2.5 Mesquite Woodlands

3.4.2.5.1 Vegetation

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 and occur in less than one percent of the study area.

Currently, only small fragmented stands of scattered mesquite woodlands remain along the Salt River. Within the study area, one stand of mesquite woodland was located at the west end of the project near the 91st Avenue WWTP on the south side of the river. This stand had a high level of disturbance including cutting/clearing and vehicular traffic, and appeared to be in poor condition. The mesquite woodland appeared to be dominated by mature trees and did not have evidence of mesquite reproduction, probably due to the factors described above.

3.4.2.5.2 Wildlife

Mesquite is common throughout the region, but has been reduced to remnant patches within the study area. Although no wildlife species are completely dependent on this habitat type, mesquite provides cover, foraging, and breeding habitat for many wildlife species. Most wildlife species that use mesquite habitats also use other similar habitats, including quailbush and salt cedar. 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, European starling, and house finch. Mammals that use this habitat include coyotes, gray fox, bobcats, pocket gophers, black-tailed jackrabbit, desert cottontails, and cactus mice. Reptiles that often use mesquite habitat include earless lizards, side-blotched lizards, desert spiny lizards, western whiptails, gopher snakes, common kingsnakes, banded sand snakes, and western diamondback rattlesnakes.

3.4.2.6 Open Water

3.4.2.6.1 Vegetation

Open water habitat is uncommon in the project study area, occupying three percent of the total area. For the purpose of this report, the open water cover type was separated into three subtypes: sand/gravel operation ponds, small ponds not associated with sand/gravel operations, and oxidation ponds associated with the 91st Avenue WWTP. These open water subtypes may contain some narrow bands of vegetation around the edges, but are generally unvegetated.

3.4.2.6.2 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. 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. Amphibians, turtles and garter snakes are likely to be common in some of the open water habitats.

3.4.2.6.3 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 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 and submergent

aquatic 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).

3.4.2.7 Parks and Recreation Areas

3.4.2.7.1 Vegetation

Parks and recreation areas occupy one percent of the study area and include turf-covered lands used for activities such as golf and other recreation activities. These areas generally contain nonnative ornamental trees and shrubs.

3.4.2.7.2 Wildlife

Parks and recreation areas, as they occur in the 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 man-made ponds may support waterfowl. 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.

3.4.2.8 River Bottom

3.4.2.8.1 Vegetation

The river bottom cover type was located in less than one percent of the total project study area. This cover type is largely unvegetated, and is characterized by cobble in the active channel of Salt River.

3.4.2.8.2 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 flows recede during spring or summer. These small fish and tadpoles are prey for water birds (e.g., herons, egrets, and gulls), raccoons, skunks and aquatic snakes.

Quailbush is found in the river bottom habitat. It 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 association with habitats of sand/gravel operations.

3.4.2.9 Scrub-Shrublands

3.4.2.9.1 Vegetation

Scrub-shrublands are common and are present within the active channel of the river occupying 12 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 OHV traffic and gravel mining activities, and contain little or no vegetation cover. If the total vegetation cover was less than ten percent, the area was mapped as unvegetated river bottom. If water was present, it was mapped as low flow channel.

3.4.2.9.2 Wildlife

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.

3.4.2.10 Sand/Gravel Operations

3.4.2.10.1 Vegetation

Sand/gravel operations are common in the project study area, occupying 11 percent 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 operations are characterized by a large amount of disturbance in the active channel, vegetation is mostly lacking. However, mostly weedy non-native species that tend to colonize quickly after disturbance may be present.

3.4.2.10.2 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 association with river bottom habitat.

3.4.2.11 Upland Buffer Zone

3.4.2.11.1 Vegetation

The upland buffer zone is uncommon in the study area, occupying only five percent of the area. It is characterized by a mixture of non-native and native species on the upper terraces and floodplain of the river. The presence of the upland buffer zone is highly variable, depending on the level of disturbance from urban, industrial and agricultural uses. Typical species associated with this zone include mesquite, rabbitbush, acacia, paloverde, creosote, salt cedar and tree tobacco.

3.4.2.11.2 Wildlife

Although the upland buffer zone area supports good plant diversity and structure, it offers only low to moderate wildlife value due to its small area and its proximity to disturbed habitats.

3.4.2.12 Urban Areas

3.4.2.12.1 Vegetation

Urban areas are the most common land use in the project study area, occupying 34 percent of the total area. Major land uses in this type include residential, commercial and industrial developments. Vegetation in urban areas is generally dominated by non-native ornamental plants and small patches of turf.

3.4.2.12.2 Wildlife

Urban areas make up one-third of the available wildlife habitat within the project study area. This habitat has low wildlife value because it provides 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.

3.4.2.13 Ruderal Areas

3.4.2.13.1 Vegetation

Ruderal areas are common in the project study area, occupying six percent 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 and non-native shrubs including Russian thistle, saltbush, creosote, and burrobush.

3.4.2.13.2 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, the 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 owl habitat, have made it increasingly uncommon in Maricopa County (Witzeman et al., 1997). No burrowing owls are known to be present within the project implementation area.

3.4.3 SPECIAL-STATUS SPECIES

Species included on federal or state (or, in some cases, county or local) listings for the purpose of regulatory consideration are collectively referred to as special status species. For the Rio Salado Oeste feasibility study, special-status species are those animals in the following categories:

- Animals listed or proposed for listing as Threatened or 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), and;
- Wildlife of Special Concern (WSC) to the Arizona Game and Fish Department (AGFD, 1996)

The US Fish and Wildlife Service (FWS) defines an Endangered Species as an animal or plant species in danger of extinction throughout all or a significant portion of its range. A Threatened Species is an animal or plant species likely to become Endangered within the foreseeable future throughout all or a significant portion of its range. Finally, a Candidate Species is a plant or animal species for which the USFWS, or the National Oceanic and Atmospheric Administration - Fisheries (NOAA Fisheries, or National Marine Fisheries Service), has on file sufficient information on biological vulnerability and threats to support a proposal to list as Endangered or Threatened. When the Arizona Game and Fish Department (AGFD) formally classifies a species as Wildlife of Special Concern (WSC), known threats and documented population declines are the most important factors considered. Potential threats and perceived declines also receive consideration (AGFD, 1996).

The U.S. Army Corps of Engineers (Corps) has coordinated with the U.S. Fish and Wildlife Service (FWS) and the Arizona Game and Fish Department (AGFD) pursuant to the Fish and Wildlife Coordination Act (FWCA). As part of this coordination, the FWS provided a Planning Aid Letter on June 21, 2002, and a Coordination Act Report on June 20, 2005. These documents provide recommendations for alternative formulation and future OMRR&R activities, and state that the FWS is unaware of any federally listed Threatened or Endangered species within the project area.

The Corps received a Section 7 concurrence letter stating the US FWS concurs with the findings that this project may affect, but is not likely to adversely affect any of the species of concern. The purpose of the Section 7 consultation is to ensure that proposed actions are not likely to jeopardize the continued existence of listed species, or result in destruction or adverse modification of critical habitat. No critical habitat has been designated in the study area. In addition, no special-status plants (other than protected native plants) or fish have been recorded in or are expected to occur in the study area. Protocol surveys for federally Threatened and Endangered species, as well as WSC, would be conducted prior to project construction if they are warranted. The scientific and common names of plants and wildlife discussed in this section are listed in Appendix B.

There are ten special-status species with the potential to occur in the study area: the lowland leopard frog, desert tortoise, Mexican garter snake, bald eagle, Yuma clapper rail, southwestern willow flycatcher, western yellow-billed cuckoo, cactus ferruginous pygmy owl, American peregrine falcon, and the lesser long-nosed bat. All ten of these special status species are considered to be WSC by AGFD. The bald eagle, Yuma clapper rail, southwestern willow flycatcher, cactus ferruginous pygmy owl, and lesser long-nosed bat are also federally listed. The federal and state status for each of these species is summarized on Table 3.4-2.

Aside from an occasional visit by a migrating or foraging bald eagle, no special-status species have been recorded in the study area (CH2M HILL et al., 1997). The following discussions and Table 3.4-2 summarize the habitat requirements and distribution of the ten special-status wildlife species that could potentially occur in the study area.

3.4.3.1 Lowland Leopard Frog

The lowland leopard frog has no federal listing, but is included on the draft review list of WSC in Arizona (AGFD, 1996). This amphibian occurs below 5,500 feet in elevation, south and west of the Mogollon Rim (AGFD, 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 has probably declined for a variety of reasons, including predation and competition from non-native fish and amphibians, and from stream alteration and flow diversion (AGFD, 1988; AGFD, 1996).

3.4.3.2 Desert Tortoise

The Sonoran Desert population of the desert tortoise has no federal listing, but is included on the draft review list of WSC in Arizona (AGFD, 1996). This tortoise inhabits much of southwestern and south central Arizona's Sonoran Desert, principally in rocky foothills and less often on lower bajadas and in semidesert grassland. Sonoran Desert populations in the Tucson and Phoenix areas have declined because of urban and agricultural development, road construction, wildfires, illegal collection, and use of off-road vehicles in unauthorized areas (AGFD, 1996).

3.4.3.3 Mexican Garter Snake

On January 4, 2006, the U.S. Fish and Wildlife Service announced that a petition to list the Mexican garter snake as Threatened or Endangered under the Endangered Species Act may be warranted (FR Vol. 71, No. 2: pp 315 – 324). As a result, the agency is initiating a status review to determine if the Mexican garter snake should be proposed for listing. This review includes a 60-day public comment period to allow all interested parties the opportunity to provide information on the status of this species throughout its range. The Mexican garter snake is already included on the draft review list of WSC in Arizona (AGFD, 1996). 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 (AGFD, 1996).

3.4.3.4 Bald Eagle

The bald eagle was federally listed as Endangered on March 11, 1967, and then reclassified to threatened on July 12, 1995 (60 FR 35999). No critical habitat has been established. The bald eagle has been proposed but not finalized for delisting on July 06, 1999 (50 CFR Section 17). This species is also on the draft review list of wildlife of special concern (WSC) in Arizona (AGFD, 1996). Bald eagles are currently found in all Arizona counties. Bald eagles nest in large trees near lakes and streams, and hunt for waterfowl and fish in wetlands and along rivers and lakes. In Arizona, a small resident population of approximately 40 pairs nests along the Salt, Verde, Gila, Bill Williams, Agua Fria, San Pedro, and San Francisco Rivers, and Tonto and Canyon Creeks. There are at least 200 to 300 individuals that winter throughout the state each year.

Bald eagles have been reported nesting along Salt River east of Phoenix since the 1930s (Witzeman et al., 1997). Bald eagles do not nest in the study area as here is a general lack of suitable nesting trees. However, 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 study area (CH2M HILL et al., 1997). The open water marsh in the study area may be suitable foraging habitat for bald eagles. Restoration of cottonwood/willow gallery forest may eventually provide suitable nesting habitat for bald eagle.

3.4.3.5 Yuma Clapper Rail

The Yuma clapper rail was federally listed as Endangered on March 11, 1967 (32 FR 4001) without critical habitat designation. The Yuma clapper rail is also on the draft review list of WSC in Arizona (AGFD, 1996). This inland clapper rail requires a wet substrate, such as a mudflat, sandbar, or slough bottom that supports cattail and bulrush stands of moderate to high density adjacent to shorelines (USFWS, 2002). It occurs in cattail, sedge, and bulrush marshes along the Colorado River, the lower Gila and Salt Rivers below the Verde/Salt River confluence, and Pichacho Reservoir (AGFD, 1996; Edelman 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 (AGFD, 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). However, the habitat within the study area is ephemeral, scarce and insufficient habitat for this species to occur. If suitable habitat develops in the project area prior to construction, protocol surveys will be conducted and consultation reinitiated, if necessary. Restoration of the river channel and associated wetlands (190 acres) throughout the project area should provide suitable habitat for the Yuma clapper rail in the future.

3.4.3.6 Southwestern Willow Flycatcher

The southwestern willow flycatcher was federally listed as Endangered on February 27, 1995 (60 FR 10693). Critical habitat designations were made on July 22, 1997 (62 FR 39129), August 20, 1997 (62 FR 44228), and October 19, 2005 (50 CFR 60886). A recovery plan was completed on August 30, 2002. This Neotropical migrant is also on the draft review list of WSC in Arizona (AGFD, 1996). The breeding range for this species includes southern California, Arizona, New Mexico, southern Utah, southern Nevada, far western Texas, perhaps southwestern Colorado, and extreme northwestern Mexico (USFWS, 1995). Wintering grounds are in Central and South America. The willow flycatcher prefers nesting in dense willow riparian habitats, and is also found in areas of salt cedar 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 willow flycatcher nested along 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 damage reduction projects, development, and intensive grazing. Brown-headed cowbird nest parasitism may also have contributed to the species' decline (AGFD, 1996). This species is currently considered an uncommon transient in Maricopa County, with only a few historic summer records (Witzeman et al., 1997). While the study area has approximately 130 acres classified as cottonwood/willow and salt cedar habitat. While up to 110 acres may be modified with project construction, much of that has all ready been scoured by flooding in 2005 or cleared by private activities in recent months. Remaining stands of vegetation are largely immature and not tall or dense enough to be suitable habitat for willow flycatcher. However, should habitat become suitable prior to construction, protocol surveys will be conducted and consultation reinitiated if necessary. The proposed project will increase the cottonwood/willow habitat by approximately 375 acres, potentially resulting in the establishment of suitable habitat.

3.4.3.7 Western Yellow-billed Cuckoo

The western yellow-billed cuckoo is federally listed as a Candidate species for addition to the list of Threatenend and Endangered species (66 FR 38611, July 25, 2001). This bird is also included on the draft review list of WSC in Arizona (AGFD, 1996). 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 (AGFD, 2001b). This species has declined due to degradation and loss of mature riparian habitat within its range. The western yellow-billed cuckoo is considered an uncommon local summer resident (Witzeman et al., 1997).

3.4.3.8 Cactus Ferruginous Pygmy Owl

The cactus ferruginous pygmy-owl was federally listed as Endangered on March 10, 1997 (62 FR 10730), and critical habitat was designated on July 12, 1999 (64 FR 37419) and November 27, 2002 (67 FR 7102). This owl is also on the draft review list of WSC in Arizona (AGFD, 1996). Historically, the cactus ferruginous pygmy owl occurred as far north as the confluence of Salt and Verde Rivers. This species occurs in desert scrub, mesquite bosques, and Sonoran riparian deciduous woodland areas with mature cottonwoods 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 (AGFD, 1996; AGFD, 2001a). Areas of recent occupancy include xeric riparian washes in Organ Pipe Cactus National Monument, riparian forests of the lower San Pedro River, and saguaro forests near Tucson (AGFD, 1996).

3.4.3.9 American Peregrine Falcon

The American peregrine falcon was federally listed as Endangered or Threatened before being removed from the endangered species list (delisted) on August 25, 1999 (64 FR 46541). This falcon remains on the draft review list of WSC in Arizona (AGFD, 1996). The 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 falcons 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 (AGFD, 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 study area (Phillips et al., 1964; Witzeman et al., 1997).

3.4.3.10 Lesser Long-Nosed Bat

The lesser long-nosed bat was federally listed as Endangered on September 30, 1988 (53 FR 38456). 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 (AGFD, 1996). There are records for this species from the Phoenix area, so it could potentially occur in the study area.

Table 3.4-2. Special Status Species that may occur in the Rio Salado Oeste project area.

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Lowland leopard frog (*Rana yavapaiensis*)	--/WSC	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 study area is in the lowland species' geographic range. Areas along the Salt and Rivers appears to be suitable habitat; no recent records.
Desert tortoise (*Gopherus [=Xerobates] agassizii*)	--/WSC	Occurs across much of Arizona's Sonoran Desert, including the Phoenix area.	Desert areas 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.	Not likely to occur in the study area due to marginal habitat and presence of factors that have caused its decline.
Mexican garter snake (*Thamnophis eques megalops*)	--/WSC	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; not likely to occur in the study area due to presence of factors that have caused its decline.
Bald eagle (*Haliaeetus leucocephalus*)	T/WSC	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 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 study area are suitable foraging habitats.

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
Yuma clapper rail (*Rallus longirostris yumanensis*)	E/WSC	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.	The Salt River supports suitable habitat; known to occur in areas of suitable habitat along the Gila River.
Southwestern willow flycatcher (*Empidonax trailii extimus*)	E/WSC	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 damage reduction 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*)	C/WSC	Summer resident only in central and southern Arizona.	Nests in mature cottonwood/willow riparian forests; salt cedar 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/WSC	Historically occurred as far north as the confluence of the Salt and Verde Rivers.	Occurs in desert 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.	Once fairly common in south central Arizona; only recent records are from Organ Pipe Cactus National Monument, near Ajo, and suburban Tucson. Not likely to occur in the study area due to disturbance and lack of suitable habitat.

Species	Status* Federal/State	Arizona Distribution	Habitat Requirements	Reasons for Decline	Potential for Occurrence in the Study Area
American Peregrine Falcon (*Falco peregrinus anatum*)	--/WSC	Nearly global distribution; Breeds in Arizona where sufficient prey is available near cliffs, such as the Mogollon Rim and the Grand Canyon.	Optimum habitat consists of cliffs overlooking habitats with abundant bird life, such as woodlands and riparian areas. Suboptimal habitat consists of smaller cliffs in ponderosa pine forest, or large cliffs in xeric areas.	Declined in the 1950s and 1960s and the rest of the U.S. due to DDT contamination. Increased development forced the peregrine falcon to nest in sub-optimal habitat.	Low potential to occur in study area except while migrating. Tall buildings are occasionally used as nesting sites. If this were to occur in downtown Phoenix, it could increase the potential for this species to utilize the study area.
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)	E/WSC	Summer resident of central and southeastern Arizona; a few late-summer records of immature individuals from the Phoenix area.	Roosts colonially in large numbers; feeds on agave and saguaro flower nectar and pollen. Unable to withstand cold weather; migrates to Mexico each fall.	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 study area; no systematic surveys have been conducted in the 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.

C = listed as a Candidate species under the federal Endangered Species Act.

-- = no listing.

State

WSC = Wildlife of Special Concern in Arizona (Arizona Game & Fish Department, or AGFD)

3.5 CULTURAL RESOURCES

3.5.1 REGULATORY SETTING

3.5.1.1 National Historic Preservation Act

For federal undertakings, in compliance with the National Historic Preservation Act (NHPA - Public Law 89-665; 16 U.S.C. 470-470m, as amended, 16 U.S.C. 460b, 470l-470n), cultural resources are located using two principal methods. Before starting a project, a records and literature search is conducted at repositories of archeological site records. The search may show that an archaeological or historical survey has been conducted in the project area and that cultural resources have been identified. That information may be enough to proceed with the significance evaluation stage of the project. If no previous survey has been done, or if a previous survey was either out of date or inadequate, a pedestrian survey of the ground surface within the proposed project boundaries may be conducted. Subsurface testing may also be performed if deemed appropriate by the cultural resources professional.

After a cultural resource(s) has been identified during a survey or record and literature search, the federal agency overseeing the undertaking proceeds to determine whether 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 located at 36 CFR 800.2(c)-(d). 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. 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.

3.5.1.2 American Indian Religious Freedom Act of 1978

Public Law 95-341; 42 U.S.C. 1966., the American Indian Religious Freedom Act, may also apply to the project. This law makes it policy of the federal government to protect and preserve the inherent rights of American Indians, Eskimos, Aleuts, and Native Hawaiians 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 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.

3.5.1.3 Native American Graves Protection and Repatriation Act of 1990

Public Law 101-601, 25 U.S.C. 3001 et seq. , the Native American Grave Protection and Repatriation Act, 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.

3.5.2 PREHISTORY

3.5.2.1 Paleo-Indian and Archaic

Thus far, there are no known Paleo-Indian sites in the Phoenix Basin or surrounding environs. Little is known of the archaic occupation of the area, but newly acquired excavation data is becoming available. The current construction boom in Scottsdale has required new surveys, which in turn has prompted excavation of previously unknown archaic sites. Presently, much of that information is locked up in unpublished, possibly proprietary reports.

Ongoing archeological and geomorphic surveys on the Gila River Indian Reservation have uncovered discrete Archaic features and occasional diagnostic Archaic projectile points. Site AZ T:11:94(ASM) in the Tres Rios project area may have Archaic components (Onken, 2005). Sufficient knowledge to quantify or characterize the archaic sequence is still quite scarce (Mike Waters and Robert Neily, pers. comm.., 1999). Additional Archaic sites will assuredly be discovered, but in the meantime, they are buried beneath a thick mantle of Gila River alluvium.

3.5.2.2 Hohokam

The principal prehistoric cultural manifestation in the project area is the Hohokam culture. Hohokam is a Pima word that means "those who have gone" (Gladwin and Gladwin, 1933), or more poetically, "those who have vanished" (Wormington, 1973). The name Hohokam has

endured and is still the preferred name in spite of some other prehistoric cultures being renamed. The four southern O'odham tribes crafted a policy statement that stated, "We recognized Indian Tribes have mutually agreed to promote and protect the archaeological artifacts and remains of our ancestors, the Hohokam..." (SRPMIC, 1989). The earliest investigations into the Hohokam probably began with Frank Hamilton Cushing's work at Los Muertos in 1887 and 1888, in what was to become the City of Tempe (Gumerman, 1991). The bulk of the effort expended toward defining the Hohokam came from the work of Harold and Winifred Gladwin, and Emil W. Haury of the Gila Pueblo Archaeological Foundation in Globe.

After accumulating five years of knowledge from excavating at Casa Grande, combined with their detailed stratigraphic analyses, the Gladwins formulated the basis for a ceramic sequence and sketchy ideas for a Hohokam culture history. The concept of the Hohokam as a unique southwestern culture was first proposed in the Gladwins' (1933) paper on ceramics. The archeological community finally accepted the Hohokam culture concept after publication of Excavations at Snaketown: Material Culture (Gladwin et al., 1937). Until then, Frank H. H. Roberts (1935) considered the idea of the Hohokam as a separate culture to be a "bunch of hokum."

Throughout the 1940s, Harold Gladwin continued to tinker with the 1937 chronology that had been developed at Snaketown (Doyel, 1986: 202-204; Gumerman and Haury, 1979). Among other issues, Gladwin developed irreconcilable differences with the temporal/cultural placement of the Pioneer Period. Gladwin (1942) was critical of the phase sequence at Snaketown and published a rebuttal of sorts. He posited that Haury's work on chronology was incorrect and he continued to revise the chronology until it was virtually unintelligible (Doyel, 1986).

To clarify the problems surrounding Hohokam origins, Haury decided that a return to Snaketown was in order. In the winter of 1964-1965, Haury revisited Snaketown to verify the accuracy of his original chronology. In addition to fine tuning the chronology, Haury also surmised that the Hohokam were not derived from the Cochise base. Instead, he ended up agreeing with Gladwin, DiPeso, and Schroeder that the Hohokam were migrants from Mexico. However, he stuck to his argument that the Pioneer Period began at about 300 B.C (Doyel, 1986). Later research concluded that the Pioneer period was rooted in the Archaic Period.

As with all chronological systems, there always seems to be dissention. This is usually because various researchers have data suggesting a localized variant on a chronological scheme, or they are advancing their own ideas. Others, however, are content to use Haury's system (Holly Young, pers. comm., 1999). Hohokam research in the 1980s took a different look at the origin, and the temporal placement of the phases within the Pioneer period.

After considerable deliberation, Dean developed a chronology for the Phoenix Basin that has become the basis for the prevailing sequence. He disavowed the viability of the Polvoron phase because its "provisional" place in the sequence was based on one valid date (Dean, 1991:87). Deaver (1997: 459) developed a concordance of chronological sequences showing the geographic and temporal variation for the various centers of the Hohokam culture. He included the Polvoron phase in the sequence for the Phoenix Basin. Deaver's Phoenix Basin sequence is based on Haury's 1976 chronology, refined by Dean (1991), with the Polvoron phase added.

Even though the Polvoron phase is still controversial (Deaver, 1997), there appears to be a consensus for the Polvoron phase as a cultural manifestation. However, the disagreement is generally based on the temporal placement of the phase (Owen Lindauer, pers. comm., 1999).

Under Haury's system (1976), the five Hohokam cultural periods (Pioneer, Colonial, Sedentary, Classic, and Post-Classic) were broken down into nine developmental phases. Three problems that persist with the cultural periods involve questions of when and why they began and why they ended. Two phases were added to hopefully address these problems: Red Mountain, which identified the Archaic-Pioneer Transition; and Polvoron, the final Post-Classic phase. As of 1997, the Polvoron was still a controversial phase (Deaver, 1997:463). Dean (1991:62) restates the existing problems with Hohokam chronology. He agrees that there are few problems of concurrence on the sequence of phases and dating of the Colonial-Sedentary and Sedentary-Classic transitions. Dean continues to say that there is still considerable disagreement with phase dates, particularly in Pioneer and Colonial periods, and the beginning and termination of the Hohokam expression. He concluded that, "given these circumstances, it can be seen that a rather uncertain foundation underlies any effort to evaluate the Hohokam chronology." However, since Dean completed his analysis, major advances in refining Hohokam chronology have been made (Richard Ciolek-Torello, pers. comm., 1999).

Rather than a full description of the chronology of the Hohokam; ethnohistory and ethnography; history; and Previous Work in the Area, as part of this report, please see *The Tres Rios Survey: An Archeological Survey of 700 Acres for the Proposed Tres Rios, Arizona Feasibility Study, Maricopa County* (McLean and Perry, 2002) for a complete discussion. A Bibliography is also included for additional information.

3.5.3 ETHNOHISTORY AND ETHNOGRAPHY

The Gila River Indian Community (Reservation) is located immediately south of the Salt River. The Gila River bisects the Reservation before its confluence with the Salt River at its northwest corner. Familiarly known as the Pima, the residents prefer their traditional name, Akimel O'odham, meaning the River People. The suffix O'odham means "we the people" (Fontana, 1983). Akimel refers to their inhabiting a riverine environment. Their cultural counterparts, the Tohono O'odham, are the Desert People. Remove the upper case "O" from "O'odham" and the term odham is singular (Barnaby V. Lewis, pers. comm., 1999). They originated in the Salt River Valley, then moved south into the Gila River Valley (Swanton, 1969 [1953]). The O'odham were called Pimas Altos, or upper Pima Indians, by the Spanish to distinguish them from their southern relatives in lower Sonora. The term Pima was used when Ezell (1983) wrote his history of the O'odham. However, since O'odham is preferred, this term will be used here.

There has been a longstanding, unresolved question regarding the lineal relationship between the O'odham and the Hohokam. The question is not with the contemporary O'odham who clearly see themselves as direct descendents. Archeologically, that is another issue because a link has not been firmly demonstrated. Paul Ezell (1983) offered arguments both ways. Haury (1976) wrote that "to assert that there was no connection between the Pima people and the Hohokam requires the removal of the latter from the area by about A.D. 1450 and the introduction of the Pimas with an impressively similar lifeway almost immediately." Verifying the relationship

between the Hohokam and the O'odham is not currently a major research issue. Undoubtedly, someone will find a site that will bridge the gap and finally answer the question archeologically.

The early O'odham were organized around a patrilineal extended family system. Family members included the parents, married sons, and unmarried daughters. Families belonged to clans that were broken down further into moieties. Clans held something of a legitimizing function in the culture. Because they were a patrilineal culture, children of non-O'odham fathers were not accorded clan membership. Marriage was very informal; the couple simply moved in together. Divorces were also subject to the same lack of ceremony. They also had marriage rules that governed incest avoidance. The couple had to be separated by at least five generations.

Even under Spanish colonial rule, the Gila River Indians, known as GileZo's, enjoyed something of a privileged position (Ezell, 1983). This privilege was a result of several factors. They were cultivators as opposed to collectors and were thus considered to be productive. While some of the Gila Pimas took part in the revolt of 1843, the followers of Culo Azul stayed out of the fray and thus were considered loyal to the Spanish. The closest Spanish outpost was in Tucson at San Xavier del Bac, so their presence was very understated. They were able to control their lands because of the assumption that they would easily be incorporated into the Spanish or later Mexican, commonwealth (Ezell, 1983:153). Land titles were issued and following the Gadsden Purchase in 1853, the O'odham demonstrated clear Spanish title to their lands.

Neighboring Apaches and Yavapai stepped up attacks on the wealthy O'odham villages. This caused the normally peaceful O'odham to develop a militaristic society. The O'odham changed their raiding strategy from vengeance raids to Spanish-styled offensive incursions. Prowess in battle became honored and the further movement toward a war-oriented culture became quite evident.

Due to the requirements of intensified agriculture and increased raiding by the Apaches and Yavapai, the settlement patterns became denser. By necessity, this caused the further coordination and formalization of the society. Village autonomy suffered because the office of hereditary, paramount chief was established. Culo Azul, who claimed the role of governor, forced this change in political power. Pressure from Apaches was the catalyst that caused the push toward complex political organization and irrigation management (Hackenburg, 1983 citing Drucker, 1941). By the end of the Hispanic period, the O'odham were formally considered a "nation." The Spanish, Mexicans, and Anglo-Americans easily acknowledged this designation.

For a brief 15-year period, it appeared that the economic times had changed for the O'odham. A very wet period, "the wettest conditions in many centuries" (Hackenburg, 1983) lasted from 1905 until 1920. However, 40 years of extreme drought followed, wiping out all the gains they had recently made. Unfortunately, problems that arose in this debilitating 40-year period persisted until the 1980s, and only now are close to rectification with a new Bureau of Reclamation sponsored irrigation project. The Pima-Maricopa Irrigation Project is only in the early stages of implementation, with the preliminary archeological surveys now underway (Gila River Indian Community, 1998).

Table 3.5-1. Hohokam Chronology for the Phoenix Basin

Hohokam Chronology for the Phoenix Basin

	Conventional Periods and Subdivisions		Ceramic Markers	Phoenix Basin Phase Sequence
A.D. 1450?	Post-Classic			Polvoron
	Classic	Late	Gila Polychrome	Civano
		Early	Casa Grande R/B Smudged Red Wares	Soho
A.D. 1150	Sedentary	Late Middle Early	Sacaton R/B	Sacaton
	Colonial	Late	Santa Cruz R/B	Santa Cruz
A.D. 900		Early	Gila Butte R/B	Gila Butte
	Pioneer	Late	Snaketown R/B	Snaketown
A.D. 700		Middle	Sweetwater R/G	Sweetwater
A.D. 400			Estrella R/G	Estrella
		Early	Red Ware	Vahki
			Plain Ware	Red Mountain
A.D. 1				

Source: Deaver 1997:459

3.5.4 HISTORY

The potential value of the Salt River was realized when, in 1867, John W. "Jack" Swilling first ventured from Wickenburg to John Y. T. Smith's Hay Station, approximately four miles from present day Phoenix (Granger, 1960). Without a doubt, one of the more colorful people in Arizona's history, Swilling had compiled quite an impressive resume after arriving in Yuma in 1858.

In 1867, as a farmer visiting Smith's Hay Station, he observed the long, low earthen ridges radiating out from the Salt River and concluded that these were the remnants of a long forgotten irrigation system (Salt River Project [SRP], 1979; Myers, 1961). This observation prompted him to envision the irrigation potential of the Salt River. Swilling, together with Henry Wickenburg (formerly Heinrich Heintzel), discoverer of the extremely rich Vulture Gold Mine and founder of

Wickenburg, and Yuma Ferryman Louis J. F. Jaeger, started the Swilling Irrigating and Canal Company. Jack Swilling's vision resulted in the growth of Phoenix.

One of the workers hired to begin digging the first canal was the well-schooled Englishman and possible British Army deserter, Lord Bryan Philip Darrel Duppa (Granger, 1960). The impetus to actually begin work on the canal probably was with the erudite Duppa's pronouncement that a canal could be created when he commented, "of course it's feasible. I've seen it done in Persia" (Myers, 1961). Swilling's fledgling company was incorporated in Prescott and officially opened for business on December 10, 1867.

The original canal, located in Hayden's Ferry, was Swilling's first effort to reopen a prehistoric Hohokam canal. But, he quit after hitting caliche and bedrock. Undaunted, he shifted his operation four miles downstream to another location just east of modern 40th Street (SRP, 1979). This second attempt was successful and became known as the Salt River Valley Canal. It was completed on April 5, 1868 (Myers, 1961; Carlin, 1981) for the meager sum of $400.00 (Horton, 1941:65).

Other canals followed Swilling's Ditch, developing the agricultural potential of the Salt River Basin. The Maricopa Canal was completed in 1869, the Arizona Canal in 1887, and the Highlands Canal was constructed in 1888. The early canals were beset by their own problems stemming from Salt River floodwaters. Flooding washed out the diversion dams, leaving the head gates high and dry and rendering them useless (Walker and Bufkin, 1986). A number of the historic canals were reconstructed from the old Hohokam canals. The only functional difference between the Hohokam and modern canals is the lack of drop structures and drainage canals in the Hohokam systems according to Nials and Gregory (1989). Nials and Gregory compiled a list of the prehistoric canals and the historic counterparts (1989:45, Table 3.5-2) based on Turney's research (1929:51-52).

Table 3.5-2. Prehistoric Canals and Their Historic Counterparts

Prehistoric Canal System	Historic Equivalent
One	Tempe
Two	Grand (Swilling's first attempt)
Three	Ditch to Maricopa Reservation
Five	Dutch
Six	Farmers
Seven	Hayden and San Francisco
Twelve	St. John's

Source: Nials and Gregory, 1989, adapted from Turney, 1929

The Swilling Irrigation Canal Company moved its headquarters from Tempe back to Smith's Station. But the necessity to have an address for supply deliveries prompted the group to find a more identifiable name (Granger, 1960). In honor of his confederate heritage, Swilling

suggested Stonewall. Another trial name was Salina. That was voted down because of the implications that the area was a salt marsh. The final selection was Duppa's who was mindful of the group's efforts to reopen the Hohokam canal, and had been reverentially impressed with the Hohokam's engineering skills. While clearing the old canal, Duppa expected that the Hohokam were able to set a proper gradient. During construction of the new canal, Duppa had quipped to Swilling, "I'm counting on them, though it's hard to see how they did it without a logarithm in their breech clouts" (Myers, 1961).

Duppa foresaw a new city as a Phoenix rising from the ashes of the old civilization. He is credited with giving the valley its name by declaring..."As the mythical phoenix rose reborn from its ashes, so shall a great civilization rise here in the ashes of a past civilization. I name thee Phoenix." Duppa is also quoted with a different version of his famous proclamation (Horton, 1941:15). Alternatively he may have said "A new city shall spring Phoenix-like upon the ruins of a former civilization." In any event, Phoenix became the new town's name.
By 1871, Phoenix was an official town. The number of townspeople had risen to 300, a far cry from the old Smith Hay Station: population 1. All the original lots had been sold and the town was formally mapped. Phoenix was one-mile-long, one-half-mile-wide, and encompassed 96 blocks. Washington Street was the first main street running east west. The Salt River Valley Post Office was moved to Phoenix, and the first County election was held. In 1872, the 320 acre Townsite of Phoenix was officially filed in Prescott.

In 1877, the newly incorporated Sacramento Canal Company (SCC) drew 10,000 miner's inches of water from the north side of the Salt River, 7.5 miles east of the Agua Fria River. The SCC canal was ten miles long comparable to the Farmers Canal also on the north side of the Salt River and eight miles to the east. Lowendorf (n.d.) noted that the head of the SCC canal was probably between today's 75th and 83rd Avenues. After further analysis, Lowendorf concluded that the SCC canal was probably a reopened Hohokam Canal that was affiliated with the nearby Hohokam site at Cashion. Both Omar Turney and Frank Midvale had identified a prehistoric feature at the site of the head of the SCC canal.

W. H. St. John and three colleagues constructed the 12-mile-long old St. Johns Canal near the present project area in Cashion in 1887. The canal's head was near where 83rd Avenue is located. By 1907, apparently all the other canals had disappeared. Surveyors for the Salt River Project (SRP) had mapped the area and the old St Johns Canal was the only one shown. An article in the Phoenix Herald in 1887 (Lowendorf, n.d.) drew attention to the new canal. An unnamed columnist wrote that four men, A. B. Smallwood, W. H. St. John, H. Warren, and Dan Martin had been working for a month on a new canal on the Salt River. The canal was designed to carry 5,000 miners inches of water and irrigate a 40 square mile area. The canal will be diverted on the Agua Fria near Yuma Road at a point where a "reef of rocks" provided a steady flow of water. According to Lowendorf (n.d.), other canals including the prehistoric Cashion Canal were probably dug in the same area.

Due to changing times, possibly associated with all the dams on the Salt and Verde Rivers drying up its water source, the old St. Johns Canal ceased to exist (Lowendorf, n.d.). In its place is the modern St. Johns Canal, which is fed from a well. The modern canal runs parallel to Southern Avenue for four miles and stops about one-half mile past its intersection with Dysart Road.

3.5.5 PREVIOUS WORK IN STUDY AREA

The earliest known archaeological work in the vicinity of the Rio Salado Oeste project involved Adolph Bandelier's and Frank Cushing's studies in the 1880s of Pueblo Grande approximately 15 miles to the east (Downum and Bostwick, 1993:17-21) and investigations of the prehistoric Hohokam canals (Hodge, 1893; Patrick, 1903).

The eastern portion of Cashion Ruin was recorded by Frank Midvale in 1923. Turney documented the western portion of Cashion Ruin in 1925 with updates in 1929 and 1935. Cashion Ruin was recorded again and trenched in 1939 by Audie R. Kelley as part of the Salt River Valley Stratigraphic Survey financed by the U.S. Works Progress Administration and headquartered at Pueblo Grande Museum under Director Odd Halseth (Downum and Bostwick, 1993:212-220).

Glen Rice (pers. comm., 1999) said that Midvale's Canal Cashion may not have actually been a canal, and that Midvale's site map was south of the site's actual location. During the Museum of Northern Arizona's (MNA) excavation of the Cashion Site, Antieau (1981) noted that he was unable to locate either the Canal Cashion or three Casa Grande type ballcourts, probably due to this locational error. Midvale mapped all the ruins in the Palo Verde project area right-of-way in 1967 and in some cases corrected Turney's locations (cf. Legend on Midvale's' map of the Cashion ruins in Antieau (1981:42). Antieau's excavations verified that Turney was in fact correct and Midvale was incorrect (Antieau, 1978).

Following Turney, Frank Midvale developed an interest in prehistoric irrigation and spent the 1920s, 30s, and 60s investigating every lead he could in an attempt to retrace the flow of irrigation water through the Salt-Gila Basin (Antieau, 1981:8). He had also mapped the five sites that were excavated by the MNA for the Palo Verde Nuclear Generating Station Wastewater Conveyance System (PVNGSWCS).

The Cashion site, NA 14690, was excavated by the MNA in 1977 and 1978 (Antieau, 1981). Midvale originally mapped the Cashion site in 1927 when he called it Los Conejos (Antieau, 1981:144). Estimated to cover approximately 640 acres, the Cashion site was listed on the National Register of Historic Places on December 19, 1978 (reference No. 78000547). It is the largest site excavated near the confluence of the Salt and Gila Rivers, one of the largest and the most complex in the Salt-Gila River Valley (Stein 1977), and equals Snaketown in size (Antieau, 1981). Encompassing dates from A.D. 500 - 1150, the Cashion site was occupied from the Pioneer through the Classic Periods (Stein, 1977; Antieau, 1981). By the end of the Classic Period, Cashion was largely abandoned.

3.5.6 RECORDS AND LITERATURE SEARCH

For the purposes of the record and literature investigation, the following description was used. The study area is approximately eight miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Baseline Road on the south. The project implementation area extends from 19th Avenue on the east to 83rd Avenue on the

west, and is the area within the 100-year floodplain of the Salt River. The project Area of Potential Effect (APE) is on average approximately two-thirds of a mile wide and consists of approximately 3,315 acres.

A literature search of the proposed project area was performed through the Arizona State Museum, Arizona State Office of Historic Preservation, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed the APE.

3.5.7 RECOMMENDATIONS

Geoarchaeological investigations were conducted for the Tres Rios project (Onken et al., 2005), which provide a very good reconstruction of the floodplain history just west (downstream) of the Rio Salado Oeste study area, at the junction of the Salt and Agua Fria Rivers with the Gila River. The results of the Tres Rios geomorphological investigation suggest that 94 percent of that project area has no or low sensitivity for buried prehistoric sites.

Given Rio Salado Oeste's study area location upstream of Tres Rios, it is reasonable to conclude that the alluvial stratigraphy of the lower Salt River might be comparable. The entire length of the Salt River within the Oeste study area boundary appears to have been more disturbed than areas downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys would be conducted as necessary during the design phase.

A letter was sent to the Arizona State Historic Preservation Officer (SHPO) on July 6, 2005, with our determinations in accordance with 36 CFR 800.4(d). The SHPO provided a response in a letter dated August 10, 2005. This letter concurred with the APE as described in Section 3.5.6 above. The SHPO requested a written report of the survey conducted by Corps personnel. A Memorandum of Record (MFR) was completed describing the survey conducted in March, 2004. Copies of all these documents can be found in Appendix N of the Feasibility Report. The Rio Salado Oeste project is in compliance with Section 106 (36 CFR 800) of the National Historic Preservation Act (NHPA – Public Law 89-665; 16 USC 470-470m, as amended, 16 USC 460b, 470l-470n).

All supporting documentation required under 36 CFR 800.11(d) were sent to the SHPO. This includes the draft environmental impact statement (DEIS). The archeologist representing the City of Phoenix has received copies of SHPO communications in addition to a copy of the DEIS.

3.5.8 NATIVE AMERICAN CONCERNS

Section 106 of the National Historic Preservation Act and the American Indian Religious Freedom Act of 1978 require that government agencies consult with Native Americans to determine their interests in federal projects. For the Rio Salado Oeste study, consultation was initiated with the following tribes: Ak-Chin Indian Community; Gila River Indian Community; Hopi Tribe; Pascua Yaqui Tribe; Salt River Pima-Maricopa Indian Community; Tohono O'odham Nation, and; Yavapai-Apache Nation. Letters including project descriptions and requests for comments were sent to these tribes noted below on July 6, 2005. The memorandum for record was transmitted to the tribes on October 6, 2005. The DEIS, including all identification, evaluation, and mitigation studies, was sent to the tribes for comment. A copy of the FEIS will also be sent.

3.6 AESTHETICS

3.6.1 INTRODUCTION

This section describes the existing aesthetic resources and conditions in the study 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 3.1, "Geology and Topography," 3.2, "Hydrology and Water Resources," and 3.11 "Land Use," for other details on the physical conditions that influence the visual and aesthetic character of the study area.

3.6.2 GENERAL PROJECT SETTING

The study area is located in the eastern portion of Maricopa County, just north of the southern City of Phoenix boundary and South Mountain. The study area is located within a subdivision of the Sonoran Desert referred to as the Lower ColoradoValley, the Lower Sonoran 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 (*Cercidium floridum*), creosotebush (*Larrea tridentata*) and bursage (*Ambrosia spp.*) (City of Phoenix, 1998).

Terrain ranges from hills and rock outcrops south of the study area to alluvium within the river floodplains to the north. Surrounding land on the western end of the study area is relatively flat and rural (rural residential, agricultural, dairy farms, open space and gravel mining), while the eastern portion of the study area is generally urban in character and land uses (residential, agricultural, light industry, manufacturing, commercial, gravel mining and vacant land). The slopes in the study area range from 0 and 2 percent (Maricopa County, 1992a). The study area includes the floodway and adjacent land uses. The study area stretches through urbanized Phoenix on the east and rural areas to the west, and is essentially a wide dry wash dominated by large expanses of sand, cobbles and sediment (silt and clay). The interior floor of the Salt River Valley is comprised of thick layers of alluvium on nearly level or gently sloping surfaces.

3.6.3 GENERAL DESCRIPTION OF THE PROJECT AREA

Views of the study area are limited due to existing development and lack of public access points along the banks. Views within the wash are characterized by diverse channel widths and include dry cobble/dirt, trash, debris and open water-dominated reaches. Generally, area topography is flat. This lack of topographic features limits long-range viewing opportunities along river channels. Very few vegetative communities exist within or along the sides of the wash. Visible degradation of the streambed in the eastern half of the study area has resulted from illegal dumping of garbage, household trash, commercial waste, used furniture, appliances, abandoned cars, tires, off-road vehicle use, gravel mining, and debris left over from unauthorized/illegal target shooting activities. Prominent features that can be viewed adjacent to Salt River include power lines and towers, scattered rural development on the western half of the study area, and light industrial, manufacturing and commercial auto salvage uses along the eastern half. Most notably, sand and gravel mining operations within and along the banks of the study area have significantly degraded visual resources and aesthetic conditions. Long-distance views include Sierra Estrella and South Mountain to the south, Camelback Mountain and the Phoenix Mountains to the northeast, and the White Tank Mountains to the northwest. Descriptions of the views from various locations along the study corridor are provided below.

35th Avenue: Views of the Salt River from the vicinity of 35th Avenue are wide open, revealing broad, relatively flat areas of cobble and dirt. Surface sediment is mostly fine sand, silt and clay. This portion of Salt River is used as an illegal dumping site for commercial and residential refuse and other materials. Domestic refuse and construction debris is common along this river section. Vegetation is exceedingly sparse in this area. To the north are gravel mining operations, industrial and warehouse uses. To the south are auto salvage and commercial uses.

43rd Avenue: Views of the Salt River from the vicinity of 43rd Avenue are unobstructed. This portion of the Salt River is also used as an illegal dumping site for commercial and residential refuse and other materials. Trash and debris are common along this section of the Salt River. Vegetation on the flat, dry landscape is very sparse in this area. Power lines and buildings can be seen in the distance. To the north are gravel mining operations. To the south are residential and manufacturing uses. Gravel mining continues on both sides of the wash from 43rd Avenue to the western end of the study area.

83rd Avenue: The study area east of 83rd Avenue consists of riparian habitat, including cottonwood/willow and salt cedar growing adjacent to the river channel at the on-grade river crossing. Vegetation on the flat, dry landscape is very sparse to the east of this crossing. Low-density, agriculture-related residential structures and crop fields are present to the north and south.

Broadway Road: The study area between the channel and Broadway Road consists of gravel mining operations in and along the channel and agricultural fields to the north. Vegetation within the channel is very sparse. New residential development is expanding from east to west along Broadway Road, displacing agriculture and dairy farms.

3.6.4 REGULATORY SETTING

Pertinent regulations, plans, goals and policies, related to aesthetic resources of the Rio Salado Oeste study area, are described below.

3.6.4.1 Maricopa County

Portions of the study area are within unincorporated Maricopa County and governed by county planning. The Maricopa County General Plan is divided into a series of land use plans for the area. Plans relative to the Oeste Project include the Maricopa County Comprehensive Plan, the Estrella Planning Area Land Use Plan, the Laveen Planning Area Land Use Plan (Maricopa County, 1997), and the City of Phoenix General Plan.

3.6.4.2 Maricopa County Comprehensive Plan

The Comprehensive Plan seeks to establish a network of protected open spaces that correspond to regionally significant mountains, rivers, washes and upland deserts. The existing and future open space areas are important to the quality of life in the county and are intended to be planned and managed to protect, maintain and enhance their intrinsic value for recreational, aesthetic and biological purposes. 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 in Tonto National Forest. Dedicated Open Space currently comprises approximately 2,000 square miles, with another proposed 650 square miles of open space in the unincorporated areas of the county.

According to the Comprehensive Plan, complementing open spaces and parks are visual resources. These are to include scenic corridors and vistas that offer county residents an opportunity to view the natural environment without manmade intrusions. Major rivers and washes thread through the region providing uninterrupted views of mountains, vegetation and wildlife native to the county. Major roads offer motorists scenic vistas as they travel.

3.6.4.3 Estrella Planning Area Land Use Plan

The Estrella Planning Area Land Use Plan (Maricopa County, 1992a) regulates planning and development activities within its jurisdiction of unincorporated Maricopa County. The Estrella Planning Area is currently highly rural in character and is considered an island of farming activity, surrounded by more urban-type development. The Salt River and the areas immediately north of it are designated as "Open Space" by the Estrella Land Use Plan. This category denotes areas that would be best precluded from development for any reasons except as open space or recreation areas, to potentially include parks, drainageways and scenic areas (Maricopa County, 1992a).

3.6.4.4 Laveen Planning Area Land Use Plan

The Laveen Planning Area Land Use Plan (Maricopa County, 1992b) regulates planning and development activities for approximately 30 square miles of unincorporated Maricopa County south of the Salt River. The area is generally characterized by rural ranchettes, cultivated farmland and dairy farms. There is a small urban area within Phoenix in the northeastern portion of the planning area. The portion of the Laveen Planning Area along the south banks of the Salt River is currently vacant. Minor amounts of developed land and agricultural land use are nearby. Industrial development and a considerable number of auto wrecking and salvage operations are located in the northeast quadrant closest to Phoenix (Maricopa County, 1992b).

3.6.4.5 City of Phoenix General Plan

The City of Phoenix General Plan (City of Phoenix, 2001b) regulates planning and development activities within incorporated areas of the city in the study area vicinity. The General Plan's mission is to help achieve the City's vision by preserving the culture, heritage and natural and manmade environment. The General Plan also acknowledges that preserved natural areas provide visual and emotional relief from day-to-day stresses of life in the urban setting, recreation, and habitat for native flora and fauna. Sonoran Desert, mountains, and wash terrain features define these major natural areas (City of Phoenix, 2001b).

3.6.4.6 Gila River Indian Community

The Gila River Indian Community (GRIC) is considered a Sovereign Nation, and is not under the regulatory or political jurisdiction of any local government or the federal government. No GRIC lands are located within the project implementation area, though some project features could be visible from tribal lands. The GRIC does not have any established regulations or plans for visual resources.

3.7 AIR QUALITY

3.7.1 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.

3.7.2 CLIMATE AND METEOROLOGY

The proposed Rio Salado Oeste project is located within Salt River Valley (Valley) at an elevation of approximately 335 meters (1,100 feet). The Valley is oval shaped and flat, except for scattered precipitous mountains rising to as much as 460 meters (1,500 feet) above the Valley floor. The study area is characterized as a desert with hot summers, mild winters, and low annual rainfall. As shown in Table 3.7-1, summer mean high and low temperatures (July) in Phoenix are 41°C (106°F) and 27°C (81°F), respectively. Mean high and low temperatures for winter (January) are 19°C (66°F) and 5°C (41°F), respectively. Precipitation in the study area is approximately seven inches annually.

Precipitation occurs in two distinct seasons of the year; the summer monsoon season (July, August, September, and into October) and winter (December, January, February, and March). Rainfall is unusual in late May and June. There is a transition from generally dry conditions during the spring and early summer associated with the prevailing mid-latitude westerlies, to deep southeasterly or southerly winds that transport moisture from the Gulf of Mexico and the tropical eastern North Pacific. The change in air mass provides conditions favorable for the formation of deep convection that is typical of the summer in the southwest U.S. (ASU, 2005). Summer rains in the form of thunderstorms originate in moist air that flows into Arizona from the Gulf of Mexico and the tropical east Pacific. These storms generally occur in middle to late afternoon, and are usually of local extent. Approximately 80 percent of the thunderstorms over the basin occur in the summer months. Floods can occur from heavy thunderstorms, but are typically of short duration (lasting up to three hours).

Winter precipitation is normally associated with the passage of cyclonic storm centers originating in the Pacific Ocean, which commonly are a result of interaction between polar Pacific and tropical Pacific air masses. Some snow falls at the higher elevations, but the effect on flood flows is negligible. Individual storms usually are of several days' duration and wide aerial extent, with slow and steady intensity. Winter floods from these storms are of longer duration with lower flood crests.

As described in Table 3.7-1, the Valley is characterized by light wind speeds that range from 8.2 kilometers per hour (kph) [5.1 miles per hour (mph)] in December to 11.4 kph (7.1 mph) in July. Less frequently, widespread gusty winds occur over all areas of the Valley.

Table 3.7-1. Monthly Temperature, Precipitation and Wind Speed in Phoenix

Month	Temperature				Precipitation		Wind	
	Maximum		Minimum				Speed	
	°F	°C	°F	°C	inches	cm	mph	Kph
January	65.9	18.8	41.2	5.1	0.67	1.7	5.3	8.5
February	70.7	21.5	44.7	7.1	0.68	1.73	5.8	9.5
March	75.5	24.2	48.8	9.3	0.88	2.24	6.6	10.6
April	84.5	29.2	55.3	12.9	0.22	0.56	6.9	11.1
May	93.6	34.2	63.9	17.7	0.12	0.3	7.0	11.3
June	103.5	39.7	72.9	22.7	0.13	0.33	6.8	10.9
July	105.9	41.1	81	27.2	0.83	2.11	7.1	11.4
August	103.7	39.8	79.2	26.2	0.96	2.44	6.6	10.6
September	98.3	36.8	72.8	22.7	0.86	2.18	6.3	10.1
October	88.1	31.2	60.8	16	0.65	1.65	5.8	9.3
November	74.9	23.8	48.9	9.4	0.66	1.68	5.3	8.5
December	66.2	19	41.8	5.4	1.0	2.54	5.1	8.2
Source: National Climatic Data Center, Phoenix Annual Summary of the Local Climatological Data								

3.7.3 EXISTING AIR QUALITY

3.7.3.1 Criteria Pollutants

The quality of the surface air (air quality) is evaluated by measuring ambient concentrations of pollutants that are known to have deleterious effects. The degree of air quality degradation is then compared to the ambient air quality standards (AAQS). A summary of the air quality status in the study area (i.e., generally the urban area of Maricopa County) relative to the AAQS, is provided in Table 3.7-2.

Table 3.7-2. Attainment Status and Conformity Thresholds

December 2005 Maricopa County Area, Arizona			
Pollutant	Attainment Status	Federal Register Citation	Conformity Threshold
Carbon Monoxide	Maintenance Area	70 FR 11553 March 9, 2005	100 tons/yr
Ozone: VOC & NOx	**8-hr Standard** Basic Nonattainment Area	69 FR 23858 April 30, 2004	VOC: 100 tons/yr. NO_X: 100 tons/yr
PM-10	Serious Nonattainment Area	June 10, 1996 (61 FR 21372)	70 tons/yr
PM-2.5	Attainment Area	70 FR 944 January 5, 2005	N/A

Non-attainment is a term used to indicate the violation of a particular AAQS. Both the Arizona Department of Environmental Quality (ADEQ) and Maricopa County have adopted the federal AAQS, and do not enforce a separate set of standards. Air quality in the vicinity of the study area has experienced exceedances of the AAQS for fine particulate matter (PM-10) on several days each year. As a result, the U.S. Environmental Protection Agency (EPA) and ADEQ have classified Maricopa County as a serious non-attainment area for federal AAQS for PM-10. A portion of Maricopa County is also in basic nonattainment of the 8-hour ozone standard. The Ozone and PM-10 nonattainment areas are shown in Figure 3.7-1.

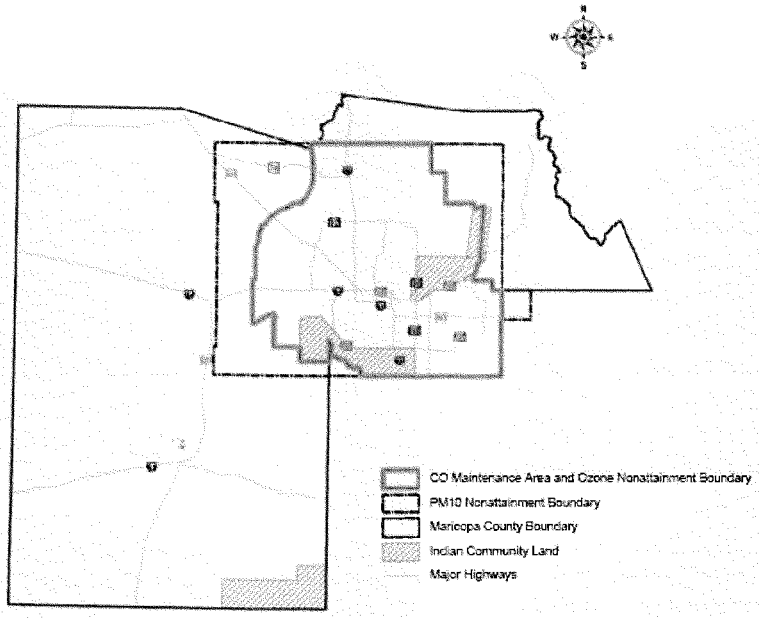


Figure **3.7-1. Maricopa County PM-10 and Ozone Nonattainment Areas (MCAQD, 2004a)**

Source: 2002 Periodic Emissions Inventory for PM-10 for the Maricopa County, Arizona, Nonattainment Area, June 2004, Revised March 2006, prepared by the Maricopa County Environmental Services Department and the Maricopa Association of Governments

ADEQ and Maricopa County Air Quality Department operate a countywide network of air pollution monitoring stations, including several in the study area. The air quality monitoring station nearest the study area is the West Forth Third Station (43rd Avenue and Broadway Road), located at a Maricopa County Department of Transportation storage lot. The second closest station is the Durango Complex (27th Avenue and Durango Street), located one mile northwest from the former Salt River site in the Maricopa County Flood Control District storage yard. Data from these sites provide a general profile of air quality within the study area. Table 3.7-3 lists the monitoring stations and presents ambient air quality concentrations recorded for PM-10 in 2002 through August, 2006, as well as the number of days the ambient concentrations exceeded federal/state AAQS. Ozone (O_3), nitrogen dioxide (NO_2), and carbon monoxide (CO) are not monitored at these stations. This is because the EPA guidance on siting monitors requires that monitors for ozone, nitrogen dioxide and carbon monoxide levels be located where levels of these pollutants are higher. PM-10 monitors are located in the study area because of the PM-10 sources in the vicinity.

Table 3.7-3. Air Quality Monitoring Stations

Pollutant Standards	Monitoring Station									
	27th Ave. & Durango Street					43rd Ave. & Broadway Road				
	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
Ozone (O_3)										
Maximum Concentration (ppm)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Days > NAAQS (0.08 ppm)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Nitrogen Dioxide (NO_2)										
Maximum Concentration ($\mu g/m^3$)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Days > NAAQS (100 $\mu g/m^3$)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Particulates (PM-10)										
Maximum Concentration	232	195	209	206		172	157	251	233	
Days > NAAQS (150 $\mu g/m^3$)	2	1	0	13	9*	1	1	1	13	13*
Carbon Monoxide (CO)										
Maximum Concentration (ppm)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Days > NAAQS (9.0 ppm)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

Notes: ppm = parts per million; $\mu g/m^3$ = micrograms per cubic meter; NM = not monitored.
Source: Maricopa County Air Quality Department Website. http://www.maricopa.gov/aq/status.aspx.
*2005 exceedances for PM-10 are based on preliminary data that has not been quality assured.

3.7.3.2 Toxic Air Contaminants

Hazardous Air Pollutants: In addition to criteria pollutants, other regulated pollutants include hazardous air pollutants (HAPs) which are suspected or known to cause cancer, genetic mutations, birth defects or other serious illnesses in exposed people. HAPs are not regulated by federal AAQS, but are addressed by National Emissions Standards for Hazardous Air Pollutants (NESHAPs) and Title III of 1990 Clean Air Act Amendments.

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. Impacts from toxic pollutant emissions tend to be site specific and their intensity is subject to constantly changing meteorological conditions.

3.7.4 REGULATORY SETTING

3.7.4.1 Federal, State, and County Regulations

Federal, state and regional agencies have established standards and regulations addressing air pollutant emissions that affect proposed projects. The following federal and state regulatory considerations may apply to the project.

- The federal Clean Air Act of 1970 directs the attainment and maintenance of National AAQS for six "criteria" pollutants (e.g., ozone, carbon monoxide, etc.).
- The 1997 Clean Air Act enacted legislation to control seven air toxic pollutants. EPA adopted the National Emission Standards for Hazardous Air Pollutants (NESHAP), which was designed to control Hazardous Air Pollutants (HAP) emissions to prevent adverse health effects in humans.
- The 1990 Amendments to this Act determine attainment and maintenance of 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).
- Clean Air Act implements the New Source Review (NSR) and Prevention of Significant Deterioration (PSD) regulations.
- Maricopa Air Pollution Control Regulations Rule 310.
- Arizona State revised Statute Title 49.

3.7.4.2 Federal Conformity Requirements

Federal projects are subject to either the Transportation Conformity Rule (40 Code of Federal 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 State Implementation Plans (SIP) so that they do not interfere with strategies employed to attain the NAAQSs. The rule applies to federal projects in areas designated as non-attainment areas for any of the six criteria pollutants for which the EPA has established NAAQSs and, in some areas, designated as maintenance areas. Maintenance areas are former non-attainment areas which have subsequently met the NAAQSs, and that have submitted an approved Maintenance Plan to demonstrate continued attainment. The General Conformity 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 minimus* threshold levels, and;
- certain other projects that are exempt or presumed to conform.

The study area is in a serious non-attainment area for federal PM-10 standards. The area is also designated as a maintenance area for carbon monoxide (CO), and a basic non-attainment area for 8-hour ozone (O_3). The applicable *de minimus* thresholds are provided in Table 3.7-2. If the Rio Salado Oeste project would result in total direct and indirect emissions in excess of the *de minimus* 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 minimus* levels, the project is presumed to conform and no further analysis or determination is required.

3.7.4.3 Regional and Local Regulations

The proposed project would be located entirely within Maricopa County, and is under the jurisdiction of the Maricopa County Air Quality Department (AQD). Therefore, emissions that would result from the construction and maintenance of the project are subject to rules and regulations of the Maricopa County AQD. The rules and regulations of this agency help achieve defined air quality standards that are protective of public health by specifying emission controls and control technologies for each type of emitting source.

3.8 NOISE

3.8.1 INTRODUCTION

This section describes the existing noise setting in the vicinity of the Rio Salado Oeste study area, including noise sources and the regulatory setting for noise. General information about noise is also provided.

3.8.2 GENERAL NOISE SETTING

A noise environment consists of a base of steady background noise 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 flyovers, traffic noise from area streets, and sand and gravel mining operations along the study area.

3.8.2.1 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 (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. 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.

3.8.2.2 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 environmental noise and its characteristics. The amount of interference in non-listening 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.

3.8.2.3 Noise Sources

The study area is located in a mixed setting containing both urbanized areas and semi-rural areas. The study area has a moderate activity level and few sources of adverse noise. Sand and gravel mining operations are the largest contributors to ambient noise levels in the area. Vehicular traffic on streets that cross the study area (across the Salt River in a north-south direction) is another contributor of ambient noise. Study area traffic noise may be characterized as light and not considered to be significant. Aircraft departing from and entering Phoenix Sky Harbor

Airport also contribute to the ambient noise in the study area. This 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. Because aircraft produce intense noise and pass over the area at relatively low altitudes, these aircraft are considered to be moderate noise sources.

3.8.2.4 Sensitive Receptors

The study area contains residential, agricultural, industrial, and commercial land uses. Sensitive receptors for noise in the study area consist of residential uses located to the north of the river channel and a few scattered houses on the south side of the river channel.

3.8.3 REGULATORY SETTING

3.8.3.1 Federal and State Standards and Regulations

The Department of Housing and Urban Development (HUD) has identified the relationship between noise levels and human response. HUD has determined that over a 24-hour period, an 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," HUD set 55-dBA day-night average sound level (L_{dn}) as the basic goal for residential noise intrusion. 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). 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.

3.8.3.2 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.

3.8.3.2.1 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, 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).

3.8.3.2.2 City of Phoenix

The Phoenix Zoning Ordinance specifies the average noise levels for various land use categories. The City Code includes specific hours for construction operations (Section 23-14, h). During weekdays, construction hours include the period between 6:00 a.m. and 7:00 p.m. from the first day of May to and including the 30th day of September, and between the hours of 7:00 a.m. and 7:00 p.m. beginning the first day of October to and including the 30th day of April. Extended construction work hour permits would be required for Saturdays, Sundays, and hours that are beyond the construction periods described above.

3.9 SOCIAL AND ECONOMIC RESOURCES

3.9.1 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 1990 and 2000 U.S. Census Bureau surveys for Maricopa County, Maricopa Association of Governments (1997) and Arizona Department of Economic Security (1997 and 2000) web sites. These sites provided information regrading population- and housing-growth forecasts and other demographic projections for the County and local municipalities. In this socioeconomic report section, the term *study area* refers to the group of census tracts that exist within or extend into the study area. Whenever possible, the 1990 census information has been supplemented by the most current information available from the aforementioned sources and from the online database of the City of Phoenix (2002).

3.9.2 GENERAL SOCIOECONOMIC SETTING

3.9.2.1 Population

The southern portion of the study area lies in the southwest portion of the City of Phoenix, Arizona (City), which has a total population of 1,321,045 (U.S. Census Bureau, 2000). Table 3.9-1, "Population and Household Characteristics in the Vicinity of the Study Area," shows the 2000 population and household and family structure for the County and 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 (MAG, 2002). The study area includes only 1.6% of the total County population (U.S. Census Bureau, 2000).

Table 3.9-1. 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	3,027,366	2.67	763,110	3.21
Study Area	48,854	11,504	3.93	9,362	4.20
Source: U.S. Census Bureau, 2000					

3.9.2.2 Ethnicity

Table 3.9-2, "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, 1.4% American Indian and Alaskan Native, 2.1% Asian, 0.05 % Native Hawaiian or other Pacific Islander, 0.1% other races, and 1.5% two or more races (U.S. Census Bureau, 2000).

Table 3.9-2. 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 Lation	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%
Rio Salado Oeste Study Area	11,714	2,918	3,019	166	31	47	30,543	416
Percent of Study Area Total	24.0%	6.0%	6.2%	0.3%	0.1%	0.1%	62.5%	0.9
Source: U.S. Census Bureau, 2000								

The ethnic composition of the study area differs from that of the County as a whole, most notably in the proportions of white and Hispanic residents. The proportions of the other races do differ as well, although not as much. The approximate population breakdown in the study area is: 24.3% white, 62.0% Hispanic, 5.9% African American, 6.2% American Indian and Alaskan Native, 0.3% Asian, 0.06% Native Hawaiian or other Pacific Islander, 0.09% other races, and 0.85% more than two races.

3.9.2.3 Housing

The housing within the study area is characterized by urban, rural residential, and rural farming. Table 3.9-3, "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 1,123,866 (89.8%) 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 will have approximately 604,938 housing units by 2010, and approximately 701,091 housing units by 2020 (MAG, 1997).

Table 3.9-3. Occupancy Rates in the Vicinity of the Study Area

Jurisdiction	Housing Units	Households	Occupancy
Maricopa County	1,250,231	1,123,866	89.8%
Study Area	12,448	11,504	92.4%
Percent of County Total	1.0%	1.0%	
Source: U.S. Census Bureau, 2000			

Table 3.9-4, "Housing-Unit Type and Housing-Unit Median Value in the Vicinity of the Study Area," shows that in 1990, 7,620 people (40.8% of the total population of the study area) resided in urban areas in the study area, while 3,417 people (31%) lived in rural areas (185 residing on farms and 3,232 on non-farmland). In the County, approximately 921,947 people (96.8% of the total population of the County) lived in urban areas, and approximately 30,352 people (3.2%) lived in rural areas. The housing units within the study area had a median value of $50,055.

Table 3.9-4. Housing-Unit Type and Median Value in the Vicinity of the Study Area

Urban	Rural		Urban		Median Unit Value
	Farm	Non-Farm	Inside	Outside	
Maricopa County	750	29,603	896,344	25,603	$85,300
Study Area	185	3,232	7,620	0	$50,055
Source: U.S. Census Bureau, 1990					

3.9.2.4 Employment

According to the Arizona Department of Economic Security, 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 3.9-5, "Industry Employment in Maricopa County, January 2002," shows 1,528,500 people are currently employed in the County (Arizona Department of Economic Security, 2002), a slight decrease from two years before.

Table 3.9-5. Industry Employment in Maricopa County, January 2002

Employment	Jobs
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	
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

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 Phoenix is expected to have 821,325 persons employed by 2010 and 873,975 people employed by 2020 (MAG, 1997).

3.9.2.5 Income

Table 3.9-6, "Median Household Income in the Vicinity of the Study Area," shows median household income for residents within Maricopa County and the study area for the year 1990. In 1990, the median household income for the County was $30,797, whereas for the median household income for the study area was substantially less, averaging $19,493 (U.S. Census Bureau, 1990).

Table 3.9-6. Median Household Income in the Vicinity of the Study Area

Jurisdiction	Median Income Amount
Maricopa County	$45,358
Study Area	$27,847
Source: U.S. Census Bureau, 2000	

3.9.3 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.

3.10 TRANSPORTATION

3.10.1 REGIONAL PLANNING

As the designated Metropolitan Planning Organization for the Maricopa region, the Maricopa Association of Governments plans and finances the regional transportation system. The Regional Transportation Plan (RTP) provides a broad vision for the regional transportation system for the next two decades, addressing freeways and other highways, streets, transit, airports, bicycle, and pedestrian facilities.

3.10.2 FREEWAYS AND SURFACE STREETS

The dominant mode of transportation in the Rio Salado Oeste study area is the automobile. Interstate Highway 10 (I-10) services Phoenix from the east and west, while Interstate 17 (I-17) brings travelers to and from Flagstaff, 130 miles to the north. These interstate highways are connected by an extensive network of limited access freeways, including State Routes 51, 101, 202 and 303. In addition to the interstate highways, State Highways 60, 85 and 87 are major transportation routes.

Major surface streets are generally laid out in north-south and east-west directions at one mile intervals, though this pattern is interrupted by topography and restrictive land uses (such as airports) in some areas. Nearly all local streets and arterials near the Rio Salado Oeste study area are part of this north-south, east-west grid roadway network. Four local roadways cross the Salt River in the study area: 19th, 35th, and 51st Avenues (bridges) and 67th Avenue (at-grade crossing). All of these major surface arterials streets have interchanges with interstate 10 three to four miles north of the Salt River.

3.10.3 MASS TRANSIT

Valley Metro provides transportation services for the greater metropolitan area, including rideshare services and a large fleet of public transit buses. The area's first light rail line is expected to begin providing service between Phoenix, Tempe, and Mesa in 2008, with future extensions scheduled through 2025 (MAG, 2006)

3.10.4 AIRPORTS

Phoenix owns and operates three airports, Phoenix Sky Harbor International Airport (Sky Harbor), Phoenix Deer Valley Airport and Phoenix Goodyear Airport. Sky Harbor is served by 23 airlines which provide nonstop service from Phoenix to 89 cities in the United States and 17 cities in Canada, Mexico, and Europe (City of Phoenix, 2006). With more than 1,700 daily arrivals and departures, and 36 million passengers annually, Sky Harbor is the fifth busiest airport in the word (Sky Harbor Coalition, 2006). The Rio Salado Oeste study area is located approximately five miles west of Sky Harbor. Deer Valley Airport and Goodyear Airport are general aviation reliever airports for Phoenix Sky Harbor. Luke Air Force Base, while not a public airport, is a major consideration in airspace planning in the Phoenix area.

3.10.5 RAILROADS

The Phoenix area is serviced by two major railroads, Union Pacific and the Burlington Northern Santa Fe Railway. These rail lines are currently used for freight. The Maricopa Association of Governments is studying the feasibility of using these freight lines as the basis for a regional commuter network (MAG, 2006). No rail lines cross the Salt River in the study area.

3.10.6 REGULATORY SETTING

The Rio Salado Oeste 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 City of Phoenix, the Maricopa County Department of Transportation, and the Federal Aviation Administration. ADOT has jurisdiction over activities occurring on or affecting I-10 and I-17 near the study area.

3.11 LAND USE

3.11.1 INTRODUCTION

This section describes the existing land uses and recreational opportunities in the vicinity of the Rio Salado Oeste 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.

3.11.2 LAND USE IN THE PROJECT STUDY AREA

Based upon the City of Phoenix General Plan (revised February, 2001), most of the land area on the north side of the Salt River between 19th Avenue and 59th Avenue is zoned as industrial, with some high-density residential between 43rd Avenue and 60th Avenue. From 60th Avenue to 83rd Avenue, the primary land use is low-density residential. South of the Salt River, there is some land between 19th Avenue and 35th Avenue zoned as commercial. Otherwise, the prevailing land use designation is low- to medium-density residential.

Estrella Village and Laveen Village are the two primary planning areas that lie adjacent to the Salt River between 19th Avenue and 83rd Avenue. Estrella Village is characterized by an ample supply of undeveloped land, large parcels, natural and scenic amenities, and excellent transportation access. As noted on the City of Phoenix web site, the village also poses unique challenges, given the isolation of its existing residential neighborhoods and the extensive industrial activities that have developed over the years. Approximately 62 percent of the Village is undeveloped, either vacant or with agricultural uses. However, there are 21 residential developments in various phases of approval and development. Over 8,000 new single-family housing units were approved in this area in 1999 alone.

The Laveen Village contains largely undeveloped and agricultural properties. Primary agricultural crops grown in the area include cotton, citrus, and corn. The area has been valued by farmers, equestrians, and those looking for solitude and mountain access. However, development pressures have increased in this area due to its proximity (about seven miles) to downtown. This pressure is expected to increase along with access to the future South Mountain

Loop transportation corridor. There are 12 residential developments in various phases of approval and development in the Laveen Village area, which is anticipated to result in a doubling of population over the next decade.

The South Mountain planning area is also primarily composed of vacant land, agriculture, and low-density residential uses. These categories, along with open space, represent over 85 percent of the space in this planning area (see Figure 3.11-1).

3.11.3 REAL ESTATE

The majority of the land within the project area is privately owned. Within the floodplain, or the area where restoration measures would be proposed, this ownership includes sand and gravel companies, the State of Arizona, Maricopa County, and the City of Phoenix. The City of Phoenix currently owns approximately 511 acres in the project area and has a Recreation and Public Purposes Lease on an additional 159 acres of Bureau of Land Management property. A general summary of land ownership within the 100-year floodplain is presented in Table 3.11-1. Refer to the Feasibility Report, Appendix G, Economic Evaluation, for more details.

Table 3.11-1. Property Ownership within the Study Area (100-Year Floodplain)

Ownership	Acres
City of Phoenix	511
Maricopa County	118
State of Arizona	261
Federal	190
Private	2094
Total	3174

3.11.4 NEARBY RECREATION RESOURCES

Arizonans place high importance on the State's outdoor recreation resources. In the 1994 Statewide Comprehensive Outdoor Recreation Plan survey, 94 percent of respondents stated that parks and recreation areas are important to their everyday lifestyles. With the exception of the recently opened Rio Salado Phoenix project (Section 5.1.5), the greater Phoenix area does not 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. However, it is likely that many visitors would be drawn from even greater distances.

3.11.5 REGULATORY SETTING

Although the proposed project is being undertaken by U.S. Army Corps of Engineers (Corps), the State, County, City and the Gila River Indian Community have jurisdiction over respective planning and development decisions in the study area. Regulatory requirements and future growth policies for these organizations are identified in several different planning documents. The regulatory setting for these organizations is presented below.

3.11.5.1 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. 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: open space, growth areas, environmental planning, cost of development, and water resources.

The State Land Department is also required to prepare a conceptual land use plan, with an annual five-year disposition or development plan for all trust lands located in urban areas. 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 ten 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. As proposed, the bill includes the following provisions, among others:

- extends the deadline for the adoption of updated General or Comprehensive Plans,
- clarifies language regarding the water resources element, and
- revises the requirements for the 60-day review period.

3.11.5.2 Maricopa County

Portions of the study area are within unincorporated areas of the County and are governed by county planning and development activities. The vast size of the County has dictated a sub-regional approach to comprehensive planning in the County during the last 20 years (Maricopa County, 1997). A series of land use plans for the area have been developed in a program to plan for unincorporated areas. Within the study area, these plans include the

Maricopa County Comprehensive Plan, Estrella Planning Area land use plan, and the Laveen Planning Area land use plan. Each of these plans is briefly discussed below.

3.11.5.2.1 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. 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 of 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 Phoenix General Plan meets these criteria and is discussed later in this chapter.

The Salt River 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 some U.S. states, and it provides a complex natural ecosystem. As part of the overriding vision for the County, protection of the unique desert environments is 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).

3.11.5.2.2 City of Phoenix

The City of Phoenix General Plan (City of Phoenix, 2001b) regulates planning and development activities within incorporated areas of the city in the vicinity of the study area. The General Plan considers areas currently outside the jurisdictional political boundaries (unincorporated county lands) for potential future annexation. Through goals, policies and recommendations, the General Plan provides a short- (within the next 10 years) and long-range (10 to 20 years) comprehensive direction for the growth, conservation, and redevelopment of all physical aspects of the city. The mission of the General Plan is to help achieve the City's vision by preserving the culture, heritage, and natural and human-made environment. The General Plan also acknowledges that preserved natural areas provide visual and emotional relief from day-to-day stresses of life in the urban setting, recreation, and habitat for native flora and fauna. Mountains and wash terrain features define these major natural areas (City of Phoenix, 2001b). As part of the strategic growth concepts adopted by the City, the Estrella and Laveen areas are two of the major target growth areas identified in the General Plan, and are within the study area. The Rio Montana Plan (2000), prepared for the eastern portion of Laveen, identifies "encouraging development and redevelopment along the Rio Salado that will be compatible with the Rio Salado Habitat Restoration Project" as one of the major issues that is unique to the area. The Estrella Plan (1999) identifies "encouraging development along Rio Salado that will be compatible with the new residential character village" as one of the major issues that is unique within the area (City of Phoenix, 2001b).

3.12 RECREATION

3.12.1 INTRODUCTION

This section presents the existing recreational opportunities in the vicinity of the Rio Salado Oeste 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. Several local government agencies have jurisdiction over recreational facilities in the area. Although the majority of the study area lies within the City of Phoenix, a substantial portion lies within unincorporated Maricopa County. The Gila River Indian Community (GRIC) has jurisdiction over the far southwestern corner of the study area.

South Mountain Park is the largest nearby recreation 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 ten miles. The park 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 encompasses about 17,000 acres of desert mountain landscape and is the largest municipal park in the United States. It contains an activity complex, hiking and riding trails (extending over 40 miles), an interpretive center, lookouts, ramadas, picnic areas, and restrooms.

The Estrella Mountains Regional Park is located southwest of the study area within the Cities of Avondale and Goodyear. The 19,840-acre park features 65 acres of grass with ten covered ramadas, picnic tables, grills, restrooms, playground equipment, two lighted ballfields, a rodeo arena, and an 18-hole privately operated golf course. In addition to the developed recreational

facilities, the park offers an extensive natural desert landscape for passive recreation. More than 33 miles of trails for hiking, mountain biking, and horseback riding are available for use.

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, 1992). This trail will provide opportunities for hiking, horseback riding, and bicycling. The existing recreational environment is provided for the respective government jurisdictions below.

3.12.2 CITY OF PHOENIX

The Phoenix Parks and Recreation Department operates more than 200 parks throughout the City, including six desert-mountain parks and 132 urban parks. The Department also administers almost 26,000 acres of desert parks and preserves within the city limits and more than 100 miles of Sonoran Desert trails (City of Phoenix, 2001a). In addition to facilities and programs offered on city-owned land, the recreation needs of the community are met in part by joint use of school facilities, such as lighted fields and school buildings. Recreational facilities within the City also include swimming pools, special facilities (such as historic sites, stadiums, and gardens), urban parks (small, pedestrian-oriented green open spaces within dense urban areas), and the West Valley Recreation Corridor (the longest recreation corridor in the Valley, extending from Lake Pleasant to Avondale along Agua Fria River and New River). In the study area, the existing streambed consists primarily of a dry wash with no recreational facilities or public access for recreation. The only improved recreation area adjacent to the Salt River in the Phoenix area is the 14-acre Rio Salado Park, which is located outside the study area at 12th Street and Elwood.

3.12.2.1 Rio Salado Phoenix Project

The Rio Salado Project is a planned recreational and habitat restoration project that is in the process of restoring the Salt River to a more natural state. It includes construction of a low-flow channel in the river bottom, and establishment of open water, wetland marsh, cottonwood/willow, open edges, and mesquite habitat on the river bottom and over banks. The project includes approximately 595-acres of restoration and 10-miles of a recreation multi-use path. Additional recreational elements include scenic overlooks, interpretive centers, gathering areas, parking, restrooms, and shade structures. Activities along the project area include bird watching, hiking, biking, and equestrian uses, wildlife observation, and fishing. The project is located immediately upstream from the project study area, and opened for public use in November, 2005.

3.12.2.3 Tres Rios Project

The Tres Rios project extends west from the 91st Avenue wastewater treatment plant to the confluence of Gila and Agua Fria Rivers. The selected plan includes a 6-mile flood control levee, a 184-acre regulating wetland that would equalize diurnal variations in discharges from the 91st Avenue treatment plant, a 300-million gallon per day pump station to convey the flow from the treatment plant to the regulating wetland, 128-acres of wetland along the north bank of the Salt River, a pipeline in the overbank wetland that would lead to 38-acres of riparian

corridor, 134-acres of open water marsh, grading the Salt River to convey surface water to supply 69-acres of riparian habitat, and a dewatering well from the treatment plant that will deliver enough water to support about 206 acres of open water marsh and about 16 acres of riparian corridor on the south bank of the Salt River. In all, approximately 775 acres of habitat will be restored and an 11-mile recreation path will be created. Construction on the levee began in 2005 and scheduled for completion in 2008.

3.12.3 GILA RIVER INDIAN COMMUNITY (GRIC)

No recreational facilities or parks that fall within the jurisdiction of GRIC were observed within the study area.

3.12.4 REGULATORY ENVIRONMENT

Although the proposed project is being undertaken by the Corps and the City of Phoenix, Maricopa County has jurisdiction over respective planning and development decisions in some portions of the study area. Because three separate jurisdictions have authority over planning and development in the study area, there are a multitude of regulations within the various planning documents.

3.12.4.1 Maricopa County

Portions of the study area are within unincorporated Maricopa County. The Maricopa County Comprehensive Plan is divided into a series of land use plans for the area. Plans relative to the Oeste Project include the Maricopa County Comprehensive Plan, the Estrella Planning Area Land Use Plan, and the Laveen Planning Area Land Use Plan. Goals and policies related to recreation facilities are discussed for each plan below (Maricopa County, 1997).

3.12.4.2 Maricopa County Comprehensive Plan

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 (the 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. This 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.

3.13 PUBLIC HEALTH AND SAFETY

3.13.1 INTRODUCTION

This section describes the existing environmental conditions in the vicinity of the Rio Salado Oeste study area relating to public health and safety.

3.13.2 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 a mostly dry riverbed whose flow is dependent on large storm events, treatment plant releases, or upstream dam releases. Depth to groundwater ranges from 70 feet below land surface near 19th Avenue to 40 feet below land surface near 83rd Avenue. The direction of flow is highly variable; however, groundwater flow is generally to the west (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 event flood damage reduction. The land uses in the vicinity of the Salt River between 19th Avenue and 83rd Avenue are sand and gravel quarries, automotive scrap yards, 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 Phoenix collects and discharges untreated stormwater from its streets and gutters into Salt River. The Salt River Project (SRP) releases water into storm drains and farmers release irrigation return into Salt River (Salisbury, pers. comm.). City ordinances do not allow gutters and storm sewers to be used for any purpose other than stormwater. EPA issued a permit to the City for this activity. According to City of Phoenix staff, stormwater is tested by the Flood Control District of Maricopa County, while dry weather runoff is tested by the City. Phoenix has cameras installed in storm drains to monitor for illegal sources of runoff.

The 23rd Avenue Phoenix wastewater treatment plant is located just south of Lower Buckeye Road. Phoenix treats and releases this municipal wastewater into Salt River under a National Pollutant Discharge Elimination System (NPDES) permit issued by the EPA and an Aquifer Protection Permit issued by ADEQ. Under the NPDES permit, Phoenix must submit an annual report with analytical results of sampling (Karnes, pers. comm.). The 2001 annual report indicates that the plant had no discharges that violated applicable EPA or local standards (Hollender, pers. comm.).

3.13.3 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.

The 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.

3.13.4 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE (HTRW)

The presence of Hazardous, Toxic, and Radioactive Wastes (HTRW) within the study area was evaluated for the study. Because of the size of the study area, approximately 23.5 square miles total, a typical Phase I Environmental Site Assessment (ESA) was not feasible. Consequently, a Modified Phase I ESA was determined to be most appropriate for the project. The basic difference is that a site reconnaissance of every property within the project area was not conducted. The Modified Phase I ESA was conducted to review past and current land use practices along the site corridor to identify areas of known or suspected contamination that may environmentally impact the subject property.

The site corridor is defined as the neighboring properties and facilities along the Salt River within an approximate distance of one mile north and south of the river's centerline, the nature of which may adversely affect or have affected environmental conditions at the site due to the presence and/or release of hazardous substances or petroleum products to the environment. URS completed the assessment under contract to the City of Phoenix (URS, 2002).

The Modified Phase I ESA was accomplished by, and limited to, a visual reconnaissance of the site from existing rights-of-way and public areas, a drive-by survey of the site corridor (or vicinity), a review of publicly available records (including aerial photographs), and a review of pertinent documentation presently and readily available from the client and/or through URS' standard resources. The following activities were conducted in accomplishing the Modified Phase I ESA:

- Review of aerial photographs.
- Review and interpretation of available archival topographic maps, historical land use maps of the site for information regarding historical site land use that could have involved the manufacture, generation, use, storage and/or disposal of hazardous substances.
- Review of the following state and federal agency lists of known or potential hazardous waste sites, and sites currently under investigation for potential environmental violations as prescribed by the American Society for Testing and Materials. All databases were

searched for areas approximately one mile from the Salt River centerline to include the project implementation area (or buffer area):

Federal National Priorities List (NPL) site list
Federal Comprehensive Environmental Response, Compensation, and Information System (CERCLIS) list
Federal Resource Conservation and Recovery Act (RCRA) CORRACTS TSD facilities list
Federal RCRA non-Corrective Action Report (CORRACTS) Treatment, Storage, and Disposal (TSD) facilities list
Federal RCRA generators list
Federal Emergency Response Notification System (ERNS) list
State lists of hazardous waste sites identified for investigation or remediation:
State-equivalent NPL
State-equivalent CERCLIS
State landfill and/or solid waste disposal site lists
State Leaking Underground Storage Tank (LUST) lists
State-registered Underground Storage Tank (UST) lists

- Review of previous environmental reports conducted within or relating to the Rio Salado Oeste study area.

- Performance of an onsite visual reconnaissance of the subject property and the area within 1-mile of the Salt River centerline in each direction to make visual observations of existing site conditions, activities, and types of land use and businesses within the project corridor area.

Sites having possible HTRW concerns include Arizona Water Quality Assurance Revolving Fund (WQARF)/National Priority List (NPL, or Superfund) sites, landfills, LUSTs, other sites included on lists of known or potential hazardous waste sites, and sites currently under investigation for potential environmental violations. Areas of groundwater quality concern are summarized in the Modified Phase I ESA prepared by URS (2002), and are depicted on Figure 3.3-2. The entire assessment is included as Appendix F to the Feasibility Report. Groundwater quality concerns are also addressed in Appendix D: Groundwater Quality and Hydrogeology Report attached to the Feasibility Report.

Sites identified with possible HTRW concerns are, for the most part, located outside the 100-year floodplain (Figure 3.3-2). Project features would be located almost entirely within the 100-year floodplain, and would be designed to avoid the known HTRW sites. In accordance with Engineer Regulation 1165-2-132, the Corps would not participate in clean up of materials regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or by the Resource Conservation and Recovery Act (RCRA).

3.13.5 WQARF/NPL SITES

There are two Arizona Water Quality Assurance Revolving Fund (WQARF)/National Priority List (NPL, or superfund) sites adjacent to or near study area. These sites are the 19th Avenue Landfill, and the West Van Buren WQARF Site. The 19th Avenue Landfill is located adjacent to the east side of the study area on 19th Avenue between Lower Buckeye Road and the Salt River. The landfill was used for disposal of municipal and local industrial waste. Historically very low concentrations of VOCs, heavy metals, and beta radiation have been detected in groundwater at the site. Remediation activities at this site have been completed and the site is currently in the operations and maintenance phase (ADEQ, 2001).

In 2001, moderate concentrations of 1,1-Dichloroethylene (1,1-DCE) were detected in two wells located in the study area and associated with the 19th Avenue Landfill NPL Site. One of these wells had a concentration exceeding the ADEQ Aquifer Water Quality Standard (AWQS) of 7 micrograms per liter (µg/L). Based on these data and data from wells east of the study area, the likely extent of groundwater with high concentrations of 1,1-DCE was estimated as shown on Figure 3.3-2.

The West Van Buren WQARF Site is located between Buckeye Road on the south and Van Buren Street on the north and between 7th Avenue on the east and 83rd Avenue on the west. Part of the study area falls within the one-mile buffer zone of the West Van Buren site. This site has elevated concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) (ADEQ, 2001).

The portion of the study area north of the Salt River and east of 51st Avenue is most likely to be impacted by poor groundwater quality from these sites. However, the study area is located up-gradient, so encroachment of poor quality groundwater from these sites is not anticipated.

3.13.6 SOLID WASTE LANDFILLS

There are three closed landfills within the study area. These include the 27th Avenue Landfill which was closed in 1995, and the SRP landfill, closed in 2000. The 19th Avenue landfill, located east of 19th Avenue, has been closed and a remediation plan has been implemented. Groundwater monitoring is conducted at the landfills. Although these landfills are within the study area, they are outside the project implementation area and would not have any impact on the project.

3.13.7 LEAKING UNDERGROUND STORAGE TANKS (LUSTS)

Thirteen LUST sites with monitoring wells on record with ADWR were identified within the study area. Description of the sites can be found within Appendix D, Groundwater Quality and Hydrogeology Report attached to the Feasibility Report. These sites may have impacts on local soil and water conditions, but are not considered likely to affect the project to be implemented within the floodplain.

3.13.8 WASTEWATER TREATMENT PLANTS

The 27th Avenue wastewater treatment plant (WWTP) is located near the upstream end of the study area, while the 91st Avenue WWTP is located just downstream of the study area. The 27th Avenue WWTP is currently active, and effluent water is discharged at the outfall point on the north side of the Salt River near 35th Avenue. There are currently eight monitoring wells surrounding the sludge drying beds and a monitoring well near the outfall point. Groundwater from these wells is sampled and analyzed periodically. The well near the 35th Avenue outfall point is monitored as part of the Aquifer Protection Permit (APP) for the site.

The 91st Avenue WWTP is currently active and effluent water is discharged to the Salt River. This effluent will be used as a water source for the Tres Rios Project, a riparian habitat restoration project that is located west of 83rd Avenue. Part of the WWTP's field of sludge drying beds is located within the study area boundary. Since the WWTP's effluent outfalls are west of the study area, and groundwater flow is to the west in the vicinity, the WWTP will likely have little influence on groundwater quality within the study area.

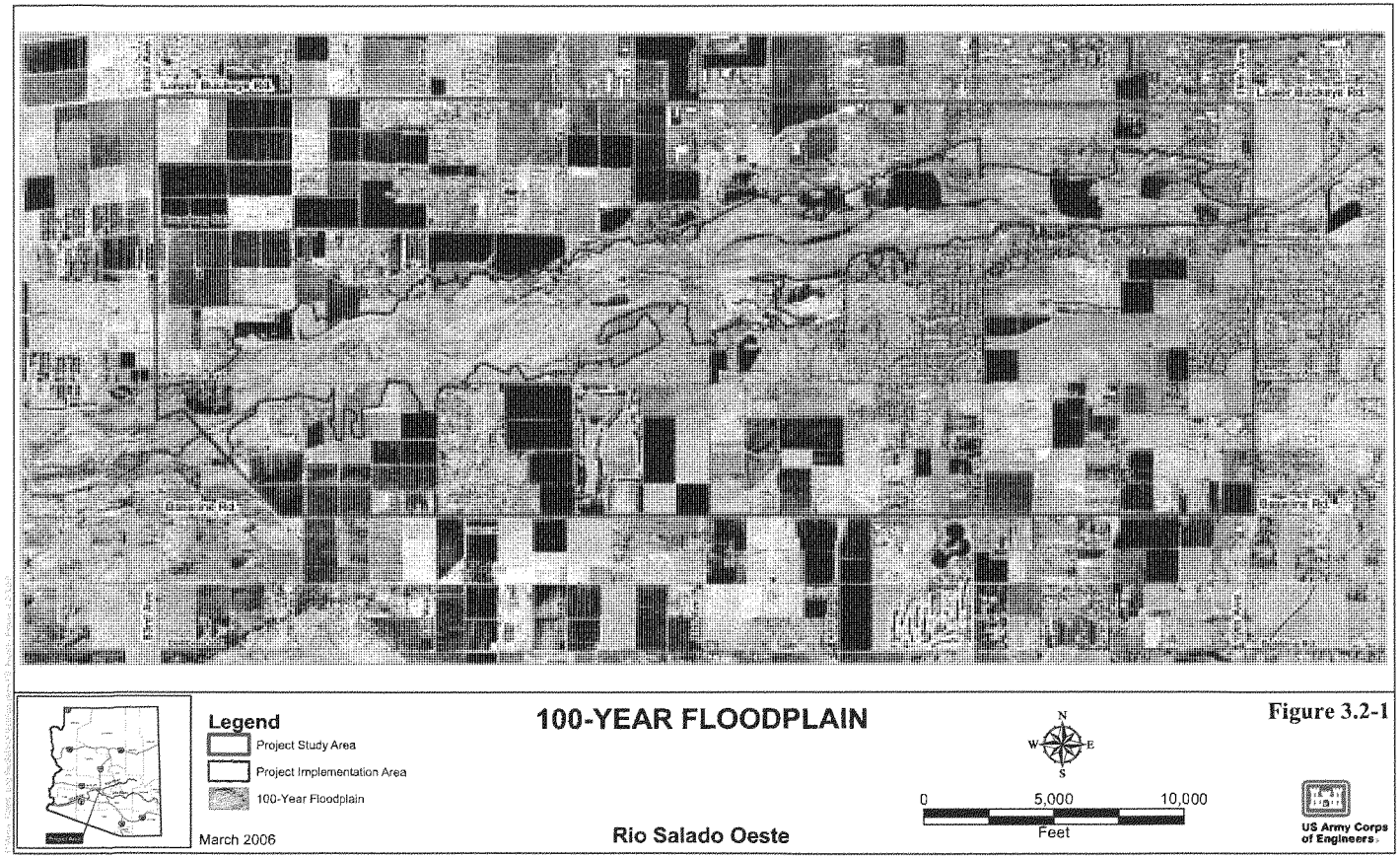
3.13.9 "WILDCAT" DUMPING

"Wildcat" or uncontrolled, illegal random dumping of materials has occurred and continues to occur along the river and study area. This dumping includes soils, concrete, asphalt, construction debris, commercial refuse, household and landscape waste, etc. The reach between 35th and 51st Avenues was at one time littered with such waste materials. However, the City of Phoenix has implemented changes that significantly reduced the amount of dumping in this through barricades and increased policing. It should be assumed that some waste is still present within the study area. Dumping could result in potential sources of contamination.

3.13.10 VECTOR CONTROL

Maricopa County Department of Environmental Services, Vector Control Division and 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.

The ecological characteristics in the study area provide a potential environment for mosquito infestation. Mosquitoes are a public health concern because of their potential to spread disease. Mosquito-borne viruses, such as St. Louis encephalitis virus, western equine encephalitis, and West Nile virus, are found every year in Arizona. Public health agencies in the state have been monitoring mosquito borne viruses for many years and added West Nile monitoring in 2003. Maricopa County Vector Control has a routine monitoring program county wide and a vector control program to help reduce the risk of mosquito-borne disease. Maricopa County monitors mosquitoes along the Salt River, primarily during the summer. Monitoring methods include carbon dioxide traps set twice each month (Ramirez, pers. comm.).


Legend
Project Study Area
Project Implementation Area
100-Year Floodplain
March 2006
100-YEAR FLOODPLAIN
Rio Salado Oeste
N
W
E
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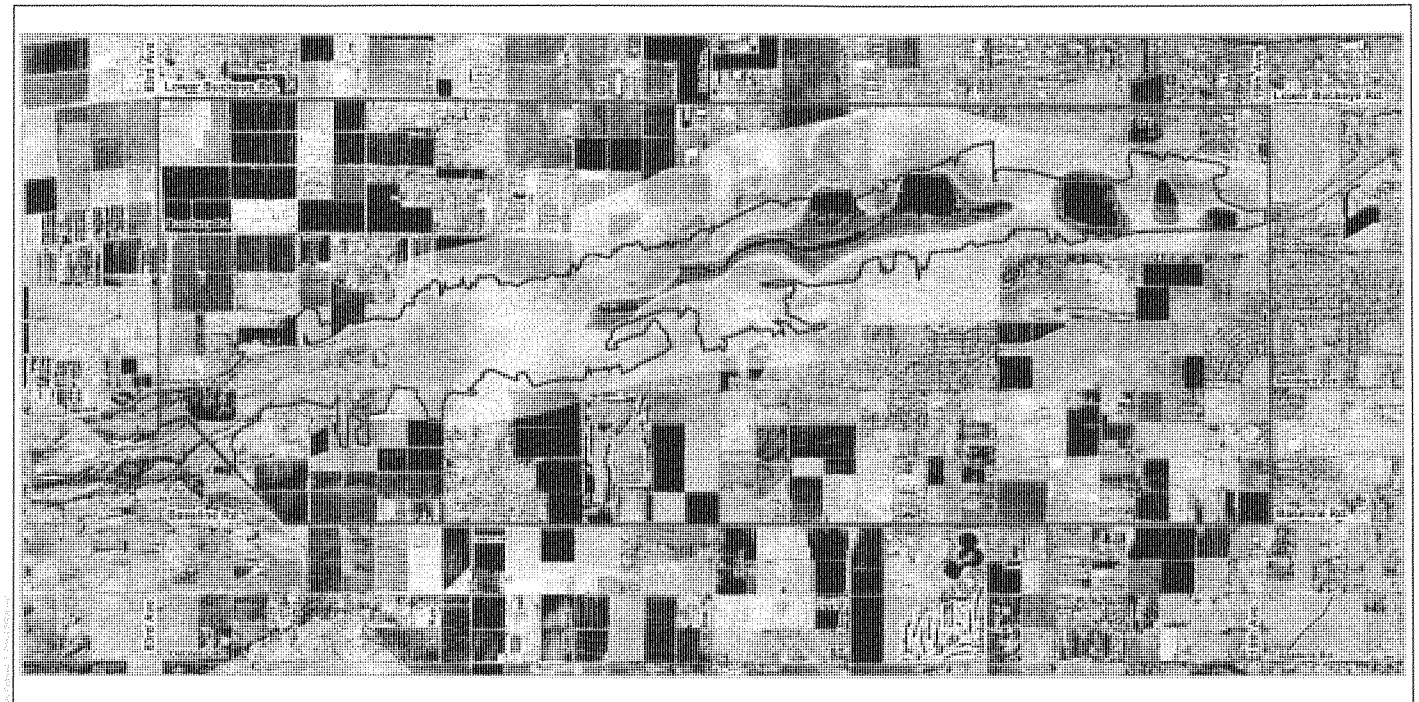
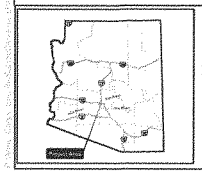
0
5,000
10,000
Feet
US Army Corps of Engineers

Figure 3.2-1





Legend

- Project Study Area
- Project Implementation Area

March 2005

Depth to Groundwater

- Surface Water
- 0 - 3 Feet
- 4 - 5 Feet
- 6 - 10 Feet
- 11 - 112 Feet

DEPTH TO GROUNDWATER

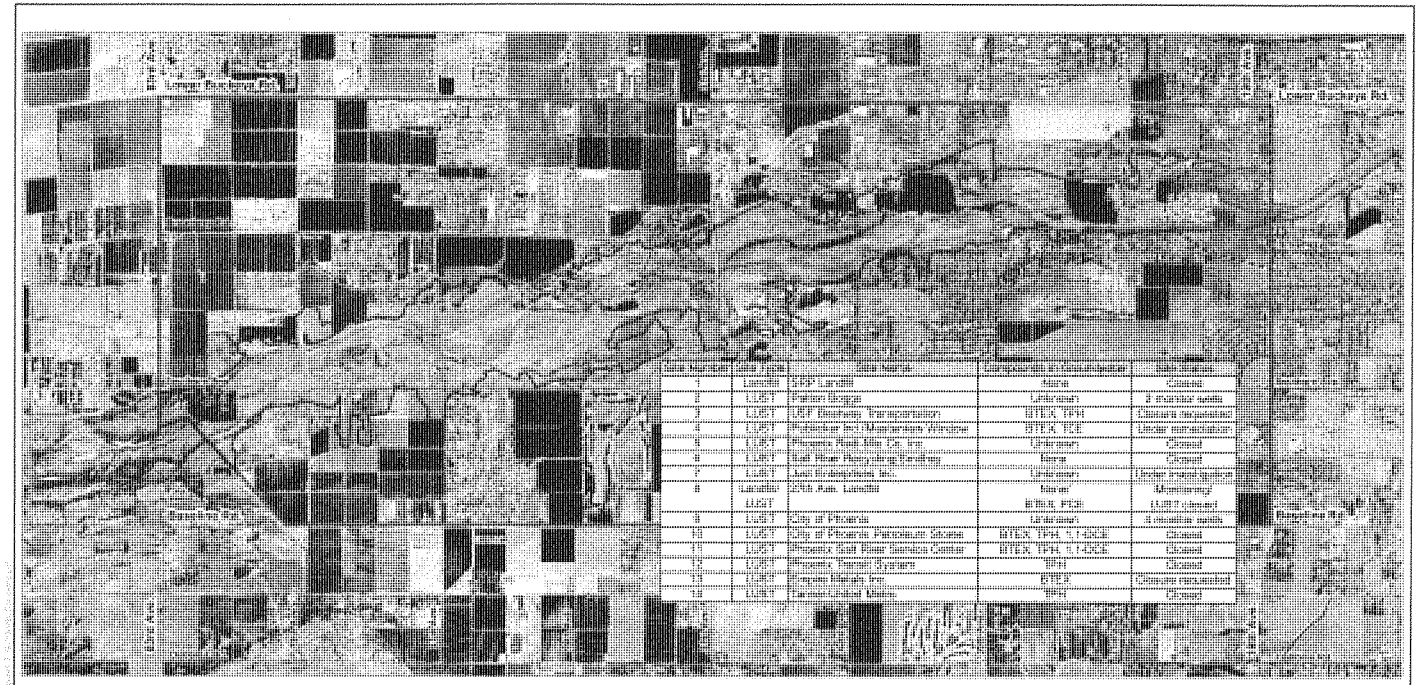
Rio Salado Oeste

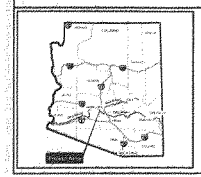
N W E S

0 5,000 10,000
Feet

US Army Corps of Engineers

Figure 3.3-1





Legend

- Project Study Area
- Project Implementation Area
- 27th Ave. Landfill
- Possible extent of 1,1-DCE plume
- 23rd Ave. Wastewater Treatment Plant
- 91st Ave. Wastewater Treatment Plant
- Wells with elevated concentrations of 1,1-DCE
- Sites with known or probable groundwater contamination
- Groundwater investigation sites with no known impacts

AREAS OF GROUNDWATER QUALITY CONCERN

Figure 3.3-2

N W E S

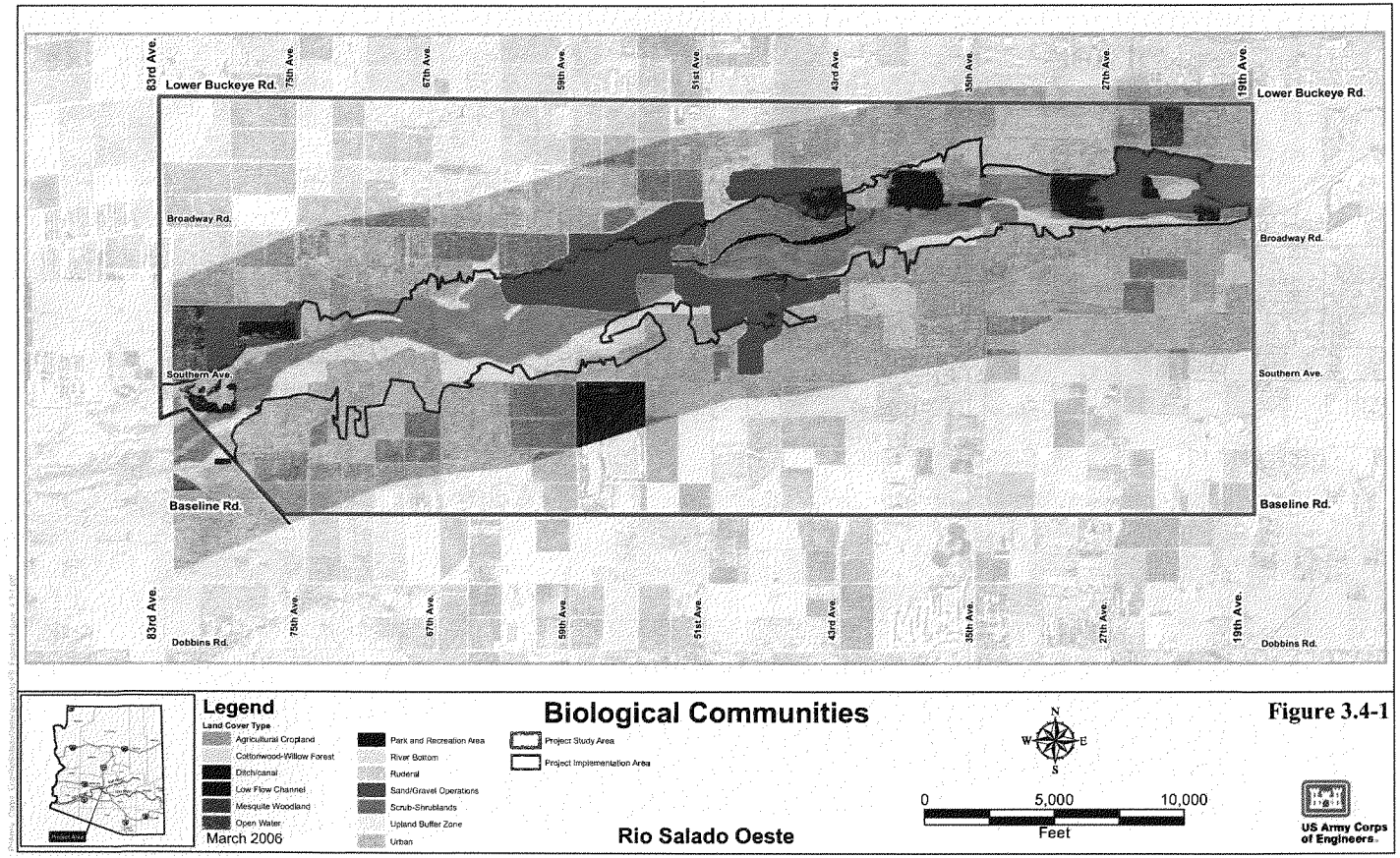
0 5,000 10,000
Feet

March 2005

Source:
Groundwater Quality and Hydrogeology Report, (URS 2002a)

Rio Salado Oeste

US Army Corps of Engineers.


Lower Buckeye Rd.
Broadway Rd.
Southern Ave.
Baseline Rd.
Dobbins Rd.
83rd Ave.
75th Ave.
67th Ave.
59th Ave.
51st Ave.
43rd Ave.
35th Ave.
27th Ave.
19th Ave.
Legend
Land Cover Type
Agricultural Cropland
Cottonwood-Willow Forest
Ditch/canal
Low Flow Channel
Mesquite Woodland
Open Water
Park and Recreation Area
River Bottom
Ruderal
Sand/Gravel Operations
Scrub-Shrublands
Upland Buffer Zone
Urban
Project Study Area
Project Implementation Area
March 2006
Biological Communities
Rio Salado Oeste
N
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5,000
10,000
Feet
US Army Corps of Engineers

Figure 3.4-1

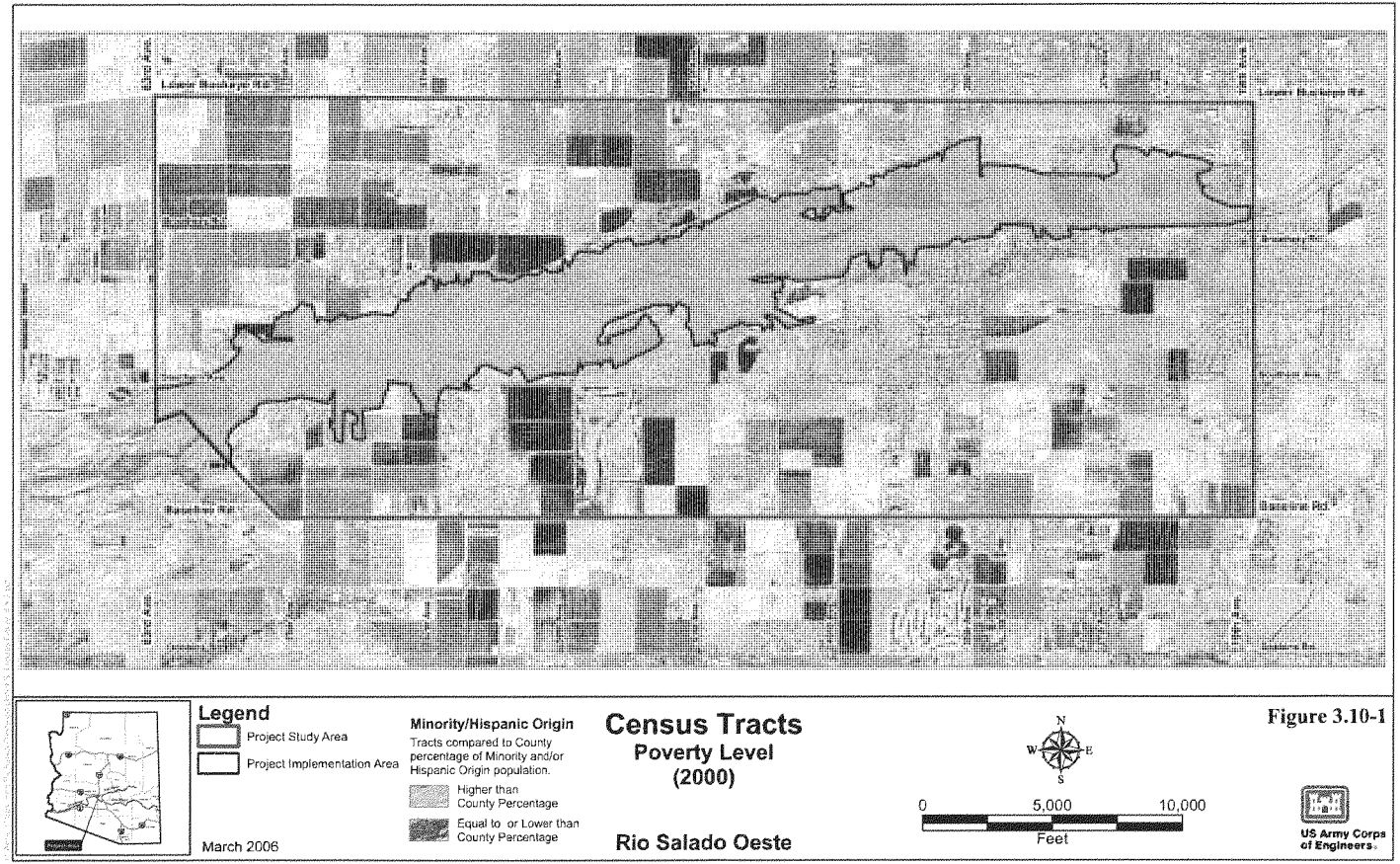

Legend
Project Study Area
Project Implementation Area
March 2006
Minority/Hispanic Origin
Tracts compared to County percentage of Minority and/or Hispanic Origin population.
Higher than County Percentage
Equal to or Lower than County Percentage
Census Tracts
Poverty Level
(2000)
Rio Salado Oeste
N
W
E
S
0
5,000
10,000
Feet
US Army Corps of Engineers

Figure 3.10-1

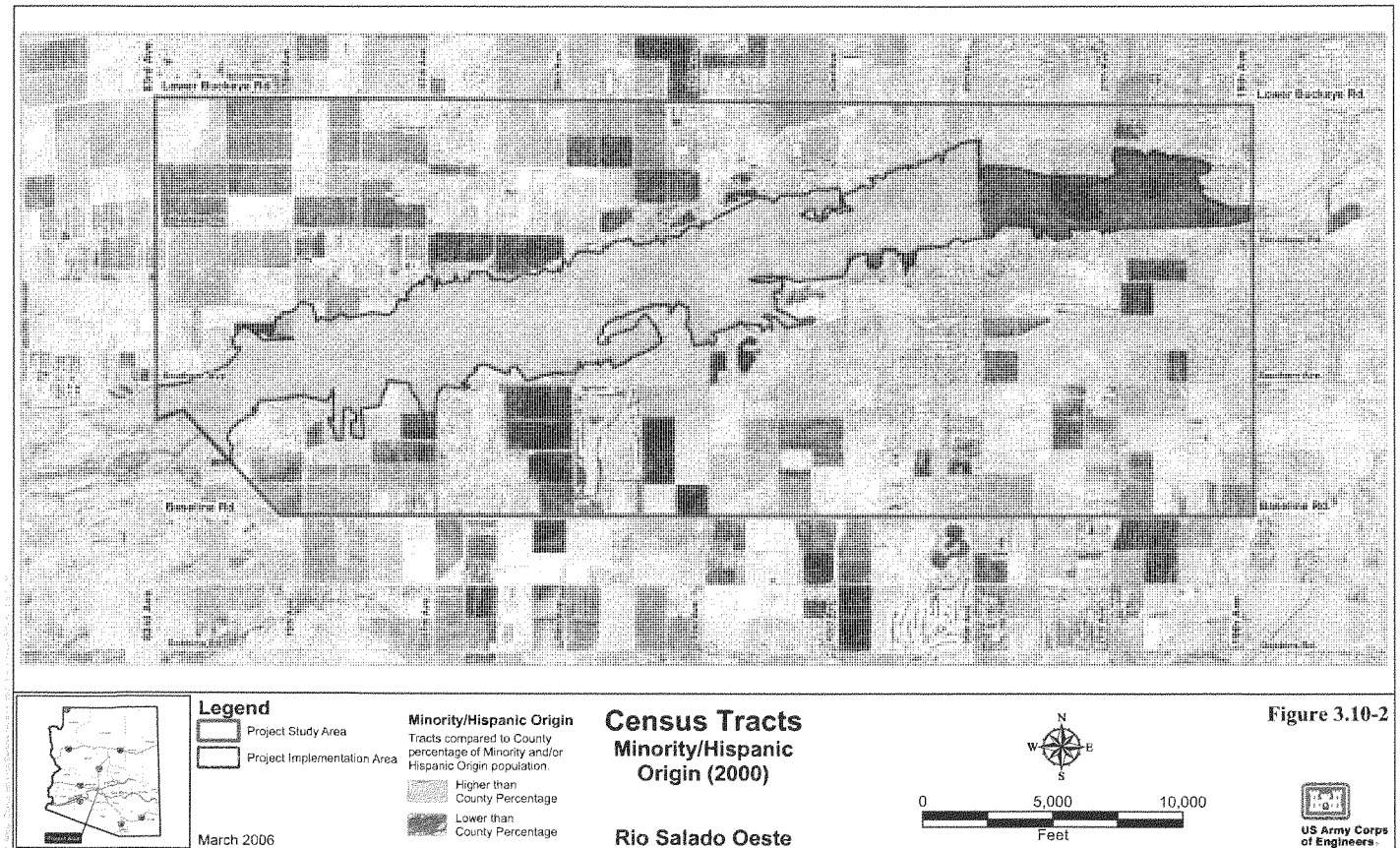
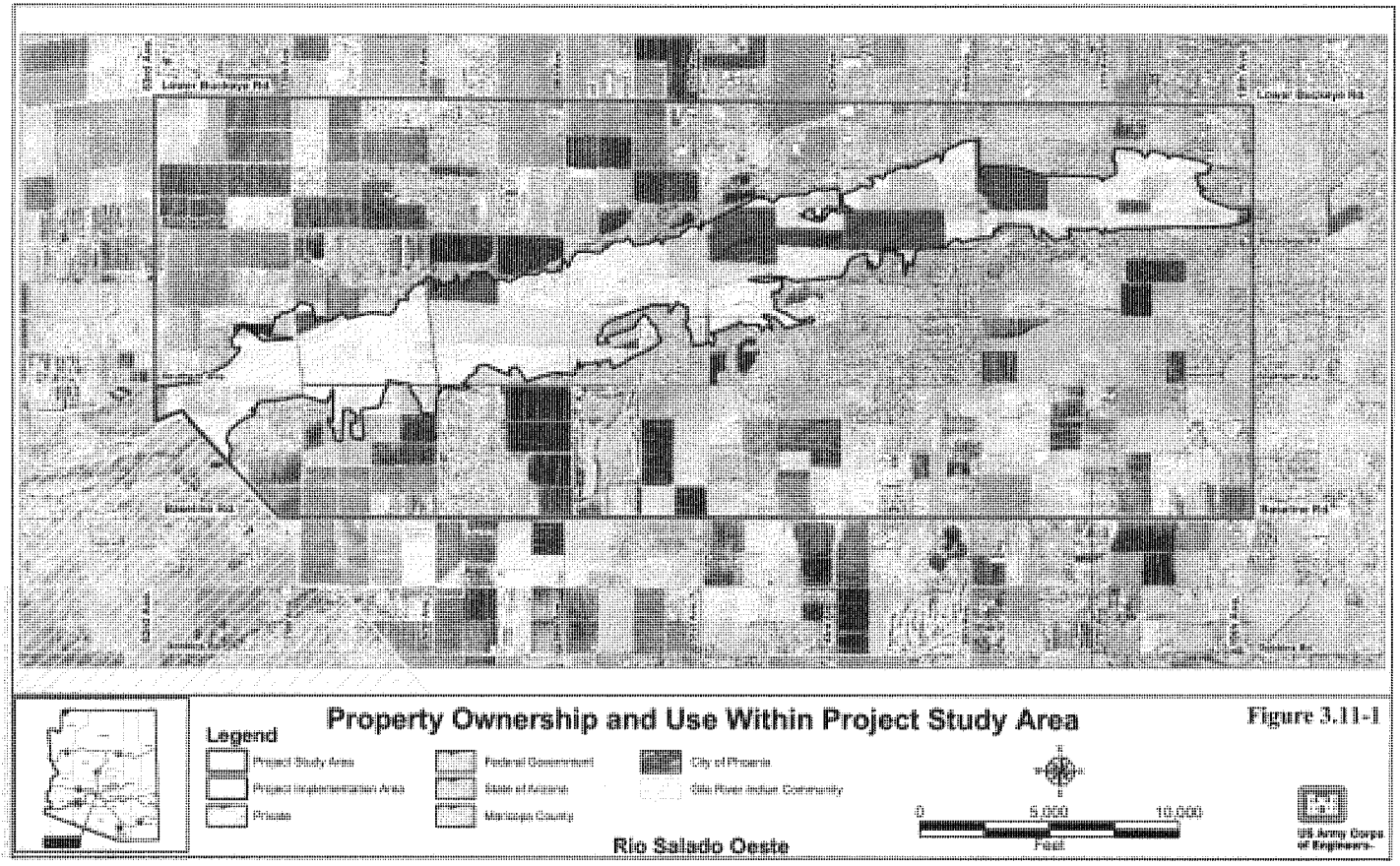
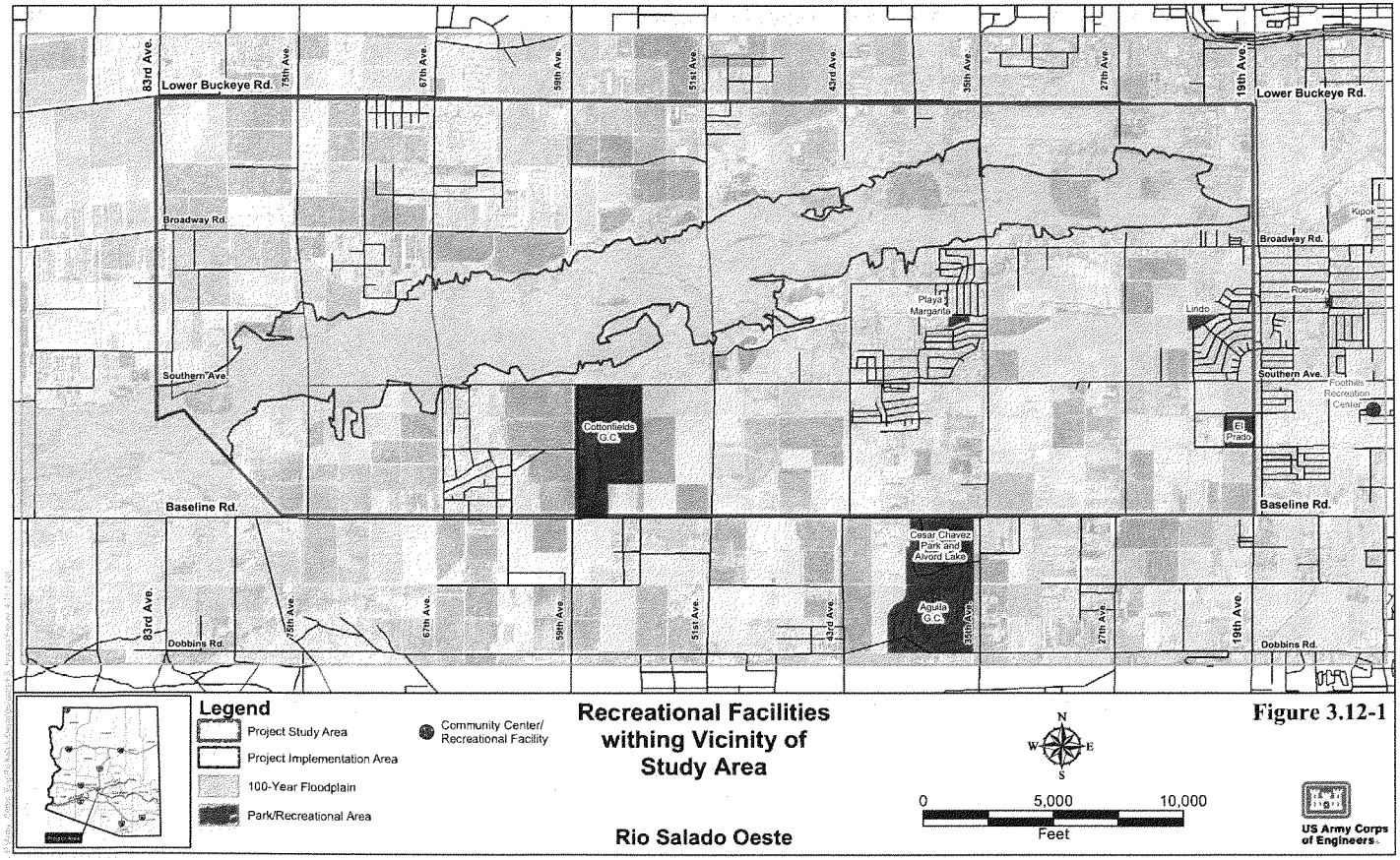

Lower Buckeye Rd.
Lower Buckeye Rd.
Baseline Rd.
Baseline Rd.
Legend
Project Study Area
Project Implementation Area
Minority/Hispanic Origin
Tracts compared to County percentage of Minority and/or Hispanic Origin population.
Higher than County Percentage
Lower than County Percentage
March 2006
Census Tracts
Minority/Hispanic Origin (2000)
Rio Salado Oeste
N
W
E
S
0
5,000
10,000
Feet
US Army Corps of Engineers

Figure 3.10-2


Property Ownership and Use Within Project Study Area
Figure 3.11-1
Legend
Project Study Area
Project Implementation Area
Private
Federal Government
State of Arizona
Maricopa County
City of Phoenix
Gila River Indian Community
0
5,000
10,000
Feet
Rio Salado Oeste
US Army Corps of Engineers



Recreational Facilities withing Vicinity of Study Area

Rio Salado Oeste

Figure 3.12-1

CHAPTER 4
ENVIRONMENTAL CONSEQUENCES

This section forms the scientific and analytic basis for the comparisons of alternatives. It describes the environmental effects associated with the No-Action alternative and each of the action alternatives. It explains the approach and methodology used to perform the analysis and the results of the analysis, both indirect and direct. The environmental effects are described separately for each resource area and alternative. Mitigation measures are provided for impacts that are substantial and adverse. While some short-term impacts would occur as a result of project construction and temporary site disturbance, the long-term impacts are expected to be beneficial.

4.1 TOPOGRAPHY AND GEOLOGY

4.1.1 APPROACH AND METHODOLOGY

Impacts involving topography and geology in or near the project area focus on how project-related construction activities and proposed site improvements may impact the soil and erosion potential. The study area is characterized by a group of soils that are often sandy to gravelly, may include lenses of finer particles, and are often redistributed by water flows associated with nearby active channels. Borrow materials are abundant and currently being utilized in the local area. Two stone borrow sites have been identified as sources of construction material and may be available for potential use by a contractor.

Other evaluated impacts include changes to the surface and/or groundwater hydrogeology. The evaluation classified the hydrogeologic units, depths, and materials composition. The potential significance for impacts was based on past field experience with similar restoration projects.

As discussed in Section 7.1 of the Geotechnical Evaluation, Appendix E of the Feasibility Report, no known active faults are known to occur on or near the project site therefore 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 not anticipated. In addition, subsidence in the project area has not occurred in the past and there is very little potential for subsidence to occur in the future. Therefore, subsidence is not projected to influence design or operation of the Rio Salado Oeste project

4.1.2 ENVIRONMENTAL IMPACTS

4.1.2.1 No-Action Alternative

Under the No-Action Alternative, no impacts would occur related to topography and geology. Conditions along the river channel are expected to remain essentially the same as current conditions. Landforms would remain approximately the same though 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. The minor recharge sources-such as seepage from canals and irrigated land, underflow along major streams, and rainfall will most likely remain the most significant source for subflow replenishment. Additionally, ongoing human encroachment and gravel mining will continue to adversely affect the river channel profile and planform. In the short-term, on-going gravel mining within the project are will cause upstream headcutting and sediment trapping within the gravel pits Sediment trapping would lead to a reduction in downstream sediment transport would lead to associated downstream channel bed and bank erosion. Long-term impacts 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.

4.1.2.2 Alternatives 2, 4, 5, 5A, and 5B

4.1.2.2.1 Impact: Minor Geomorphologic Changes in River Channel

Activities related to topography and geology under these alternatives include the modification of existing stormwater outfall areas to improve retention and water spreading and modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th Avenue to 83rd Avenue. These procedures would involve several forms of reshaping, including excavation and grading. All Alternatives, with the exception of Alternative 2, would add supplemental effluent and clay fill material, which would be used to restore increasing amounts of habitat, including in-channel wetlands. Moreover, Alternatives 5A and 5B would add significant amounts of fill material to the gravel pits at 27th and 37th Avenues to restore them to the floodplain.

Under all of the Alternatives, the geomorphologic character of the existing landscape would be permanently altered due to the many reshaping procedures planned for the project. River bottom areas would undergo surface reshaping, which includes moving soil to fill depressions or removing unwanted mounds. In addition, soils would be imported to various areas to provide the necessary substrate for new vegetation. Clay, mixed gravel, and cobble layers would be placed in areas of proposed wetland habitats in Alternatives 4, 5, 5A, and 5B.

Implementation of the project would no doubt require moving a significant amount of earth, regrading of large areas, and addition of new materials. However, the impact to the hydrogeology would be less than significant because the structure and function of the existing alluvial materials and stratification described in the Geotechnical Evaluation, Appendix E, would remain intact, with the possible exception of higher than existing levels of clay where new emergent wetlands are proposed. The soil erosion loss potential would likely be reduced with terracing and regrading, except for the initial construction-related effects.

Mitigation Measure: No mitigation required.

4.1.2.2.2 Impact: Beneficial Changes to River Channel

All of the Alternatives would decrease the potential for soil loss through regrading and terracing of the primary conveyance channel to a more natural state, and through planting new vegetation.

Alternatives 4, 5, 5A, and 5B have the potential to restore historically present surface flow in some areas through the addition of supplemental effluent and added clay fill material, both of which would be used to restore increasing amounts of habitat, including in-channel wetlands.

Alternatives 5A and 5B would add significant amounts of fill material to the gravel pits at 27th and 37th Avenues to restore them to the floodplain. This would decrease the potential for those gravel pits to trap sediments that would otherwise flow downstream.

These are all considered beneficial effects.

Mitigation Measure: No mitigation required.

4.2 HYDROLOGY AND WATER RESOURCES

4.2.1 APPROACH AND METHODOLOGY

This section describes the impacts of the various alternatives to hydrology and water resources 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 and 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. A sedimentation analysis was completed to determine the impacts of the potential changes in the shape and grading of the streambed. Groundwater hydrological impacts were analyzed to determine whether an alternative would result in a substantial loss or change in groundwater resources within the area.

4.2.2 ENVIRONMENTAL IMPACTS

4.2.2.1 No-Action Alternative

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.

4.2.2.2 Alternatives 2, 4, 5, 5A, and 5B

4.2.2.2.1 Impact: Changes in the 100-year Water Surface Elevations

Channel reshaping and vegetation planting activities proposed under all of the alternatives has the potential to increase 100-year surface elevations and to increase the potential for flooding in

the project area. As a 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, beginning with the alternative that had the most potential to increase the 100-year surface elevation, Alternative 5A. This alternative did not significantly increase the flood damages in the project area. Thus, the remaining Alternatives, 2, 4, 5, and 5B would not significantly increase flood damages either.

Mitigation Measures: No mitigation required.

4.2.2.2.2 Impact: Potential Changes in Groundwater Depths

Sediments within the Salt River are divided into four units. Rio Salado Oeste construction will occur only at the upper most unit of the basin, the Upper Alluvial Unit (UAU). This unit runs 300-400 feet deep. In the past, the UAU was the primary source of groundwater in the valley, but because of lower water levels (decreased groundwater elevations) and large areas of poor quality water, only about one fourth of groundwater pumped in the valley is from the UAU. Important sources of recharges to groundwater in the valley include infiltration of Salt River flows, mountain recharge along the McDowell and Superstition Mountains, percolation of excess irrigation water, and canal seepage.

Within project implementation area, static water level is relatively shallow, ranging from 20 to 50 feet below ground surface within the Salt River channel to 60 to 80 feet below ground surface north and south of the river. Fluctuations in static water level can be as much as 20 to 30 feet on an annual basis due to agriculture pumping demands, and have declined as much as 25 feet in the last five years (Dames & Moore, 1991; Parsons Engineering Science, 2001). Contributing factors that may cause the fluctuations are water discharge from the 35th Avenue water treatment plant outfall during winter months that produces groundwater mounding, and related radial flow during periods of discharge and basin-wide groundwater pumping and stormwater runoff into the Salt River. . In general the selected wells show a consistent water level decline without radical changes in gradient direction. Therefore, while the groundwater elevation has declined approximately 10 to 20 feet since 1997, the current contours are likely to be similar to the 1997 contours (URS, 2002).

Alternative 2 should not have any impacts on changes in groundwater elevation since it does not add water sources to the project implementation area. Alternatives 4, 5, 5A and 5B, however, add effluent to the project area in order to create additional riparian habitat. The additional water resources have the potential to increase groundwater elevation, but to insignificant levels.

Mitigation Measures: No mitigation required.

4.2.2.2.3 Impact: Beneficial Changes in Sedimentation

Based on HEC-RAS modeling, the No-Action alternative would result in a scour hole downstream of the 35th Avenue Bridge within 10-years time. Implementation of all of the alternatives would include a grade control structure in the area to prevent the development of this

scour hole. Also, all of the alternatives would create a more homogenous riverbed slope that would transport sediment more effectively and efficiently than the No-Action alternative.

Mitigation Measures: No mitigation required.

4.3 WATER QUALITY

4.3.1 APPROACH AND METHODOLOGY

This section describes the impacts of the various alternatives to 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. The 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. A Stormwater Pollution Prevention Plan (SWPPP) would be prepared for the recommended plan, and additional water quality compliance permits for project construction would be obtained in coordination and consultation with the Arizona Department of Environmental Quality (ADEQ).

The project alternatives must also comply with Section 404(b)(1) Guidelines of the Clean Water Act of 1977 which state, "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."

4.3.2 ENVIRONMENTAL IMPACTS

4.3.2.1 No-Action Alternative

Under the No-Action Alternative no construction would take place and thus, would not create any adverse temporary effects to water quality. 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.

4.3.2.2 Alternatives 2, 4, 5, 5A and 5B

4.3.2.2.1 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, irrigation system establishment, channel excavation and reshaping, and channel terracing. These activities, as well as operations and maintenance (OMRR&R) activities such as sediment removal, would result in soil disturbance and have the

potential to cause temporary discharges of soil and sediment into the river channel. Soil that is discharged into the river channel can 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 Best Management Practices.

Mitigation Measure WQ-1: Implement Erosion Control Best Management Practices (BMPs)

The Corps and its contractors shall implement erosion control measures throughout the construction period and during implementation of OMRR&R activities to minimize erosion and sediment input into the river. The Corps would oversee implementation of erosion control measures during construction. The contractor selected for the project shall:

- Conduct construction and OMRR&R 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 required clearing, grading, revegetation, or reshaping in a way that minimizes 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;
- Apply water to unpaved haul roads at a frequency adequate to maintain visible surface moisture;
- 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 diver flow around the channel and bank construction areas.
- If hay bales are used for erosion control during construction they must be sterile and weed-free.

4.3.2.2.2 Impact: Potential Adverse Effects on Water Quality Associated with Accidental Spills of Fuels or Other Toxic Materials during Project Construction

Project construction and restoration activated 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 BMPs.

Mitigation Measure WQ-2: Implement Spill Prevention Measures

The Corps and its contractors would 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 would oversee development and implementation of a stormwater pollution prevention plan. Elements of that plan would 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 clean-up procedures employed;
- staging and storage areas for equipment, materials, fuels, lubricants, solvents, and other possible contaminants are located at least 100-feet a way 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).

4.3.2.2.3 Impact: Potential Beneficial Effects on Water Quality Associated with Stormwater

All of the alternatives include the creation of additional In-Channel Wetlands. The addition of In-Channel Wetlands has the potential to increase the retention of nutrients carried in by fine sediments, which would improve water quality. The wetland plants would also act as filters by taking up nutrients (such as nitrogen and phosphorus), which can cause algal blooms and fish kills in streams and lakes. Wetland vegetation would provide additional water quality benefits, such as removing additional nitrogen through the action of soil bacteria, binding to metal pollutants such as lead, zinc and cadmium, removing some kinds of pesticides bound to sediments, retaining other pesticides long enough for them to break down into less harmful components, and preventing stormwater runoff from causing destructive downstream soil erosion by holding water after a storm and releasing it slowly (Ohio EPA Fact Sheets and Publications, 2006).

Mitigation Measures: No mitigation required.

4.3.2.3 Alternatives 4, 5, 5A, and 5B

4.3.2.3.1 Impact: Potential Adverse Effects on Water Quality Associated with Effluent

Alternatives 4, 5, 5A, and 5B add supplemental water supply in the form of effluent from the 23rd Avenue Wastewater Treatment Plant. Wastewater from this plant undergoes tertiary treatment and is released at wastewater class A+. Arizona Administrative Code, Title 18, Environmental Quality defines the classification of A+ as: "...wastewater that has undergone secondary treatment, filtration, nitrogen removal treatment, and disinfection..." In addition, A+ wastewater

turbidity must be kept below five Nephelometric Turbidity Units (NTUs), a measure of water clarity, at all times, and strict regulations minimize fecal coliform organisms and enteric viruses. In summary, no adverse effects on water quality associated with effluent use are anticipated.

Mitigation Measures: No mitigation required.

4.3.2.3.2 Impact: Potential Adverse Effects on Groundwater Quality associated with Introduction of Effluent Water Source

While the water quality of the 23rd Avenue WWTP would not adversely impact overall water quality within the project, there is a chance that portions of the additional water source may enter the groundwater within the Upper Alluvial Unit (UAU) above and beyond current conditions. If such recharging occurs, the potential for it to leach contaminants that may be present in the project implementation area exists. Appendix D of the Feasibility Report, Groundwater Quality Hydrogeology Report analyzed this potential with a modified Phase I Environmental Site Assessment. The report investigated four areas of potential groundwater concern: Water Quality Assurance Revolving Fund (WQARF) or National Priority List (NPL) sites, also known as Superfund sites, Landfills, WWTPs, and Leaking Underground Storage Tank sites (LUSTs).

The report concluded that potential adverse effects would not occur due to WQARF/NPL sites because the sites of concern are located upgradient of project features. The landfills are for the most part under the OMRR&R phase of remediation and are located outside the possible locations for project features. Therefore, potential adverse effects from landfills are considered not to be significant. Only the 23rd Avenue WWTP impacts groundwater in the project implementation area and lies within the potential project features areas. This WWTP is currently at A+ standards and is monitored regularly. No potential adverse effects are expected to occur to groundwater sources due to WWTPs. Thirteen LUST sites with monitoring wells on record with ADWR were identified within the study area. These sites may have impacts to local soil and water conditions but are not considered likely to affect the project to be implemented within the floodplain.

In conclusion, a possibility remains that additional groundwater recharge may occur due to the supplemental effluent in Alternatives 4, 5, 5A and 5B. The four investigation areas of potential concern are determined to have a less than significant impact on groundwater quality.

Mitigation Measures: No mitigation required.

4.4 BIOLOGICAL RESOURCES

This section analyzes the impact of each alternative on the biological resources of the Rio Salado Oeste study area. The impacts analysis focuses on short-term effects that project construction, implementation, and operation may have on existing vegetation and wildlife. The long-term biological impacts are expected to be beneficial because the major focus of the action alternatives is ecosystem restoration, which would increase wildlife habitat in the study area.

4.4.1 APPROACH AND METHODOLOGY

In June 2002, a team of biologists and other specialists in related fields conducted the habitat evaluation analysis for baseline and future without-project conditions using the Hydrogeomorphic (HGM) approach. The HGM team consisted of Corps (Los Angeles District [LAD] and Engineer Research and Development Center [ERDC]) personnel, representatives from the non-federal sponsor (City of Phoenix), and federal and state resource agency personnel. In May 2004, the HGM team conducted the HGM analysis for the action alternatives. The HGM analysis provides quantitative estimates of projected habitat benefits over the period of analysis for the alternatives, and also provides a means of comparing the benefits of the different alternatives, including the No-Action alternative. HGM benefits are expressed as Functional Capacity Units (FCUs). Members of the HGM team develop Functional Capacity Indices, which are the indices within the ecosystem that can be quantified to present a range of how the ecosystem is functioning and how it would function with different alternatives. Indices include such functions as: floodwater detention, internal nutrient cycling, organic carbon export, removal and sequestration of elements and compounds, maintenance of characteristic plant communities, and wildlife habitat maintenance. These FCIs can then be multiplied by acreages to derive Functional Capacity Units, or the unit that provides a means of assessing the gains or losses in functional value for a single target year of interest. For all alternatives, a baseline condition of 583 FCUs is used. The FCUs are averaged over the period of analysis for the project (51 years for this study) to determine Average Annual FCUs (AAFCUs) for each alternative. This analysis includes the AAFCUs for each of the alternatives for purposes of comparison. The detailed HGM analysis is included as Appendix I of the Feasibility Report.

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. In general, the following criteria were considered in determining significant impacts on biological resources:

- Loss of individuals or populations of a Special Status species or critical habitat for listed species
- Loss of critical habitat or sensitive plant communities
- Substantial loss of species or community diversity in natural vegetation and wildlife habitat
- Substantial loss of populations or habitat of Special Status that would jeopardize the continued existence of the species within the region
- Adverse effects on special aquatic sites (e.g., wetlands)
- Substantial loss of natural vegetation
- Loss or long-term disruption of a major wildlife movement corridor
- Take or harassment of any listed threatened or endangered species

4.4.2 ENVIRONMENTAL IMPACTS

4.4.2.1 No-Action Alternative

The No-Action Alternative would occur if no federal action is conducted. The Rio Salado Oeste study area has already been highly degraded due to construction of upstream dams, disconnection of the riparian ecosystem from groundwater sources, sand and gravel mining, and development associated with the Phoenix metropolitan area. Future characteristics along the Salt River channel are expected to remain similar to current conditions, though the location of active sand and gravel mining activities would change. The addition of increased impervious surfaces along portions of the floodplain upstream would likely result in increased flow rates for the river following rain events, particularly for those smaller events that mostly infiltrate under current conditions. Existing cottonwood/willow areas are highly fragmented and are being replaced by salt cedar. The small remnant habitat that remains is supported by stormwater outfalls and wastewater effluent discharges, which are expected to continue in theWithout-Project condition. Due to the lack of suitable habitat and the proximity of the Phoenix metropolitan area, riparian wildlife species are already largely absent from the area.

4.4.2.1.1 Impact: Long-Term Decrease in Vegetation

In the HGM functional assessment, many assumptions are proposed. The study area is quickly urbanizing with industrial and medium-density residential development. The study estimated that all 133 acres of agricultural land in the study area would be converted to urban (residential) uses within six years. As this development occurs, impervious ground cover would increase, thereby reducing both available land for native habitat and infiltration of runoff. The already rare cottonwood/willow forest is forecast to decrease in area from 112 acres to 25 acres over the next 50 years, primarily due to decreasing water availability and competition from the invasive salt cedar. The lost cottonwood/willow area is expected to slowly convert to less desirable scrub-shrub lands, which already dominate the study area. An additional five acres of wet river bottom habitat would convert to dry river bottom in the same period due to an assumed reduction in wastewater discharge at the 23rd Avenue wastewater treatment plant. While a reduction in wetland area from 30 acres to 25 acres seems inconsequential, nearly all of this habitat type has already been lost. The small amount of wetlands that would remain would be supported by wastewater effluents that are expected to continue. Ecologically important mesquite bosques have already been completely eliminated from the area and would remain absent. An additional 160 acres of desert/bare earth is expected to be created in the same period, primarily due to loss of open water areas remaining from inactive sand and gravel operations. Due to pending permit applications for new sand and gravel mining operations, it was assumed that the acreage of sand and gravel pits would remain approximately the same (671 acres), but would move to new sites at the west end of the study area. Together with the noted loss in other natural settings such as desert and open water habitats, the overall loss of wetland and terrestrial communities that serve as habitat for a myriad of wildlife species is significant.

The issue of groundwater overdraft is an extremely important one in the Salt River watershed. Despite the obvious evidence of water within the channel through many portions of the study area, the watershed throughout the area remains in a state of moderate to severe groundwater

depletion. Historic groundwater levels (that may have actually or nearly reached the surface in some reaches of the channel) now range from approximately 30 to 100 feet below the surface. This issue impacts a number of resources in the study area, notably riparian habitats and associated wildlife. All existing native riparian vegetation within the study area is completely dependent on the availability of water. Were it not for effluent flows in the channel, nothing would remain of these diverse and critical riparian resources. Without this source, the vegetation would gradually give way to xeric species more suited to desert upland settings. Current effluent flow supports a limited but significant growth of vegetation in those reaches in which water remains on the surface, or flows as shallow subsurface flow. The contribution of effluent to this shallow groundwater zone cannot be underestimated. Despite its importance, a reduction in the volume of this effluent is anticipated within the next 6 years.

4.4.2.1.2 Impact: Long-Term Changes in Fish and Wildlife Populations

The already rare cottonwood/willow forest is forecast to decrease in area from 112 acres to 25 acres over the next 50 years, primarily due to decreasing water availability and competition from the invasive salt cedar. Cottonwood-willow forest 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 provides a variety of foods and microclimate conditions for wildlife. Cottonwood-willow habitat provides substantial nesting support for large birds, such as Great Blue Heron, Red-Tailed Hawk, American Kestrel, Western Screech Owl, Great Horned Owl and the Northern Flicker. Due to the changes in vegetation, it is anticipated that wildlife that utilizes cottonwood/willow, or that requires ponded water would significantly decrease in the area.

The lost cottonwood/willow area is expected to slowly convert to less desirable scrub-shrub lands, which already dominate the study area. Thus, species that are able to survive in scrub-shrublands would likely remain and perhaps increase in number.

4.4.2.1.3 Impact: Long-Term Effects of Recreational Use to Wildlife and Vegetation

The disturbance from unregulated recreation, off-highway vehicle traffic and "wildcat" dumping is expected to continue and potentially increase in some areas, further degrading the riparian system.

4.4.2.1.4 Impact: Long-Term Decrease in Potential for Threatened and Endangered Species

Ten special-status species have the potential to occur in the study area: the lowland leopard frog, desert tortoise, Mexican garter snake, cactus ferruginous pygmy owl, Yuma clapper rail, southwestern willow flycatcher, western yellow-billed cuckoo, American peregrine falcon, bald eagle and the lesser long-nosed bat. All of these species are considered to be Wildlife of Special Concern by Arizona Game and Fish Department and six of them are considered to be a Candidate Species, Threatened or Endangered by the U.S. Fish and Wildlife Service (Table 3.4-2). Under the No-Action Alternative, these species would experience a continual degradation of their requisite habitats.

The decrease of cottonwood/willow forests from 112 acres to 25 acres effectively removes the potential for the Yuma clapper rail and southwestern willow flycatcher to return to breed within the project area. Conversion of agricultural land to urban uses, through time, would eliminate potential for recovery of the cactus ferruginous pygmy owl and lesser long-nosed bat due to lighting, noise, and loss of habitat within the urban areas.

4.4.2.1.5 Impact: No Change in Functional Capacity Units.

The average functional capacity index (FCI) score across the ten functions listed in Table IV-8 of the Feasibility Report, was 0.33, which indicates a fair to moderately low functioning wetland ecosystem at best. Over the 50-year planning horizon, the Without-Project FCUs are predicted to decline from 583 at target year (TY) 0, the year baseline conditions are established, to 579 FCUs at TY 51, the end of the period of analysis. Therefore, the without-project AACFU output is forecast to remain essentially unchanged (the slight decline from 583 AAFCU to 579 AAFCU is due to rounding error).

4.4.2.2 Alternatives 2, 4, 5, 5A and 5B

4.4.2.2.1 Impact: Potential Short-Term Decrease in Vegetation due to Construction

Clearing, grading, and other construction-related activities would eliminate a minimum of 137 acres of disturbed scrub-shrubland, sparsely vegetated river bottom habitat, and other disturbed habitat in the vicinity of the stormwater outfall areas. Alternatives 4, 5, 5A and 5B would eliminate an additional 324 acres of mostly disturbed shrub-scrublands for the creation of additional cottonwood/willow and mesquite habitats. While the quality of the vegetation is less than desirable, the temporary loss in amount of vegetation is significant. These effects can be minimized with mitigation.

Mitigation Measure BR-1: Re-vegetation Construction Management Practices.

The Corps would remove salt cedar (*Tamarix spp.*) and giant reed (*Arundo donax*) from the restoration areas as part of the restoration process (Alternatives 4, 5, 5A, and 5B). The City of Phoenix, the non-federal sponsor, would be responsible for maintaining the restored habitat areas free of invasive plants, especially salt cedar and giant reed, throughout the life of the project (Alternatives 4, 5, 5A, and 5B).

The cleared areas would be re-vegetated with habitat of higher quality and permanence than the habitat removed. Implementation of good construction management practices, especially dust suppression with water and/or non-toxic dust-suppressing chemicals or soil binders, would minimize potential impacts from fugitive dust. Also, decreases in the vegetation population 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 to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Mitigation Measure BR-2: Use Clean and Certified Foreign Soils

If any imported topsoil is used in the restoration project, it shall be clean and certified free of weeds, including seeds (Alternatives 2, 4, 5, 5A, and 5B). Feral or free-ranging cats and dogs shall be reported to the local of Animal Control office, and signs shall be posted prohibiting the release of pets of any kind and the use of the restoration area by unrestrained pets (Alternatives 2, 4, 5, 5A, and 5B).

4.4.2.2.2 Impact: Long-Term Increase in Vegetation

Restoration of the disturbed and sparsely vegetated habitat in the channel and outfall areas would result in long-term beneficial effects. All of the alternatives would restore approximately 66 acres of cottonwood/willow habitat, 43 acres of mesquite habitat and 28 acres of wetland habitat in the vicinity of the stormwater outfalls. Alternatives 4, 5, 5A and 5B would restore significantly more acres of habitat; see Table ES-1 for further detail.

Approximately 773 acres of disturbed scrub-shrublands and disturbed river bottom habitat along the channel corridor would be restored to potentially support higher quality Sonoran Desert riparian habitat. Table 2.5-1 summarizes the restored acreage of various vegetative communities for each alternative.

Mitigation Measures: No Mitigation Required.

4.4.2.2.3 Impact: Short-Term Decrease in Fish and Wildlife Populations due to Construction and OMRR&R Activities

Channel clearing and reconfiguration activities in the channel and in the vicinity of the outfalls would temporarily displace onsite wildlife. Some mortality of slower-moving ground-dwelling wildlife on site may occur with vehicular traffic during construction and OMRR&R. Noise and other disturbance associated with the operation of large construction equipment may displace additional wildlife in adjacent areas. Vector control may have slight affects to fish and wildlife populations depending on the type of control. Due to the generally low existing habitat values in the project area and the temporary nature of the disturbance, short-term impacts to wildlife would be adverse but not significant.

Mitigation Measure BR-3: Safe Harbor Agreements, Candidate Conservation Plan and Habitat Conservation Plans

The Corps will encourage the non-Federal sponsor to enter into a Safe Harbor Agreement, Candidate Conservation Plan, or Habitat Conservation Plan as necessary for the continued O&M of the Rio Salado Oeste project. It is expected that with the development of agreements for the Rio Salado and Tres Rios restoration projects an additional agreement for the Rio Salado Oeste project will be developed.

4.4.2.2.4 Long-Term Benefits to Fish and Wildlife Populations

Restoration of the disturbed and sparsely vegetated habitat in the channel and outfall areas would result in a long-term beneficial effect. This alternative would restore approximately 137 acres of disturbed scrub-shrublands and disturbed river bottom to native habitat cover types that once naturally occurred in the area. Restored habitats would increase the quantity and quality of cover, forage, and breeding areas for existing wildlife populations in the Rio Salado Oeste reach. Alternative 2 would also provide opportunities for a higher diversity of native wildlife than under existing conditions. In the vicinity of the outfalls, project features would especially benefit amphibians and birds associated with wetlands and riparian habitats. Channel restoration would greatly increase the value of the Rio Salado Oeste reach as a wildlife corridor. Channel restoration would provide habitat connectivity between the authorized Rio Salado project, immediately upstream from the Rio Salado Oeste study area, and the downstream Tres Rios Environmental Restoration project. The Tres Rios project, currently under construction, extends downstream from the Rio Salado Oeste study area for nine miles to the confluence of the Gila and Agua Fria Rivers. This wildlife corridor connection would increase the values of the upstream and downstream projects to extend beyond the benefits gained on site.

Mitigation Measures: No Mitigation Required.

4.4.2.2.5 Impact: Potential Adverse Effects of Recreation to Wildlife and Vegetation

The recreation component is broken down into three primary areas for easier analysis: the channel, the bank and the terrace. No significant adverse effects of recreation to wildlife and vegetation are expected to occur because of increases in recreational users and park rangers within the area.

The channel would be accessible by the trail system from the bank at select locations along the terrace. At each transition point to the terrace, appropriate signage would inform visitors of the new habitat they are entering, and any user restrictions and expectations. The channel would provide opportunities for environmental education and developing an understanding of how the habitat has been restored.

The banks would provide recreational experiences including hiking, biking, and horseback riding to scenic overlooks, and leisure walking. Features constructed to interpret cultural and biological components would provide educational opportunities, as well as ecological themes related to the restored desert riparian habitat.

The channel is the area where the habitat has a permanent water source to create a self-sustaining ecosystem. This area would provide more limited and controlled recreational and educational experiences, such as bird watching and guided nature walks. Some areas of the channel may be designated as "sensitive" habitat, and would be protected from public impacts. The increase in regulated use would have less than significant impacts to the wildlife and vegetation.

Mitigation Measures: No Mitigation Required.

4.4.2.2.6 Impact: Short-Term Decrease in Potential for Special Status Species and Migratory Birds due to Construction

The cottonwood/willow habitats are especially important for resident and migratory 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, willow 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. Great blue herons, double-crested cormorants, snowy egrets, great egrets, western yellow-billed cuckoos, and black-crowned night-herons also roost in the cottonwood/willow vegetation and forage in nearby habitats. No special status species are known to roost in the study area.

Channel clearing and reconfiguration activities in the channel and in the vicinity of the outfalls would temporarily decrease potential to provide suitable habitat for Wildlife of Special Concern (WSC), federally Threatened, Endangered and Candidate (T, E, & C) Species, and resident and migratory avian species. Noise and other disturbance associated with construction may decrease the potential for suitable habitat outside the study area temporarily. Due to the generally low existing habitat values in the project area and the temporary nature of the disturbance, short-term impacts to the potential for special status species, resident and migratory birds would be adverse but not significant.

Mitigation Measure BR-4: Consult with USFWS and AGFD prior to Ground-Disturbing Activities

Prior to ground-disturbing activities in existing riparian or wetland areas, the Corps would consult with U.S. Fish and Wildlife Service and Arizona Game and Fish Department to determine the potential for the occurrence of any sensitive wildlife species. If sensitive species are determined to be present or to have potential to occur, the schedule for invasive removal shall be revised to avoid breeding seasons of any sensitive species on site (Alternatives 4, 5, 5A, and 5B).

Mitigation Measure BR-5: Conduct Operation & Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

Sediment removal and other activities would only be conducted during non-nesting periods of the above listed Threatened, Endangered, Wildlife of Special Concern and migratory birds. Sediment removal would be conducted on a rotating basis so that no more than 25% of the marsh area would be affected in any one year.

Mitigation Measure BR-6: Reinitiation of Section 7 Consultation

The estimated construction date for this project to commence is 2010, pending Congressional Authorization and subsequent funding for design and construction. Project area conditions may change by that time. Should new information become available or suitable habitat for

southwester willow flycatcher or Yuma clapper rail become established prior to construction commencing, protocol surveys will be conducted and section 7 consultation reinitiated as necessary.

4.4.2.2.7 Impact: Long-Term Increase in Potential for Special Status Species

Lowland leopard frog (WSC). The action alternatives are not likely to adversely impact the potential for the lowland leopard frog to exist within the study area. The species is restricted to permanent streams and generally avoids ponds or other aquatic habitats. The lowland leopard frog has disappeared from the lower Gila River and lower Colorado River systems.

Desert Tortoise (WSC). Since desert tortoises are not known to occur in the study area, none of the action alternatives would be expected to adversely this species. It is unlikely that the restoration would create suitable habitat for the desert tortoise. Therefore, implementation of any action alternative would not be likely to affect this species.

Mexican garter snake (WSC). The alternatives are not expected to adversely impact the potential for the Mexican garter snake to exist within the study area. The Mexican garter snake occurs in permanent marshes and feeds on aquatic animals, including fish and amphibians. Rio Salado Oeste would increase the area of marshes within the Salt River and thus would not adversely affect Mexican garter snake potential habitat. However, the restoration would encourage the presence of introduced, predatory species that have lead to the decline of the Mexican garter snake. Thus, there is low potential for this species to become established regardless of which alternative is selected.

Bald Eagle (Threatened and WSC). The alternatives are not expected to adversely impact the potential for bald eagle to exist within the study area. Bald eagles do not nest in the study area as here is a general lack of suitable nesting trees. However, 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 study area (CH2M HILL et al., 1997). The open water marsh in the study area may be suitable foraging habitat for bald eagles. Restoration of cottonwood/willow gallery forest may eventually provide suitable nesting habitat for bald eagle.

Yuma Clapper Rail (Endangered and WSC). The alternatives are not likely to adversely impact the potential for the Yuma Clapper Rail to exist within the study area. 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). However, the habitat within the study area is ephemeral, scarce and insufficient habitat for this species to occur. If suitable habitat develops in the project area prior to construction, protocol surveys will be conducted and consultation reinitiated, if necessary. Restoration of the river channel and associated wetlands (190 acres) throughout the project area should provide suitable habitat for the Yuma clapper rail in the future.

Alternatives 2, 4, 5, 5A and 5B all include emergent wetland establishment in the vicinity of the stormwater outfalls, and Alternatives 4, 5, 5A, and 5B include additional emergent wetlands in the study area. These additional emergent wetlands would potentially support and benefit Yuma

clapper rails. Yuma clapper rails are known to be utilizing riparian habitats in the upstream (Rio Salado) and downstream (Tres Rios) ecosystem restoration projects.

Southwestern Willow Flycatcher (Endangered and WSC). The alternatives are not expected to adversely impact the potential for southwestern willow flycatcher to exist within the study area. Since none of the alternatives involve removal of cottonwood/willow forest habitat or other suitable southwestern willow flycatcher habitat (i.e. dense thickets of salt cedar), no adverse impact is anticipated. All five action alternatives include cottonwood/willow forest establishment in the vicinity of the stormwater outfalls, and Alternatives 4, 5, 5A, and 5B include additional cottonwood/willow forest elsewhere in the study area. These additional cottonwood/willow forest habitat areas would potentially support southwestern willow flycatchers. Alternatives 4, 5, 5A, and 5B include invasive control. Salt cedar is one of the principal target invasive species, but southwestern willow flycatchers are known to use dense mature stands of this species for nesting. At present, salt cedar in the study area does not form mature dense stands suitable for southwestern willow flycatcher nesting; therefore, its removal would not affect the species. If conditions change, and salt cedar becomes considerably denser, protocol surveys would be conducted to determine if southwestern willow flycatchers are present prior to conducting invasive control measures. If at that time southwestern willow flycatchers are present, the occupied habitat would remain undisturbed until after the nesting season.

Western Yellow-Billed Cuckoo (WSC). Implementation of Rio Salado Oeste would not adversely impact the potential for the western yellow-billed cuckoo to exist within the study area. This species nests in mature cottonwood/willow riparian forests, a habitat this project would protect and increase.

Cactus Ferruginous Pygmy Owl (Endangered and WSC). Though there are no recent records indicating this species' possible existence within the study area, small amounts of habitat which could support this species do occur in the study area. These habitats are desert scrub and riparian areas with mature cottonwood/willow. Implementation of this project would not adversely impact the potential for the cactus ferruginous pygmy owl to exist within the study area.

American Peregrine Falcon (WSC). The alternatives are not likely to adversely impact the potential for the lowland leopard frog to exist within the study area. The species is known to nest on cliffs along the Salt River east of the study area.

Lesser Long-Nosed Bat (Endangered and WSC). No effect. No suitable roosting habitat (caves) or food source (Agave and saguaro flower nectar) occurs in the study area; therefore, none of the alternatives would affect this species.

Mitigation Measures: No mitigation required.

4.4.2.2.8 Impact: Increase in Functional Capacity Units.

The functional output associated with Alternative 2 at the end of the 50-year study period, or TY 51 would be 633 FCUs and an increase of 51 Average Annual FCUs over without project conditions. The function output associated with Alternative 4 at TY 51 would be 775 FCUs with

an increase of 165 AAFCUs over without-project conditions and 114 AAFCUs over Alternative 2. The functional output associated with Alternative 5 at TY 51 would be 851 FCUs with an increase of 240 AAFCUs over without-project conditions, and an increase of 75 AAFCUs over Alternative 4. The functional output associated with Alternative 5A at TY 51 would be 879 FCU with an increase of AAFCUs over without-project conditions, and an increase of 27 AAFCUs over Alternative 5. The functional output associated with Alternative 5B at TY 51 would be 865 FCUs, with an increase of 253 AAFCUs over without-project conditions, an increase of 13 AAFCUs over Alternative 5, but a decrease of 14 AAFCUs compared to Alternative 5A. This is summarized in Table 4.4-1 below.

Table 4.4-1. With-Project Average Annual Functional Capacity Units

	No-Action	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B
TY0	583	583	583	583	583	583
TY51	579	633	775	851	879	865
AAFCUs (TY0-TY51)	0*	631	745	820	847	833
Increase in AAFCUs from No-Action Alt	-	51	165	240	267	253
Change in AAFCUs Between Alternatives	-	51	114	75	27	-14

* The slight decline from 583 AAFCU to 579 AAFCU is due to rounding error.

Mitigation Measures: No Mitigation Required.

4.4.2.3 Alternatives 4, 5, 5A and 5B

4.4.2.3.1 Impact: Potential Short-Term Adverse Effects on Vegetation

Short-term impacts of providing the additional water supply system would involve minor construction activities in disturbed areas. Impacts would be adverse but not significant.

Short-term impacts of cottonwood/willow and mesquite establishment include grading and re-contouring over 300 acres (exact number depends on alternative) of mostly disturbed scrub-shrub land habitats (in addition to the 137 acres at the stormwater outfalls). Removal of native cottonwood/willow and mesquite for the construction is not anticipated. Impacts of ground-disturbing activities would be adverse but not significant. Newly planted cottonwood, willow, and mesquite trees would begin to provide habitat benefits once the vegetation matures.

Invasive control involves the removal of undesirable non-native vegetation mechanically and/or with EPA-approved herbicides. Although a small percentage of native plants are invariably removed with the invasive species, the net short-term effect of invasive control is beneficial to native vegetation.

Short-term impacts of emergent wetland establishment would involve grading and recontouring up to five acres of mostly disturbed scrub-shrubland habitats (in addition to approximately 28

acres at the stormwater outfalls). Short-term impacts of ground-disturbing activities would be similar to the impacts associated with establishing the cottonwood/willow and mesquite habitats. These impacts would be adverse but not significant. In order to reduce the intensity of the adverse impacts, the following mitigation measures would be implemented.

Mitigation Measure BR-1: Re-vegetation Construction Management Practices.

The Corps would remove salt cedar (*Tamarax* spp.) and giant reed (*Arundo donax*) from the restoration areas as part of the restoration process (Alternatives 4, 5, 5A, and 5B). The City of Phoenix, the non-federal sponsor, would be responsible for maintaining the restored habitat areas free of invasive plants, especially salt cedar and giant reed, throughout the life of the project (Alternatives 4, 5, 5A, and 5B).

The cleared areas would be re-vegetated with habitat of higher quality and permanence than the habitat removed. Implementation of good construction management practices, especially dust suppression with water and/or non-toxic dust-suppressing chemicals or soil binders, would minimize potential impacts from fugitive dust. Also, decreases in the vegetation population 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 to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Mitigation Measure BR-2: Use Clean and Certified Foreign Soils

If any imported topsoil is used in the restoration project, it shall be clean and certified free of weeds, including seeds (Alternatives 2, 4, 5, 5A, and 5B). Feral or free-ranging cats and dogs shall be reported to the local of Animal Control office, and signs shall be posted prohibiting the release of pets of any kind and the use of the restoration area by unrestrained pets (Alternatives 2, 4, 5, 5A, and 5B).

4.4.2.3.2 Impact: Long-Term Effects on Vegetation

Long-term effects of providing additional water would include increased productivity (i.e., biomass, wildlife forage and seed production) of native vegetation, increased vegetation diversity, and a potential to restore and maintain additional acres of cottonwood/willow and mesquite habitat. In addition, wetland habitat would likely become established without human intervention where conditions are favorable along the restored channel. Increased water would also support the spread of undesirable and invasive plant species, especially salt cedar (*Tamarix* spp.) and giant reed (*Arundo donax*). The impact of increased invasives would be adverse but not significant. With the inclusion of invasive control as part of this project, the long-term effects of additional water would be beneficial.

Long-term effects of cottonwood/willow and mesquite establishment include increased productivity, increased habitat structure and diversity, increased shade and cooling of the ground surface, and reduced water temperature where tree canopy overhangs the flowing channel and the edges of lakes or ponds.

Long-term invasive control involves the periodic removal of undesirable non-native vegetation mechanically and/or with EPA-approved herbicides. Periodic removal of invasives is especially beneficial during the early years following restoration, allowing the native plants to gain a competitive advantage over the invasives. The long-term effect of invasive control is highly beneficial to native vegetation.

Long-term effects of emergent wetland establishment would be beneficial. Emergent wetlands would add another element of diversity to the habitat and provide other benefits including removal of pollutants from water, substrate stabilization, and slowing flood flows. Wetlands would replace some scrub-shrublands and other disturbed habitats.

Mitigation Measures: No Mitigation Required.

4.4.2.3.3 Impact: Short-Term Effects on Fish & Wildlife

Short-term impacts of minor construction activities to provide additional water to the habitat would temporarily displace some wildlife. Because construction-related disturbance would be minor, little or no wildlife mortality is anticipated. Impacts would be adverse but not significant.

Short-term impacts of cottonwood/willow and mesquite establishment would include grading and recontouring activities in mostly disturbed scrub-shrubland and disturbed river bottom habitats (in addition to the stormwater outfalls as described in Alternative 2). Due to the additional project features of Alternative 4, a larger wildlife population would be temporarily displaced. As with Alternative 2, impacts of ground-disturbing activities would be adverse but not significant. Newly planted cottonwood, willow, and mesquite trees would begin to provide habitat benefits almost immediately.

Invasive control, either mechanically and/or with EPA-approved herbicides, may have an adverse but not significant short-term impact on wildlife. Mechanical removal of invasives would temporarily displace some native wildlife adapted to living in salt cedar or other non-native vegetation. Herbicide application, if used, would have little or no adverse impact on wildlife because only EPA-approved herbicides would be authorized.

Short-term impacts of emergent wetland establishment would be similar to the impacts associated with establishing the cottonwood/willow and mesquite habitats. Grading, recontouring, and establishing the necessary hydrology to support wetlands would displace or eliminate a small percentage of the existing wildlife in the study area. Due to this additional project feature in Alternatives 4, 5, 5A and 5B, an incrementally larger wildlife population would be temporarily displaced than with Alternative 2. These impacts would be adverse but not significant.

Mitigation Measure BR-3: Safe Harbor Agreements, Candidate Conservation Plan and Habitat Conservation Plans

The Corps will encourage the non-Federal sponsor to enter into a Safe Harbor Agreement, Candidate Conservation Plan, or Habitat Conservation Plan as necessary for the continued O&M of the Rio Salado Oeste project. It is expected that with the development of agreements for the Rio Salado and Tres Rios restoration projects an additional agreement for the Rio Salado Oeste project will be developed.

4.4.2.3.4 Impact: Long-Term Effects on Fish and Wildlife

Long-term effects of providing additional water to the habitat would be beneficial. The additional water would support an increase in the quantity and quality of cover, forage, and breeding areas for existing wildlife populations in the Rio Salado Oeste reach. Benefits would be similar to those described for the outfall areas under Alternative 2, but Alternatives 4, 5, 5A and 5B would provide additional acres of restored habitat, including cottonwood/willow and mesquite habitat. This additional riparian habitat would sustain considerably larger wildlife populations than the riparian habitats at the stormwater outfalls alone. Due to additional water supplies, additional wetlands would likely become established without further human intervention where conditions are favorable.

Although total habitat acreage restored would be more than triple that restored under Alternative 2, the wildlife benefits may be more than proportional to the increase in area due to the increased connectivity of habitat. The larger, more contiguous areas of habitat would potentially support a higher diversity of wildlife in addition to larger populations than the smaller, more isolated patches of habitat. In the HGM analysis for the alternatives, the team determined that for Function 10, "Maintain Interspersion and Connectivity," the increase in habitat values would be more than proportionate to the increase in acreage for that habitat type.

Long-term effects of invasive control would include long-term benefits to wildlife in the project area due to the overall improvement of habitat quality. Long-term benefits of emergent wetland establishment include a greater diversity of habitats in the study area than with Alternative 2. This additional emergent wetland habitat would sustain considerably larger wildlife populations than the emergent wetland habitats at the stormwater outfalls alone. Wildlife groups that would benefit from emergent wetland establishment include amphibians, waterfowl, and wading birds.

Mitigation Measures: No Mitigation Required.

4.4.2.4 Alternatives 5, 5A and 5B

4.4.2.4.1 Impact: Short-Term Effects on Vegetation.

Short-term impacts of lake (gravel pit) restoration would include the loss of minimal areas of vegetation. Focus sites for restoration are the two larger gravel pits in the vicinity of 27th Avenue and 37th Avenue. Gravel pit lake restoration would include both riparian and wetland restoration, combined with control of water levels. Additional measures may include substrate modification to reduce permeability and an increased water supply. The majority of vegetation that would be disturbed is not native. Due to the low quality of existing vegetation, impacts

would be adverse but not be significant. In order to reduce the intensity of the adverse impacts, the following mitigation measures would be implemented.

Mitigation Measure BR-1: Re-vegetation Construction Management Practices.

The Corps would remove salt cedar (*Tamarax* spp.) and giant reed (*Arundo donax*) from the restoration areas as part of the restoration process (Alternatives 4, 5, 5A, and 5B). The City of Phoenix, the non-federal sponsor, would be responsible for maintaining the restored habitat areas free of invasive plants, especially salt cedar and giant reed, throughout the life of the project (Alternatives 4, 5, 5A, and 5B).

The cleared areas would be re-vegetated with habitat of higher quality and permanence than the habitat removed. Implementation of good construction management practices, especially dust suppression with water and/or non-toxic dust-suppressing chemicals or soil binders, would minimize potential impacts from fugitive dust. Also, decreases in the vegetation population 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 to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Mitigation Measure BR-2: Use Clean and Certified Foreign Soils

If any imported topsoil is used in the restoration project, it shall be clean and certified free of weeds, including seeds (Alternatives 2, 4, 5, 5A, and 5B). Feral or free-ranging cats and dogs shall be reported to the local of Animal Control office, and signs shall be posted prohibiting the release of pets of any kind and the use of the restoration area by unrestrained pets (Alternatives 2, 4, 5, 5A, and 5B).

4.4.2.4.2 Impact: Long-Term Effects on Vegetation

Long-term benefits of gravel pit lake restoration would potentially include increased native emergent wetland, cottonwood/willow riparian forest, and possibly mesquite woodland. These long-term effects would be beneficial.

Mitigation Measures: No Mitigation Required.

4.4.2.4.3 Impact: Short-Term Effects on Fish and Wildlife

Gravel pit lake restoration construction activities would temporarily disturb fish, amphibians, and aquatic wildlife habitat. Reconfiguration of the gravel pits is likely to eliminate some game fish and possibly a limited number of native fish. Some amphibians may also be eliminated, depending on the timing and extent of reconfiguration work. In the absence of a major draw-down of the water level, fish would tend to avoid disturbance. In this case, impacts would be adverse, but not significant. If it becomes necessary to drain or substantially lower the water level of the lakes during construction, short term localized impacts to fish could be significant.

Construction activities would also displace aquatic birds that roost around the edges of the lakes and/or feed upon the fish, invertebrates, and aquatic vegetation found in the gravel pit lakes. The temporary loss of fish and aquatic wildlife is considered a less than significant adverse impact because fish populations can be restored relatively quickly and other wildlife would return when the habitat is restored and improved.

Construction activities would also disturb terrestrial wildlife habitat adjacent to the lakes and would potentially displace or eliminate some common native wildlife including reptiles such as side-blotched lizard and western whiptail and small mammals such as deer mouse and desert cottontail. Due to the relatively low quality and small quantity of terrestrial habitat disturbed, impacts to terrestrial wildlife would be adverse but less than significant.

Mitigation Measure BR-3: Safe Harbor Agreements, Candidate Conservation Plan and Habitat Conservation Plans

The Corps will encourage the non-Federal sponsor to enter into a Safe Harbor Agreement, Candidate Conservation Plan, or Habitat Conservation Plan as necessary for the continued O&M of the Rio Salado Oeste project. It is expected that with the development of agreements for the Rio Salado and Tres Rios restoration projects an additional agreement for the Rio Salado Oeste project will be developed.

Mitigation Measure BR-7: Trap and Relocate Native Fish

If it becomes necessary to drain or substantially lower the water level of the lakes during construction, short term localized impacts to fish could be significant. To mitigate this impact, it is recommended that native fish be trapped and relocated prior to any major water draw-down.

4.4.2.4.4 Impact: Long-term Effects on Fish and Wildlife

Gravel pit lake restoration would reduce open water habitat and would increase native emergent wetland, cottonwood willow riparian forest, and possibly mesquite woodland. These restored habitats would attract and support populations of native amphibians, reptiles, aquatic birds, riparian birds, and mammals, and could be stocked with native fishes. These long-term effects are beneficial. The loss of open water habitat would reduce the capacity of the lakes to support fish populations. This impact would be adverse but not significant because the displaced fish would be primarily common, non-native species. Although the quantity of open water would be reduced, the quality of open water habitat would be improved due to slope modification, shading, and diversity of topography.

Mitigation Measures: No Mitigation Required.

4.5 CULTURAL RESOURCES

4.5.1 APPROACH AND METHODOLOGY

4.5.1.1 Significance Criteria

Adverse effects to sites and properties listed on, or eligible for, inclusion in the National Register of Historic Places 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).

4.5.1.1.2 Coordination and Preliminary Archaeological Surveys

Given the study area's location upstream of the Tres Rios project, it is reasonable to conclude that the alluvial stratigraphy of the Salt River might be comparable. The entire length of the Salt River within the Rio Salado Oeste project boundary appears to have been more disturbed than areas further downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terraces, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys may be conducted as alternatives are refined.

If upon further investigation, 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 affected tribes, Corps, the City of Phoenix and the Arizona State Historic Preservation Officer (SHPO).

4.5.2 ENVIRONMENTAL IMPACTS

4.5.2.1 No-Action Alternative

Implementation of the No-Action Alternative would not result in any direct impacts on cultural resources. However, it is probable that the disturbance from unregulated recreation, off-highway vehicle traffic and "wildcat" dumping will continue and potentially increase in some areas, further disturbing properties listed or eligible for listing on the National Register. Likewise, it is probable that sites may be disturbed or lost through natural processes such as flooding and erosion.

4.5.2.2 Alternatives 2, 4, 5, 5A and 5B

4.5.2.2.1 Impact: Potential Disturbance or Loss of Properties Listed or Eligible for Listing on the National Register

Preliminary project designs indicate low potential for adverse effects to resources eligible for listing in the National Register of Historic Places (NRHP). Once design begins for the recommended project plan, additional inventory and evaluation efforts may be required. After consideration of potential for buried cultural resources within the refined project Area of Potential Effect (APE), a determination of effect would be made in consultation with SHPO, the tribes, and the City of Phoenix.

Surface examination of this area revealed no cultural material. The potential for sub-surface resources is low. The Corps has determined that the alternatives would have low potential to adversely affect sites either listed on or eligible for listing on the National Register of Historic Places. Should artifacts be discovered upon project construction, Section 106 of the NHPA (described below) would be adhered to.

Mitigation Measures CR-1: Conclude MOA to Complete Field Surveys and Conduct Testing and Data Recovery Activities as Appropriate

Pursuant to Section 106 of the National Historic Preservation Act, 36 CFR 800.13(2)(b), any discoveries of either human remains or archeological deposits shall result in the following process:

- Contractor shall stop work.
- Corps of Engineers Archeology Staff shall be notified of discovery.
- Corps Archeology Staff shall determine if discovered cultural matter is an isolated find, or consists of a deposit of some extent. If needed, hand excavations shall be conducted to determine if the deposit is of sufficient content and integrity to be eligibly for listing on the National Register of Historic Places.
- The Corps shall determine eligibility, and effect in consultation with the State Historic Preservation Officer pursuant to 36 CFR 800(a)-(d).

4.6 AESTHETIC RESOURCES

4.6.1 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 a direct or an 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 are described by qualitatively evaluating the project components for each of the alternatives against the existing aesthetic conditions within the project area.

4.6.2 ENVIRONMENTAL IMPACTS

4.6.2.1 No-Action Alternative

Under the No-Action Alternative, the existing aesthetic environment would continue to slowly degrade over time, with localized improvements along the banks as developers sporadically change the local area with new construction. 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.

4.6.2.2 Alternatives 2, 4, 5, 5A and 5B

4.6.2.2.1 Impact: Potential Short-Term Adverse Aesthetic Effects due to Construction

The alternatives involve excavation and grading in the river corridor, construction of a grade control structure, installation of constructed wetlands, and development of cottonwood/willow, mesquite and Sonoran Scrub-shrub habitat. These temporary activities could result in impacts on the aesthetic quality of the area. Passers-by on adjacent streets 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.

Mitigation Measures: No mitigation required.

4.6.2.2.2 Impact: Potential Long-Term Adverse Aesthetic Effects

The alternatives include a grade control structure west of 35th Avenue. The structure would be similar to those installed in the upstream Rio Salado project and would consist of roller-compacted concrete and grouted stone. The structure should not be highly visible from nearby areas and the view of the structure should be reduced as vegetation matures in the adjacent areas. Thus, the installation of the grade control structure is not considered a significant aesthetic impact.

Mitigation Measures: No mitigation required.

4.6.2.2.3 Impact: Potential Long-Term Aesthetic Benefits

The alternatives would include significant increases in wetland, cottonwood/willow, mesquite, and Sonoran Scrub-shrub communities. Additionally, removal of salt cedar and other invasive vegetation species that signify habitat disturbance and degradation would improve habitat values and increase biodiversity in the project implementation area.

The alternatives also include opportunities for passive and active recreation along the Salt River in regulated areas. Thus, the increases to habitat and biodiversity would provide improved aesthetic quality in the corridor while recreation features would guide users to these areas. This is considered a beneficial effect.

Mitigation Measures: No mitigation required.

4.7 AIR QUALITY

4.7.1 APPROACH AND METHODOLOGY

Implementation of any of the proposed alternatives would generate emissions from both the construction phase, and later Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) activities. The construction-related emissions would consist of fugitive dust from disturbed soil, exhaust and dust emissions produced by the use of heavy construction equipment, and exhaust and dust emissions from construction worker commute trips. OMRR&R for any alternative other than the No-Action Alternative would also generate exhaust and dust emissions from vehicles driven by workers and recreational visitors, as well as routine maintenance. OMRR&R would be conducted by the non-federal sponsor, and would be subject to dust control under Maricopa County Rule 310.

As discussed in Section 3.7.4.2, federal projects must be evaluated to determine whether their emissions would exceed specified *de minimus* thresholds for six criteria pollutants. If the *de minimus* threshold is exceeded for a criteria pollutant, it must be demonstrated that these emissions conform with the applicable State Implementation Plan (SIP). Total project emissions of ozone precursors (Volatile Organic Compounds [VOC] and Oxides of Nitrogen [NOx]), carbon monoxide (CO), and fugitive dust (PM-10) associated with each alternative are thus compared to *de minimus* thresholds. Air quality impacts would be considered significant if the proposed action causes any of these emission thresholds to be exceeded.

Detailed information on the methods and assumptions used to estimate air pollutant emissions is provided in Appendix D. To calculate construction and OMRR&R emissions, emission factors developed by EPA's AP-42, *Compilation of Air Pollutant Emission Factors* have been used. Calculations are also based on construction information provided in this FEIS. The following types of air pollutant emission sources are included in the calculations:

- Fugitive dust emissions from haul trucks, off road equipment and passenger vehicles on unpaved roads within the construction site 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 that unpaved haul roads would be aggressively watered to reduce dust emissions.
- Fugitive dust emissions from excavating, loading, dumping, and spreading of bulk materials during channel excavation and bank stabilization were estimated based on the

assumed earthwork volumes, using the EPA's AP-42, *Compilation of Air Pollutant Emission Factors.*

- Emissions from construction equipment tailpipes were estimated based on the type and number of equipment, using recent emission factors for off-road equipment the EPA's AP-42, *Compilation of Air Pollutant Emission Factors.*

- Emissions from passenger vehicle traffic associated with the project were based upon the EPA's AP-42, *Compilation of Air Pollutant Emission Factors.*

4.7.2 ENVIRONMENTAL IMPACTS

4.7.2.1 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 unchanged, with no increases in criteria emissions resulting from new recreational use of the Rio Salado Oeste project.

4.7.2.2 Alternatives 2, 4, 5, 5A and 5B

All five build alternatives would follow a similar construction schedule, beginning with river channel restoration, followed by lake restoration/construction, revegetation and construction of recreational/maintenance features. For Alternative 5A, the Recommended Plan, channel restoration work would occur over the first two years of construction. This work would include actual restoration of the river channel, as well as wetland restoration, grade control structure installation, and removal of invasive species. Lake restoration work would be completed during the third and fourth years of construction. Revegetation would require nine months in each of the third and fourth years of construction (total duration of 18 months). Finally, construction of recreational trails and maintenance roads would be completed during in the fourth year of construction, concurrent with lake restoration and revegetation.

Air quality impacts would be distributed over the four year construction period. Table 4.7-1 summarizes the estimated annual air emissions associated with implementation of Alternative 5A. Annual emissions of VOC, CO, PM-10, NO_X and SO_X would remain below federal conformity *de minimus* thresholds during each year of project construction and operation; thus, impacts from these emissions are considered less than significant. SO_X has been included in the analysis even though Maricopa County does not violate that standard and does not have a SIP for this pollutant.

Air emissions associated with construction of Alternatives 2, 4, and 5B would be similar to or lower than those occurring under Alternative 5A. Due to the much larger volume of material regraded for lake restoration for Alternative 5 (5.4 million cubic yards compared to 3.2 million cubic yards for Alternative 5A), Alternative 5 would likely exceed the de minimus thresholds of

70 tons/year for PM-10, requiring a conformity determination. However, since Alternative 5 is not cost effective (Rio Salado Oeste Feasibility Report, Chapter V), implementation of this alternative is not anticipated.

Table 4.7-1. Estimated Air Emissions for Alternative 5A (Tons/Year)

Year 1 Construction Tasks	**VOC**	**CO**	**PM-10**	**NO_X**	**SO_X**
Channel Restoration	0.41	3.35	17.30	7.31	0.75
Wetland Restoration	0.23	2.18	6.97	4.65	0.49
Grade Control Structure	0.00	0.06	0.00	0.01	0.00
Invasive Species Removal	0.25	1.83	10.79	4.39	0.47
Total Emissions	0.89	7.42	35.06	16.36	1.71
Year 2 Construction Tasks	**VOC**	**CO**	**PM-10**	**NO_X**	**SO_X**
Channel Restoration	0.41	3.35	17.30	7.31	0.75
Wetland Restoration	0.23	2.18	6.97	4.65	0.49
Grade Control Structure	0.00	0.06	0.00	0.01	0.00
Invasive Species Removal	0.25	1.83	10.79	4.39	0.47
Total Emissions	0.89	7.42	35.06	16.36	1.71
Year 3 Construction Tasks	**VOC**	**CO**	**PM-10**	**NO_X**	**SO_X**
Lake Restoration	1.10	8.07	56.34	19.11	2.01
Revegetation	0.46	1.59	0.36	4.28	0.42
Total Emissions	1.56	9.66	56.7	23.39	2.43
Year 4 Construction Tasks	**VOC**	**CO**	**PM-10**	**NO_X**	**SO_X**
Lake Restoration	1.10	8.07	56.34	19.11	2.01
Revegetation	0.46	1.59	0.36	4.28	0.42
Trails/Maintenance Roads	0.25	1.82	4.78	4.42	0.47
Total Emissions	1.81	11.48	61.48	27.81	2.9
Federal Standards (Tons/Yr)	**VOC**	**CO**	**PM-10**	**NO_X**	**SO_X**
(Exceedance requires conformity determination)	100	100	70	100	100

4.7.2.2.1 Impact: Generation of Construction-Related and Tailpipe Emissions (CO, VOC, NO_X)

Construction and OMRR&R activities would generate emissions of ozone precursors, carbon monoxide (CO) and PM-10 in the form of tailpipe emissions. Construction tailpipe emissions would originate from a combination of construction equipment activities, and construction worker commute trips. OMRR&R activities would generate tailpipe emissions from recreational vehicle trips, employee trips, and a variety of maintenance activities.

Mitigation Measure: No mitigation is required.

4.7.2.2.2 Impact: Generation of Construction-Related and Operational Fugitive Dust (PM-10) Emissions

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Channel excavation and bank stabilization activities would generate fugitive dust emissions at the construction site. Table 4.7-1 summarizes the estimated emissions that are associated with implementation of Alternative 5A. Annual fugitive PM-10 emissions during the year of maximum construction activity (Year 4) would be less than federal *de minimus* thresholds for General Conformity. As described by the detailed emission calculations provided in Appendix D, most of the PM-10 emissions would be generated by excavation of and spreading of riverbed material, and from haul trucks on unpaved roads.

Mitigation Measure AQ-1: Implement PM-10 - Reducing Measures during Channel Excavation and Bank Stabilization

All construction, restoration and routine maintenance 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 PM-10-reducing construction practices in compliance with Maricopa County Rule 310 throughout the construction period.

- 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 in accordance with Maricopa County Rule 310.
- Minimize vehicle speed on unpaved roads.
- Water active storage piles at least with a frequency consistent with Maricopa County Rule 310.
- Cover or otherwise stabilize inactive storage piles where feasible.
- Cover haul trucks securely when transporting materials.
- Water all active construction areas with a frequency consistent with Maricopa County Rule 310. 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).

Compliance with Maricopa County rules would be made a condition of the construction contract and would be enforced through weekly inspection by the Corps.

4.7.2.2.3 Impact: Determination of Conformity

Based on the air quality analysis described in Appendix D, implementation of Alternative 5A would not have a significant impact on air quality. The total emissions of each criteria pollutant is below *de minimus* levels as prescribed in 40 CFR 93.153(b). Therefore, this proposed project conforms to the federal Clean Air Act as amended in 1990 and, as required, a Record of Non-Applicability has been prepared instead of a Conformity Determination (Appendix D).

Mitigation Measures: No mitigation required.

4.7.2.2.4 Impact: Long-Term Effects on Air Quality due to Recreational Use

Due to the location of the project and the intimacy of the expected recreation and education experience, it is projected that most visitors would arrive by private vehicle. Based on historical data maintained by the City of Phoenix for resource-based recreational sites, it is estimated that 2.75 visitors arrive in each vehicle. Additionally, an estimated one visitor per four vehicles arrives at a site by an alternate mode of transportation including bicycle, foot traffic and public transportation. It would be a legitimate goal of the Recreation/Education component to increase the ratio of visitors arriving by alternate means such as buses.

Mitigation Measure AQ-2: Promotion of Alternative Transportation and Energy Efficiency.

In order to mitigate potential environmental impacts from increased traffic, recreational facilities (e.g., multipurpose trails, walk-in access points, access control, continuity with other projects) would be developed that promote alternative transportation and energy efficiency. Initial capacity of the parking facilities would be designed for not more than 500 vehicles in order to limit the potential impact of human activities upon the restoration project.

4.8 NOISE

4.8.1 APPROACH AND METHODOLOGY

Noise impacts are analyzed using standard noise modeling methods. First, potential sources of noise are identified. Then, noise levels for each source are identified from standard references or monitoring data for similar sources. The distance from sources to noise-sensitive receptors is determined, and the projected sound level of sources at the receptor is calculated, taking into account attenuation factors, such as distance and atmospheric effects. Resulting sound levels at receptors are compared to relevant sound level criteria, if criteria exist for a project, to determine the relative magnitude of a noise effect. For each of the project alternatives except for the No-Action Alternative, noise effects would occur during the construction phase of the alternatives and during post-construction use of the site by recreationists. These effects would be in the form of increased traffic noise in the project study area.

4.8.2 ENVIRONMENTAL IMPACTS

4.8.2.1 No-Action Alternative

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, and no new project-related traffic would use area roadways. For these reasons, there would be no adverse noise effects associated with this alternative.

4.8.2.2 Alternatives 2, 4, 5, 5A and 5B

4.8.2.2.1 Impact: Short-Term Effects Upon Ambient Noise Conditions due to Construction and OMRR&R Activities

Residents living adjacent to or near the project area would be exposed to noise from construction or OMRR&R activities. Typical equipment used would include graders, loaders, rollers, bulldozers, trucks, scrapers, pumps, and generators.

The study area already 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. These would remain the largest and most significant contributor to ambient noise in the study area. Most of the construction operations would occur within the river bottom. Any increase in noise levels observed by sensitive receptors along the project area is expected to be insignificant with implementation of a few noise-reducing construction measures.

Mitigation Measure N-1: Employ Noise-Reducing Construction Measures.

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 7pm and 7am 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 a muffled 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.

4.8.2.2.2 Impact: Long-Term Effects on Ambient Noise Conditions

The restored ecosystem has the potential to increase visitation and use. The most significant possible noise increase would come from increased traffic noise. The additional traffic 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 Measures: No mitigation required.

4.9 SOCIAL AND ECONOMIC RESOURCES

Sections 3.9.2 and 3.9.3 describe the requirements for assessing environmental justice as well as identified minority and low-income populations in the socioeconomic study area.

4.9.1 APPROACH AND METHODOLOGY

Evaluation criteria used to assess social impacts include, but are not limited to: detectable increases or decreases to population, housing, employment or income due to the project and; environmental justice issues as defined in Section 3.9.3.

Socioeconomic impacts were determined through the evaluation of areas affected by each alternative. Land required for each of the alternatives was superimposed on GIS land use maps to evaluate the affected land, buildings, and transportation facilities.

4.9.2 ENVIRONMENTAL IMPACTS

4.9.2.1 No-Action Alternative

Existing socioeconomic conditions would remain relatively unaffected as a result of the project. Under the No-Action Alternative, normal fluctuations in socioeconomic conditions would continue. No substantial impacts are anticipated. No impacts involving environmental justice would result.

4.9.2.2.1 Impact: Detectable Increases or Decreases to Population, Housing, Employment or Income due to the Project

None of the alternatives would cause significant direct or indirect impacts on social or economic resources, such as population, housing, employment, or income in the study area. The minimal construction-related employment during the project and park ranger-related employment during the life of the project would not have the capacity to affect local or regional income levels or to increase employment to any significant levels locally or regionally. Normal fluctuations in socioeconomic conditions would naturally occur over time with or without the project. No substantial impacts are anticipated.

Mitigation Measures: No mitigation required.

4.9.2.2.2 Impact: Potential Beneficial Effects on Quality of Life Adjacent to Project

The existing streambed consists primarily of a dry wash with no recreational facilities or public access for recreation. The project would include trails, scenic overlooks, interpretive centers, gathering areas, parking facilities, restrooms and shade structures. Activities along the project corridor would include bird watching, hiking, biking, equestrian uses, wildlife observation and fishing. The addition of this parks system in place of the existing environment has the potential to increase the quality of life adjacent to the project area.

Mitigation Measures: No mitigation required.

4.9.2.2.3 Impact: Effects on Environmental Justice

EO 12898, "*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*" requires that Federal agencies include environmental justice as part of its mission by identifying and addressing as appropriate, the potential for disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations. The impact of Rio Salado Oeste is not expected to pose health risks or adverse environmental effects. Furthermore, comparing the project implementation area to parcel ownership information in GIS shows that the project will only affect certain industrial properties adjacent or within the river and is not expected to require the disruption or displacement of any businesses or residences in the area. Therefore, the Rio Salado Oeste project will not have a disproportionately high impact on minority or low-income populations.

Mitigation Measures: No mitigation required.

4.10 TRANSPORTATION

4.10.1 APPROACH AND METHODOLOGY

The Oeste project consists of restoration of an eight mile reach of Salt River extending from 19th Avenue to 83rd Avenue. The dominant mode of transportation for this area is the automobile. Along this reach of the Salt River, there are three bridged crossings and one at-grade crossing. Nearly all local streets and arterials near the Salt River form a north-south, east-west grid roadway network. Impacts on transportation were assessed based on how project-related construction and post-construction traffic would benefit or adversely affect existing traffic and roadway infrastructure. 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 related to high flows in the main channel. Traffic and circulation effects related to the number of vehicle trips associated with construction workers commuting to the project site were based on estimates of labor hours. Estimates of daily vehicle trips were developed using the following assumptions:

- Eight labor hours generate one person-round-trip.
- 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 from the proposed project sites. Because Sky Harbor Airport would not be affected by this project, no detailed analysis related to this facility was performed. Haul routes were assumed to be either within the river channel or via local primary streets to I-17.

4.10.2 ENVIRONMENTAL IMPACTS

4.10.2.1 No-Action Alternative

Under the No-Action Alternative, traffic volume would continue to increase as the surrounding areas became more developed. This is especially true in the western part of the project area where new housing developments are being constructed. In addition, to accommodate the increase in traffic volumes, the roadways would continue to be widened, typically up to six lanes with a median. 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 adverse effects on transportation would result under this alternative.

4.10.2.2 Alternatives 2, 4, 5, 5A and 5B

4.10.2.2.1 Impact: Temporary Increase in Traffic on Existing Roadways during Project Construction and OMRR&R Activities

The alternatives would create a less than significant increase in vehicle volume around the study area. The arterial streets have adequate capacity to accommodate this temporary, short-term increase in project-related traffic. However, should construction or OMRR&R activities cause lane or road or sidewalk closures or detours, the following mitigation measure would be implemented to reduce impacts.

Mitigation Measure T-1: Implement Traffic Control Plan

This work shall consist of traffic control, and use of devices and flagmen or pilot cars in accordance with Section 401 of the City of Phoenix Supplements and the City of Phoenix Traffic Barricade Manual, dated 1998.

All traffic and/or traffic control devices on this project shall be provided, maintained and/or controlled as specified in the City of Phoenix Traffic Barricade Manual, dated 1998.

Permission to restrict city streets, sidewalks and alleys (street closure permits) shall be requested as specified in Section III of the City of Phoenix Traffic Barricade Manual.

Unless otherwise provided for in the following General Traffic Regulations, all traffic on this project shall be regulated as specified in Section IV of the City of Phoenix Traffic Barricade Manual.

4.10.2.2.2 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 that is avoidable with mitigation.

Mitigation Measure T-2: 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 over each roadway and with the intent to return the roadways to the conditions existing immediately prior to the commencement of the project.

4.10.2.2.3 Impact: Generation of Additional Vehicle Trips by Recreationists

Due to the location of the project and the intimacy of the expected recreation and education experience, it is projected that most visitors would arrive by private vehicle. Based on historical data maintained by the City of Phoenix for resource-based recreational sites, it is estimated that 2.75 visitors arrive in each private vehicle. Additionally, an estimated one visitor per four vehicles arrives at a site by an alternate mode of transportation including bicycle, foot traffic and public transportation. Prime recreation time is defined as weekends and holidays, while non-primetime is weekdays. Therefore, the greater number of recreationist trips would occur during off-peak hours outside of the weekday commute times. Therefore, no significant impacts are anticipated on traffic and circulation.

Mitigation Measures: No mitigation required.

4.11 LAND USE

4.11.1 APPROACH AND METHODOLOGY

Each of the alternatives includes a range of approaches to provide ecological restoration and recreation within the project implementation area. Potential impacts are identified by evaluating each alternative against existing land use patterns within the project area. The alternatives are 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 are considered significant.

4.11.2 ENVIRONMENTAL IMPACTS

4.11.2.1 No-Action Alternative

Under the No-Action Alternative, land use conditions would continue to change at rapid rates. The Maricopa Association of Governments Regional Transportation Plan (November, 25, 2003) states that Maricopa County is projected to double in population over the 2000 base population, with an anticipated total of 6.24 million people. This means that the region will experience a growth of approximately one million people during each decade. By 2025, the largest Municipal Planning Area – Phoenix, will contain 2.1 million persons. By 2025, Maricopa County is projected to nearly double its reported 2000 employment total. This means that employment within the region will grow at a number of approximately 575,000 jobs each decade.

Therefore, growth and land use change would impact the surrounding Rio Salado Oeste area, but there would be no short-term impacts from construction of Oeste to affect adjacent land. Land use and planning policies to enhance and restore biological habitat and riparian areas and provide flood damage reduction and recreation opportunities in open space areas would not be fully realized.

4.11.2.2 Alternatives 2, 4, 5, 5A and 5B

4.11.2.2.1 Impact: Temporary Adverse Effects on Land Use during Project Construction

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 on-going low- to medium-density residential construction in the study area. Construction and later OMRR&R activities could disturb that development with brief road blocks or partial closures, but the effects would be too short-term to significantly impact other construction. Most of the impacts on land use are within the 100-year floodplain. This land all ready has large restrictions on use. Converting the area into an ecosystem restoration site would not have any adverse effects on land use.

Mitigation Measures: No mitigation required.

4.11.2.2.2 Impact: Compatibility with Land Use Plans and Policies of Local Government Jurisdictions

Jurisdictional plans impacting the study are the Maricopa County Comprehensive Plan, Estrella Planning Area Land Use Plan and the Laveen Planning Area Land Use Plan. The Salt River is identified as a "Proposed Open Space" within these plans. 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). In addition, the City of Phoenix Land Use Plan calls for enhancement and restoration of biological habitat and riparian areas and to provide flood damage reduction and recreation opportunities. Implementation of the project would be compatible with local government jurisdictional plans.

Mitigation Measures: No mitigation required.

4.11.2.2.3 Impact: Long-Term Beneficial Impact on Land Use Experience

Rapid population growth is anticipated for the City of Phoenix and Maricopa County as a whole. Significant development of residential and non-residential land will be required to accommodate the projected growth. In the study area, existing land uses are primarily comprised of agriculture, industrial and low-density residential. It is anticipated that additional low- to medium-density residential development will take place due to the close proximity of the area to the City core. Existing vacant lots and agricultural land will likely be converted to residential uses. All five action alternatives would develop the river corridor in a manner that does not contribute significant traffic, noise, limited vistas or other effects of development. Therefore, the

river corridor's transformation into a low-use restoration area would make it easier for the area to absorb the adjacent higher-use development. Likewise, urban demand for water supply will not affect the Oeste project benefits because there is a committed supply of effluent for this project.

In addition, the project provides opportunities for current City of Phoenix land use and planning policies to be realized. Such policies call for enhancement and restoration of biological habitat and riparian areas and to provide flood damage reduction and recreation opportunities.

Mitigation Measures: No mitigation required.

4.12 RECREATION

4.12.1 APPROACH AND METHODOLOGY

Each of the action alternatives utilizes a variety of components to provide ecological restoration, recreation, and incidental flood damage reduction within the project area. Potential impacts to recreation resources are identified by evaluating each of the alternatives against the existing recreation features within the project area. Alternatives are also analyzed regarding their compatibility with existing recreation plans and policies that are relevant to the project area. Impacts to recreation resources within the project implementation area would be significant if the proposed project is found to be inconsistent with current recreation plans and/or policies.

4.12.2 ENVIRONMENTAL IMPACTS

4.12.2.1 No-Action Alternative

Under the No-Action Alternative, recreation conditions would stay substantially the same. There would be no short-term impacts from construction that would affect adjacent recreation activities. Recreational experiences would also not be enhanced. Land use and planning policies to enhance and restore biological habitat and riparian areas and provide flood damage reduction and recreation opportunities in open space areas would not be fully realized.

4.12.2.2 Alternatives 2, 4, 5, 5A and 5B

4.12.2.2.1 Impact: Temporary Adverse Effects on Recreation during Project Construction and OMRR&R Activities

The existing streambed consists primarily of a dry wash with no recreational facilities or public access for recreation. Therefore, project construction would have no impact on current recreation. OMRR&R activities may briefly affect recreational use. However, impacts would occur in small, localized areas in a way that would have little impact on use.

Mitigation Measures: No mitigation required.

4.12.2.2.2 Impact: Long-Term Beneficial Effect on Recreational Experience

The project would include trails, scenic overlooks, interpretive centers, gathering areas, parking facilities, restrooms and shade structures. Activities along the project would include bird watching, hiking, biking, equestrian uses, wildlife observation and fishing. Completion of this project would also facilitate connectivity between two other restoration projects on the Salt River: Tres Rios and Rio Salado Phoenix. Given that no current regulated or designated recreational uses exist on this reach of the Salt River, implementation of this project would bring significant beneficial effects to the recreational experience.

Mitigation Measures: No mitigation required.

4.13 PUBLIC HEALTH AND SAFETY

4.13.1 APPROACH AND METHODOLOGY

The proposed project is intended to enhance the ecological health of Salt River and its related habitats. As a result of the project, there may be potential impacts associated with public health and safety. Impacts are evaluated by estimating the potential effects of each alternative against existing environmental conditions and reviewing potential public health and safety issues in the project study area.

4.13.2 ENVIRONMENTAL IMPACTS

4.13.2.1 No-Action Alternative

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.

4.13.2.2 Alternatives 2, 4, 5, 5A and 5B

4.13.2.2.1 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 into receiving surface waters and leached into subsurface waters. 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. If released into water sources, construction materials such as fuels, oils, paints, and concrete are potentially harmful to fish and other aquatic life. The extent of potential environmental effects depends on several factors. Some examples

of factors that would lead to adverse environmental effects are: highly erodible soil types; poor construction practices; large disturbed area under construction for a long period of time; precipitation during large excavations or soil transport periods, and; construction proximal to drainage channels. Implementation of Best Management Practices would reduce construction impacts to water quality to a less-than-significant level.

Mitigation Measure PHS-1: Implement HTRW Management Measures

Best Management Practices (BMPs) would be implemented during construction. Some examples of these BMPs follow. Construction activities should be conducted in the dry weather season to the extent possible to minimize exposure of disturbed construction sites to rainfall and stormwater runoff. The general contractor for the project would 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. BMPs must be implemented before predicted rain events. In addition, the construction contractor would implement standard hazardous materials management practices to reduce the possibility of chemical spills or releases of contaminants in runoff.

4.13.2.2.2 Impact: Temporary Construction and OMRR&R-Related Area Safety Issues

Project construction and restoration activities proposed under this alternative include grading, site preparation for vegetation planting, irrigation system establishment, channel excavation and reshaping, and channel terracing. These activities, as well as operations and maintenance (OMRR&R) activities such as sediment removal, would result in potential safety hazards. These hazards would be minimized with the implementation of the following mitigation measure.

Mitigation Measure PHS-2: Implement Construction and OMRR&R Management Measures

The Contractor shall provide temporary fencing, barricades, and/or guards, as required, to provide protection in the interest of public safety. Whenever the Contractor's operations create a condition hazardous to the public, he shall furnish at his own expense and without cost to the Government, such flagmen and guards as are necessary to give adequate warning to the public of any dangerous conditions to be encountered and he shall furnish, erect, or maintain such fences, barricades, lights, signs and other devices as are necessary to prevent accidents and avoid damage or injury to the public. Flagmen and guards, while on duty and assigned to give warning and safety devices shall conform to applicable city, county, and state requirements.

Should the Contractor appear to be neglectful or negligent in furnishing adequate warning and protection measures, the Contracting Officer may direct attention to the existence of a hazard and the necessary warning and protective measures shall be furnished and installed by the Contractor without additional cost to the Government. Should the Contracting Officer point out the inadequacy of warning and protective measures, such action of the Contracting Officer shall not relieve the Contractor from any responsibility for public safety or abrogate his obligation to furnish and pay for those devices. The installation of any general illumination shall not relieve the Contractor of his responsibility for furnishing and maintaining any protective facility.

4.13.2.2.3 Impact: Potential Increases in Mosquito Breeding

Increased standing water would potentially attract mosquitoes that may be carriers of serious diseases including West Nile virus and various strains of encephalitis. The outfall wetlands would be designed to maintain flowing water under most conditions, and other areas with increased water supply would be designed to minimize standing water. Under some conditions, standing or slow-moving water may be unavoidable, for example, in the borrow pit lakes during drought periods when inflow is minimum or absent. A vector control program for these area would probably be necessary to protect public health.

Mitigation Measure PHS-3: Monitoring Plan, Natural Controls and Chemical Pesticides

Chemical pesticides would be avoided in favor of natural controls because chemical pesticides often adversely affect desirable fish and wildlife species, as well as humans. Restored habitat would attract some natural predators of mosquitoes, including insects such as water striders, giant water bugs, common backswimmers, dragonflies, and water boatman. Vertebrate predators, including barn swallows, black phoebes, song sparrows, and several species of bats would also potentially populate the habitat following restoration. Native insect and vertebrate predators of mosquitoes could be introduced to the habitat, but unless conditions are optimum, populations may not remain adequate for long-term mosquito control.

Large populations of mosquitoes often occur even in relatively undisturbed habitats where water is present. The Gila topminnow (*Poeciliopsis occidentalis occidentalis*), a small native fish that is federally listed as Endangered, may effectively control mosquitoes. Special protocols would be required to introduce this species to the project area due to its endangered status, but Gila topminnow may be a good option in areas where non-native predators (including mosquito fish) are not present. Western mosquito fish (*Gambusia affinis*), a species of small fish native to the United States from eastern Mississippi to eastern Texas that feeds on mosquito larvae, are commonly stocked in ponds as an efficient and economical biological method of mosquito abatement. Mosquito fish also consume eggs and fry of native fish, as well as desirable insect species, which would be detrimental to native fish populations. In the borrow pit lakes, where fish populations consist primarily of introduced game species, mosquito fish may be an acceptable biological control, provided that they are confined to the lakes. A bacterium, *Bacillus thuringensis* var *israeliensis*, which is specific to mosquito larvae but harmless to most other organisms, is another effective biological control that may be compatible with ecological restoration.

In addition to the above possible measures, Maricopa County has a routine monitoring program county wide and a vector control program to help reduce the risk of mosquito-borne disease. Maricopa County Vector Control monitors mosquitoes along the Salt River primarily during the summer months. 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.

4.13.2.2.4 Impact: Beneficial Decrease in Illegal/Unauthorized Activities in the Project Area

The existing streambed consists primarily of a dry wash with no recreational facilities or public access for recreation. 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 implementation 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 jurisdictions who will become responsible for policing these areas and protecting recreationists from illegal activities. This is a beneficial impact.

Mitigation Measures: No mitigation required.

4.13.2.2.5 Impact: Potential Increases in Public Access and Use

Growth projections show that the non-residential land around the Oeste PIP will be required to accommodate the county's projected growth. In the study area, existing land uses are primarily comprised of agriculture, industrial and low-density residential. It is anticipated that additional low- to medium-density residential development will take place due to the close proximity of the area to the City core. Existing vacant lots and agricultural land will likely be converted to residential uses. This increase in population combined with the increase in recreational features that will be provided by Rio Salado Oeste will increase the number of visitors to this area of the Salt River. An increase in the number of visitors could potentially increase the amount of trash, crime and vandalism to the property. We suspect that these occurrences will be minor due to regulated points of entry, the presence of maintenance and park ranger staff, and regulated hours of operation.

CHAPTER 5
CUMULATIVE IMPACT ANALYSIS

This section is included in the EIS to address the cumulative impacts associated with the proposed project. Cumulative effects result from the proposed action's incremental impacts when these impacts are added to the impacts of other past, present, and reasonably foreseeable future actions, regardless of the agency or person who undertakes them. Cumulative effects can result from individually minor, but collectively significant actions that take place over time (Bass, Herson & Bogdan, 2001). A cumulative impact, then, is the additive effect of all projects in the same geographic area. In addition, federal regulations implementing NEPA (40 CFR 1500-1508) require that the cumulative impacts of a proposed action be assessed.

5.1 PROJECTS WITHIN POTENTIAL CUMULATIVE IMPACT ZONE

For the purpose of this analysis, the Rio Salado Oeste cumulative impact zone is identified as the Salt River corridor stretching from Granite Reef Dam to the confluence of the Agua Fria and Salt Rivers. Five projects, four upstream and one downstream, are located along the Salt River in Maricopa County. Upstream of the proposed Rio Salado Oeste Project on the Salt River are Va Shly'ay Akimel, Rio Salado Tempe, Tempe Town Lake, and Rio Salado Phoenix. Directly downstream of Rio Salado Oeste is the Tres Rios project. The Rio Salado Pathway project also plays a key role in the recreation corridor that is developing along the river. Information on these projects is provided below. These projects are expected to span nineteen years (1998-2017).

5.1.1 VA SHLY'AY AKIMEL

Va Shly'ay Akimel (Vash) is a primary purpose ecosystem restoration project with proposed incidental benefits of passive and active recreation and aesthetics improvements. The project is in the pre-engineering design (PED) phase, with construction estimated to occur from 2009 to 2017. The project is a collaborative effort of the U.S. Army Corps of Engineers, the Salt River Pima Maricopa Indian Community (SRPMIC), and the City of Mesa. The study area 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 (SR 101) and Granite Reef Dam. The area is approximately two miles wide and encompasses approximately 17,345 acres. The alternative to be constructed includes channelization, installation of a grade control structure, removal of invasive plant species, irrigation via a surface braided irrigation network, irrigation from a new groundwater well and from effluent, the creation of wetlands features, the establishment of new cottonwood, mesquite and Sonoran Desert habitats. A total of 1,712 new habitat acres are expected to be created, in addition to approximately five miles of multi-use recreation paths.

5.1.2 RIO SALADO TEMPE

Another primary purpose ecosystem restoration plan, Rio Salado Tempe, also includes incidental benefits of passive and active recreation. This Corps of Engineers/City of Tempe project is divided into three sections around Tempe Town Lake: Indian Bend Wash, a tributary of the Salt River located between Rural Rd and McClintock Rd, and the portions of the Salt River streambed directly upstream and downstream of the Tempe Town Lake Dams. In total, this 1.2-river mile project planned to restore 169 acres of habitat. To date, construction has been completed on the Indian Bend Wash section, which provides about 41 restored acres. The upstream segment includes roughly 0.5 miles of recreational path. The downstream section is currently in construction and expected to be complete by mid 2007. The upstream section is scheduled to complete construction about a year later in mid 2008.

5.1.3 TEMPE TOWN LAKE

Tempe Town Lake is entirely a City of Tempe project having two primary purposes – economic development and recreation. Incidental benefits include aesthetic improvements and passive restoration both upstream and downstream of the dams. The 220-acre lake was completed in 1999, though construction of resorts, restaurants, retail shops, business parks and condos still continues around the lake. The primary recreation components, which have all ready been constructed, include the 25-acre Tempe Beach Park on the south bank, five miles of paved multi-use paths along the north and south banks, and a marina on the north bank.

5.1.4 RIO SALADO PATHWAY

The Rio Salado Pathway (Tempe to Phoenix) is an accessible, shared-use path proposed along the south bank of the Rio Salado beginning at Priest Drive in Tempe and ending at approximately 28th Street in Phoenix. Through support of both the City Councils of Tempe and Phoenix, and the Regional Council of Maricopa Association of Governments, $150,000 was approved to conduct a feasibility study on the shared-use trail and public amenities for the nearly four mile gap between Rio Salado Tempe and Rio Salado Phoenix. Now that the study is completed, the cities of Tempe and Phoenix are currently seeking a combination of private and public funding to construct Rio Salado Pathway (City of Tempe, Tempe Town Lake website, 2006). No estimate for construction completion currently exists.

5.1.5 RIO SALADO PHOENIX

Rio Salado Phoenix extends from 28th Street west to 19th Avenue, which is the upstream end of the Rio Salado Oeste study area. This Corps of Engineers/City of Phoenix collaboration has the primary purpose of ecosystem restoration with incidental benefits of recreation and aesthetic improvements. The project includes approximately 595 acres of restoration, and ten miles of recreational multi-use paths. It includes construction of a low-flow channel in the river bottom, and establishment of open water, wetland marsh, cottonwood/willow, open edges, and mesquite habitat on the river bottom and overbanks. The recreational elements associated with this project would include trails, scenic overlooks, interpretive centers, gathering areas, parking, restrooms, and shade structures. Construction was completed in 2005 along the riverbed from 16th Street to

19th Avenue. The final phase of this project, 16th Street to 28th Street, is scheduled to be completed in 2007.

5.1.6 TRES RIOS

Tres Rios is one of the more important projects when analyzing cumulative impacts for Rio Salado Oeste. This is because the two projects are contiguous, and construction is expected to occur consecutively. Tres Rios is estimated to finish construction in 2010 and Rio Salado Oeste is not expected to begin construction until 2010. However, there is a slight chance that the construction phases of the two projects may overlap due to the uncertainty of future appropriations. Therefore, a slightly more in-depth analysis of Tres Rios is included below.

Tres Rios is a U.S. Army Corps of Engineers/City of Phoenix ecosystem restoration project that extends along the Salt River from the west end of Rio Salado Oeste at 83rd Avenue downstream to the Agua Fria River. The study efforts were directed toward improving and increasing fish and wildlife habitat values and diversity for Threatened and Endangered species, as well as providing flood damage reduction, and recreation. Potential incidental benefits are associated with water quality and supply.

The selected plan includes a six mile long flood control levee, a 184-acre regulating wetland that would equalize diurnal variations in discharges from the 91st Avenue treatment plant, a 300-million gallon per day pump station to convey the flow from the treatment plant to the regulating wetland, 128 acres of wetland along the north bank of the Salt River, a pipeline in the overbank wetland that would lead to 38 acres of riparian corridor, 134 acres of open water marsh, grading the Salt River to convey surface water to supply 69 acres of riparian habitat, and a dewatering well from the treatment plant that will deliver enough water to support about 206 acres of open water marsh and about 16 acres of riparian corridor on the south bank of the Salt River. In all, approximately 775 acres of habitat will be restored and an 11 mile long recreation path will be created. Construction on the levee began in 2005, and is scheduled for completion in 2008. The final phase: "Pump Stations and Piping to Wetlands" is estimated to begin late 2007 and finish in 2010. However, as with all projects, construction continuation is always subject to the availability of future appropriations.

Table 5.1-1. Summary of Projects within the Potential Cumulative Impact Zone

Project Name	Location	Salt River-Approx. River Miles	Approx. Acres to be Restored	Approx. Recreation Path Miles	Estimated Years in Construction
Va Shly'ay Akimel	Granite Reef Dam to SR-101	14	1,712	5	2009 - 2017
Rio Salado Tempe	Indian Bend Wash, W. of McClintock Dr. to Town Lake East Dam, and West Dam to Priest Dr.	1	169	0.5	2003 - 2007
Tempe Town Lake	W. of McClintock Dr to East of Priest Dr.	3	-	5	1998 - 2004
Rio Salado Pathway	Priest Dr. to 28th Street	3	-	3	TBD
Rio Salado Phoenix	28th St. to 19th Ave.	5	595	10	2001 - 2007
Rio Salado Oeste	19th Ave. to 83rd Ave.	8	1,528	16	2010 - 2017
Tres Rios	83rd Ave to W. of Agua Fria Confluence	8	775	11	2005 - 2010
TOTALS	Granite Reef Dam to W. of Agua Fria Confluence	42	4,734	58.5	1998 - 2017

5.2 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. An analysis of cumulative impacts to each of the resource areas is presented below.

5.2.1 GEOLOGY AND TOPOGRAPHY

The projects that would impact the topography and soils within the Salt River stream bed are Va Shly'ay Akimel, Tempe Town Lake, Rio Salado (Tempe and Phoenix reaches), and Tres Rios. With the exception of the Tempe Town Lake dams, the projects involve reshaping the channel in a way that prevents erosion and sedimentation problems. Several of the projects include active bank stabilization measures, such as gabion walls and soil cement and protection for potentially disturbed roads and bridges through levees and grade control structures. The measures within

the projects that would increase soil stabilization and address known sedimentation problem areas would create beneficial effects for the cumulative impact zone.

5.2.2 HYDROLOGY AND WATER RESOURCES

The cumulative impacts of the proposed project, in combination with the other projects along the Salt River, are not expected to produce any adverse impact to surrounding water uses or the local environment. The proposed project would not cause raised surface water elevations during flooding, or depletion of water on the project site. Cumulatively, the Corps ecosystem restoration projects will not raise the 100-year flood levels, and will slightly lower them overall. In addition, the projects have each been determined to not adversely impact groundwater levels. When examined cumulatively, the projects would not collectively result in significant adverse impacts to groundwater.

5.2.3 WATER QUALITY

The Phoenix area is serviced by a regional WWTP located at 91st Avenue and the Salt River. The plant discharges approximately 154 mgd of effluent to the Salt River. In 1995, a Tres Rios Demonstration Project was placed within the floodway of the Salt River below the 91st Avenue plant. The project provides final treatment of approximately 2 mgd of effluent within ten acres of constructed wetlands. This project is immediately downstream of the Rio Salado Oeste Study area.

Surface water from storm drains is of poor quality and is only sporadically available. The poor quality of stormwater results from land uses in the watershed, and the usually long duration between rainfall events. Neither of these factors would be affected by the ecosystem restoration projects, either individually, or considered cumulatively. Groundwater has somewhat better quality, though there are still concerns with some contaminants. The cumulative effect of the Salt River ecosystem restoration projects on groundwater quantity or quality is expected to be negligible.

In all of the ecosystem restoration projects, incidental water quality improvement would be obtained through incorporation of wetlands into the restoration plan. Effluent that would be used for these projects is of excellent water quality. Tempe Town Lake is constantly monitored and adaptively managed for water quality issues. The projects have the potential to collectively benefit water quality along the Salt River.

5.2.4 BIOLOGICAL RESOURCES

The ecosystem restoration projects have the potential to create a biologically diverse and highly functional riparian more closely resembling what once existed in the Salt River. Three conditions prevent project continuity from Granite Reef Dam to the Salt-Agua Fria River confluence: the area spanning approximately one-mile from SR101 to west of McClintock is not part of a restoration project; the Tempe Town Lake is not consistent with riparian habitat and allows for large amounts of recreation to constantly disrupt wildlife activities, and; the area from Priest Drive to 28th Street in Phoenix will not be restored to reduce the possibility of bird strikes

with turbine engine aircraft using Sky Harbor International Airport (Federal Aviation Administration Advisory Circular 150/5200-33A, Hazardous Wildlife Attractants On or Near Airports, Dated July 27, 2004).

Despite these three interruptions in habitat contiguity, the Salt River would have a total of approximately 4,734 restored acres. Restoration would be continuous for approximately 21 river miles, from 28th Street to the Salt-Agua Fria River confluence with the implementation of Rio Salado Oeste. These ecosystem restoration projects would have significantly beneficial effects on biological resources. These benefits include providing biologically diverse and desirable vegetative communities, and new fish and wildlife habitat. Restored areas may include habitats with potential to support federally Threatened and Endangered species, and wildlife of special concern to the AGFD. The functional capacity of the Salt River as defined by the HGM model would also be greatly increased. Finally, newly restored riparian habitat would help to offset potentially significant adverse impacts from construction and other substantial OMRR&R measures by providing proximal habitat for mobile wildlife species to temporarily relocate.

5.2.5 CULTURAL RESOURCES

It is likely that the construction of this project would not have unavoidable significant impacts on prehistoric and historic cultural resources. In the event that any NRHP-eligible cultural resource is uncovered, compliance with Section 106 of the National Historic Preservation Act would be executed and Memorandums of Agreement among all stakeholders would be completed.

5.2.6 AESTHETIC RESOURCES

The Salt River has become an illegal dumping ground, home to squatters, and is also an unregulated fishing/recreation area. The streambed has been littered with construction waste, old tires, vehicles and other waste. Habitat has been of low quality and poor biodiversity. The stream banks have shown signs of erosion and degradation. These projects have already started to provide, and would continue to provide, beneficial cumulative impacts on the Salt River. Tempe Town Lake was able to make the area aesthetically pleasing enough to draw large amounts of developmental economic resources. The City of Phoenix concurrently planned the "Beyond the Banks" project, which aimed at redeveloping the area outside Rio Salado Phoenix to a more aesthetically pleasing commercial and residential zone to better coincide with the improvements to the Salt River.

5.2.7 AIR QUALITY

Based on the air quality analysis presented in Appendix D and Section 4.7.2 above, it has been shown that implementation of Alternative 5A would not have a significant impact on air quality. However, since there may be multiple construction projects in progress at any given time, the cumulative impact of these projects on air quality needs to be considered. Since Maricopa County is in a serious non-attainment area for PM-10, the most critical cumulative impact consists of PM-10 emissions. Cumulative contributions to the Maricopa County PM-10 and ozone nonattainment area emissions inventories by three federal ecosystem restoration projects

along the Salt River in Maricopa County (Rio Salado Oeste, Va Shly'ay Akimel and Tres Rios) are considered below.

The Rio Salado Oeste and Va Shly'ay Akimel projects are expected to be under construction concurrently. The period of concurrent construction would run from 2010 to 2017. It is also possible that the Tres Rios project would not be completed before construction work on Rio Salado Oeste and Va Shly'ay Akimel commences in 2010. The final year of construction for Tres Rios will consist mostly of completing "punch-list" items and light construction. Nevertheless, there is a short period of time around 2010 during which all three of these projects may be under construction at the same time. The projected cumulative VOC, CO, PM-10 and NO_X emissions for all three projects have been compared to the overall emissions inventories for the Maricopa County PM-10 and ozone nonattainment areas (MCESD, 2004a and 2004b). SO_X emissions for Rio Salado Oeste and the PM-10 nonattainment area are included, but were not calculated for the Va Shly'ay Akimel and Tres Rios projects. These emissions are compared in Table 5.2-1.

Table 5.2-1. Comparison of Air Emissions From the Salt River Ecosystem Restoration Projects and the Maricopa County Ozone and PM-10 Nonattainment Areas

Source of Emissions	POLLUTANTS OF CONCERN (Tons/Year)				
	VOC	CO	PM-10	NO_X	SO_X
Va Shly'ay Akimel	5	44	23	39	--
Tres Rios	2	18	10	24	--
Rio Salado Oeste (Year 4)	1.81	11.48	61.48	27.81	2.9
Maricopa County Ozone Nonattainment Area (2002)	88,964	496,334			
Maricopa County PM-10 Nonattainment Area (2002)			67,893	107,503	2,341

From the above comparison, it is apparent that even concurrent construction work on all three projects (using the highest annual emissions data for Rio Salado Oeste) would contribute less than 0.15 percent of the total PM-10 emissions for the Maricopa County PM-10 nonattainment area. Contributions to the emissions inventory for ozone precursors in the ozone nonattainment area would be negligible.

On a more local scale, the Rio Salado Oeste project would be constructed in an area that is already generating large amounts of emissions. The 2002 Periodic Emissions Inventory for Maricopa County (the last year for which a complete report is available) identifies more than 50 point sources of emissions within the 24 square mile study area. These sources include aggregate mining, retail and fueling facilities, materials handling, manufacturing, motor vehicles, trains, planes, small business and household activities, lawn mowers, and some portable equipment. Additional emissions originate from use of consumer products, road dust, farming operations, and fireplaces. Fugitive emissions from windblown disturbances, equipment leaks, and evaporative processes are also present. Finally, there are biogenic emissions from animal management operations, such as concentrated animal feeding operations (CAFO's).

Point source emissions can be directly calculated, and estimates of area sources, nonroad mobile sources, onroad mobile sources and biogenic sources of emissions are available for both the PM-10 and ozone nonattainment areas. However, air emissions from these various sources cannot be determined for a small portion of a nonattainment area, such as the Rio Salado Oeste study area (MCAQD, 2006). Nevertheless, it is possible to estimate air emissions from these sources by using a land size ratio between the Rio Salado study area (24 sq. mi.) and the ozone and PM-10 nonattainment areas (1,946 sq. mi. and 2,880 sq. mi., respectively). Using this methodology, it is possible to obtain a very general approximation of the emissions inventory for the Rio Salado Oeste study area (MCAQD, 2006). The air emission totals generated in this manner are summarized in Table 5.2-2.

Table 5.2-2. Approximate Air Emissions Inventory for the Rio Salado Oeste Study Area

Rio Salado Oeste Study Area Air Emissions (Tons/Year)	VOC	CO	PM-10	NO_X	SO_X
Point Sources	100.82	51.31	191.95	43.20	27.11
All Sources	1,150.28	6,152.66	749.1	912.23	44.92
Rio Salado Oeste (Year 4)	1.81	11.48	61.48	27.81	2.9

Using this method of comparison, the highest annual emissions associated with construction of Alternative 5A (year 4 of construction) would contribute less than 10 percent of the PM-10 emissions in the immediate study area. Contributions to the local emissions inventory for VOC, CO, NO_X and SO_X would be negligible.

Over the longer term, construction of Alternative 5A would displace some of the activities currently generating air emissions in the study area. Emissions associated with construction of the project itself would eventually cease, with the exception of the OMRR&R activities. The ecosystem restoration work would stabilize the loose soils in the area with landscaping and irrigated vegetation. The vegetation itself would serve as a windbreak, reducing the potential for wind-blown dust (PM-10).

In summary, the Rio Salado Oeste project would not have a significant long term effect on air quality, nor would it contribute to a significant cumulative impact on air quality. It would be important for all construction activities to abide by Maricopa County Rule 310 to ensure that *de minimus* thresholds are not exceeded. Compliance with Maricopa County Rule 310 would be made a condition of the construction contracts, and would be enforced through weekly inspection by the Corps.

5.2.8 NOISE

Residents living adjacent to or near the Salt River in the Phoenix area are likely to be exposed to some level of noise from construction, OMRR&R, and recreational activities associated with one of the Salt River projects. The highly urbanized Salt River corridor already has moderate activity levels and many sources of ambient noise. These include highway noise, widespread construction activities not associated with ecosystem restoration, sand and gravel mining operations, and aircraft approaching and departing Sky Harbor International Airport. The

principle sources of noise in the immediate vicinity of the Salt River are sand and gravel mining operations. These would remain the largest and most significant contributor to ambient noise along the river.

Unlike air pollution that can accumulate throughout a large area, noise attenuates as the distance from its source increases. The Salt River projects most likely to have concurrent construction periods would be Rio Salado Oeste and Va Shly 'ay Akimel. Since these projects are located 12 river miles apart, sensitive receptors would not be exposed to ambient noise from both projects at the same time. As discussed above, there is a small chance that Tres Rios would be completing construction as Rio Salado Oeste begins construction. The final construction work on Tres Rios (improvements to the pump stations and piping water to wetlands) would be located some distance from the western end of Rio Salado Oeste. Therefore, noise generated by construction equipment on the two projects would be unlikely to have a cumulative effect.

While construction at any single location along the Salt River would occur during a relatively short period of time, OMRR&R and recreational activities would continue in perpetuity. However, these noise sources would be minor contributors to ambient noise levels along the Salt River. OMRR&R work would occur on an infrequent basis at any one location along the river. Thus, no significant cumulative impacts to noise levels would occur within the cumulative impact zone along the Salt River.

5.2.9 SOCIAL AND ECONOMIC RESOURCES

The presence of Tempe Town Lake has created a highly desirable waterfront area that has spurred residential and commercial development along its banks. The City of Phoenix, through its "Beyond the Banks" program, is actively pursuing redevelopment along the Salt River corridor. These effects would be considered positive and beneficial by most people, but have a limited area of effect. In the context of Maricopa County, the Salt River ecosystem restoration projects would not have significant cumulative effects on population, housing, employment, or income.

5.2.10 TRANSPORTATION

Construction activities for the Salt River projects would cause local, temporary inconveniences for motorists utilizing roads along or crossing the Salt River. Since most of these impacts would be on surface streets, motorists would be unlikely to encounter delays associated with more than one project during their everyday activities. With the exception of additional commuter trips for construction workers, and delivery of construction materials and equipment to and from the work sites, there would be little cumulative impact on the local network of limited access highways. In the context of the traffic volume already present in Maricopa County, any cumulative impact would be inconsequential.

Long-term recreational use would generate additional vehicle trips within the cumulative impact zone. However, recreation would occur in higher volume during non-peak traffic times (i.e., week nights and weekends). Interstate highways and state routes provide limited access service throughout the zone of cumulative impacts. These freeways have numerous exits so that the

accumulation of any additional vehicle trips by recreationists would not adversely impact any single area.

5.2.11 LAND USE

The Salt River is identified as "Proposed Open Space" on local land use maps. 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 City of Phoenix 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 Maricopa Association of Governments Regional Transportation Plan (November, 25, 2003) states that Maricopa County is projected to double in population over the 2000 base population, with an anticipated total of 6.24 million people. This means that the region will experience a growth of approximately one million people during each decade. By 2025, the largest Municipal Planning Area – Phoenix, will contain 2.1 million persons. By 2025, Maricopa County is projected to nearly double its reported 2000 employment total. This means that employment within the region will grow at a number of approximately 575,000 jobs each decade. The river corridor's transformation into a low-use restoration area would make it easier for the area to absorb the adjacent higher-use development.

The County's size and environmental diversity is greater than some U.S. states, and it provides a complex natural ecosystem. As part of the overriding vision for the County, protection of the unique desert environments is 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). Rio Salado Oeste, when combined with the other restoration and recreation projects, collectively achieves the Proposed Open Space land use designation.

5.2.12 RECREATION

Cumulatively, the Salt River ecosystem restoration projects would create approximately 58.5-miles of recreational paths along the Salt River. Moreover, the sections from Rio Salado Tempe to Tres Rios are part of a larger 100-mile Regional Loop, a non-vehicular transportation corridor that will encircle the Phoenix metropolitan area. Therefore, the addition of Rio Salado Oeste to the other projects along the Salt River would have cumulative beneficial impacts.

5.2.13 PUBLIC HEALTH AND SAFETY

The Salt River corridor has become an illegal dumping ground, home to squatters, and is an unregulated fishing/recreation area. Implementation of the Salt River ecosystem restoration projects would eliminate wildcat dumping, and would create a more regulated environment for recreationists. The recreational use of the Salt River corridor is expected to increase because of an increase in development along the river corridor and increased opportunities for recreation. An increase in crime and property damage has the potential to accompany an increase in use. Therefore, the presence of park rangers and maintenance staff, regulated hours of operation and regulated points of entry would help create a river corridor that is safer for public use. Fishing opportunities in sand and gravel pits converted to riparian habitats would be lost. Addressing problems with squatters is a sensitive issue that would be more difficult to address.

Vector issues have the potential to occur wherever standing water lingers. Maricopa County has a routine monitoring program county wide, and a vector control program to help reduce the risk of mosquito-borne disease. Maricopa County Vector Control monitors mosquitoes along the Salt River primarily during the summer months. 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.

The increase in wetlands and other riparian habitats would aid in removing potentially harmful pollutants from stormwater. Pollutants that are not removed or broken down have the potential to infiltrate into the groundwater supply. The Salt River projects would also ensure a hydraulically designed river channel for conveyance of flood flows, with incidental flood damage reduction benefits. The cumulative impact of the Salt River ecosystem restoration projects would be a net beneficial effect on public health and safety.

5.3 CONCLUSIONS

The Rio Salado Oeste project, in concert with the five other projects along the Salt River, would be expected to bring desirable, positive increases in desirable native vegetation, wildlife habitat, and an extended riparian corridor for the local area. Other beneficial impacts would include a decrease in erosion and sedimentation problems, potentially improved water quality through the creation of new wetlands, improved aesthetic resources, a land use that fulfills the Maricopa County Comprehensive Plan, a continuous recreation corridor, incidental flood damage reduction benefits, and increased public health and safety along the Salt River.

CHAPTER 6
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES AND UNAVOIDABLE SIGNIFICANT IMPACTS

The Council on Environmental Quality (CEQ) NEPA regulations (42 U.S.C. 4332; 40 CFR 1502.16) require analysis of significant irreversible and irretrievable commitments. Irreversible commitments are damages to the environment that cannot be reversed, even after the life of a project. Irretrievable commitments are those that are lost for a long period of time. This includes the use of nonrenewable resources, such as metal, wood, fuel, paper, and other natural or cultural resources. These resources are considered committed because they would be used for the proposed action when they could have been conserved or used for other purposes. Another impact that is discussed in this chapter is the unavoidable impacts of the proposed action and alternatives where no mitigation is available to offset the environmental consequences.

Long term implications of the project are to enhance the degraded riparian habitat that has diminished as a viable support system for wildlife. A commitment to an efficient utilization of natural resources would allow the historically productive habitat to be restored.

6.1 IRREVERSIBLE COMMITMENTS

A defined above, irreversible commitments made during the construction of the Rio Salado Oeste project would include air pollutant emissions. The project construction would not reach *de minimus* threshold levels. However, Maricopa County is a PM-10 non-attainment area. The construction of this project would add to other emissions and create an irreversible commitment to the environment.

6.2 IRRETRIEVABLE COMMITMENTS

All of the alternatives would result in the irretrievable commitment of resources such as fuel for construction vehicles and concrete for the grade control structure. Additionally, clay and stone needed to construct some project features may be imported from offsite. All of these materials are both readily available and easily generated.

Another resource this project commits that is currently available is stormwater and effluent. Stormwater currently has no other use than to be directed into the river, though effluent is also used to irrigate agricultural lands as needed. The project would commit both of these water sources to newly constructed cottonwood/willow, mesquite, scrub-shrub and wetland habitats. These resources are both readily available and easily generated, but could realistically be needed for other uses in the future if current drought conditions and population expansion continue. Dedication of this water to the Rio Salado Oeste project would create an irretrievable commitment of this nonrenewable resource.

Finally, the proposed action would commit workforce time for construction, engineering, environmental review and compliance, and for project operation, maintenance, repair, replacement and rehabilitation.

6.3 UNAVOIDABLE SIGNIFICANT IMPACTS

This Statement finds that implementation of the Rio Salado Oeste Project is not anticipated to result in any unavoidable significant impacts. This finding includes potential impacts on prehistoric and historic cultural resources.

CHAPTER 7
ENVIRONMENTAL COMPLIANCE

The Rio Salado Oeste project would comply with several major state and federal laws, as described below:

7.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969, as amended

NEPA requires that environmental consequences and project alternatives be considered before a decision is made to implement a federal project. NEPA establishes requirements for preparation of an EIS for projects potentially having significant environmental impacts. This EIS has been prepared in accordance with the requirements set forth in Section 102 of NEPA, the CEQ Regulations for implementing the procedural provisions of NEPA (40 CFR 1500 et seq.), and the U.S. Army Corps of Engineers Regulation 200-2-2, *Procedures for Implementing NEPA*, (33 CFR, parts 230 and 325). Reasonable alternatives have been considered during the planning process. Potential environmental effects have been included in the evaluation of the proposed project actions, and all procedural review requirements of the aforementioned rules and regulations would have been met as part of the EIS process.

7.2 CLEAN AIR ACT, as amended, 1990

The US Environmental Protection Agency (EPA) is involved in local air quality planning through the federal Clean Air Act, as amended, 1990. Air quality impacts of each alternative considered at Rio Salado Oeste project fall under both federal and state conformity regulation. In Arizona, the federal conformity regulation in 40 CFR Part 93, Subpart B has been adopted by reference in the Arizona Administrative Code, Section R18-2-1438. Based on the air quality analysis described in the FEIS, the total emissions of each applicable criteria pollutant are below *de minimus* levels as prescribed in 40 CFR 93.153(b). As a result, the General Conformity Rule does not apply and no further analysis or determination is required. This project is expected to comply with the Clean Air Act, as amended, 1990.

7.3 CLEAN WATER ACT OF 1977

The Clean Water Act is the principal law governing pollution control and water quality of the Nation's waterways. The objective of the Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (33 U.S.C 1251). Each action alternative would require the discharge of fill material into Waters of the United States. A jurisdictional delineation of Waters of the U.S. has been performed for the project implementation area. A 404(b)(1) evaluation has been prepared and is included in Appendix A of the EIS. The District Commander will recommend an exemption from the requirement to obtain State water quality certification under Section 404(r) of the Clean Water Act.

7.4 ENDANGERED SPECIES ACT (ESA) OF 1973, as amended

The project is in compliance with the Endangered Species Act. This Act states that various species of fish, wildlife, and plants in the United States have been rendered extinct or depleted in numbers so that they are in danger of or threatened with extinction, or are of aesthetic, ecological, educational, historical, recreational, and scientific value to the United States. The purposes of the Act are to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a program for the conservation of such endangered species and threatened species.

In accordance with Section 7(a)(2) and 7(c), the Corps requested information on threatened and endangered species in the study area in a letter to the U.S. Fish and Wildlife Service (FWS) in December 2004. FWS responded in a March 22, 2004 letter with a reference to the Internet web page http://arizonaes.fws.gov where the Arizona Ecological Field Services Office has posted lists for state of Arizona by County. FWS assigned consultation number 02-21-04-I-0137 to this project. Copies of correspondence and the Maricopa County species information (downloaded from the Internet) are included in Appendix B. As FWS noted in their letter, the species on the county list do not necessarily occur in the study area. The species on the list have been evaluated for potential impact in the EIS. A federal agency is required to consult with FWS pursuant to Section 7 of the Act if it determines that an action may affect a listed species. The Corps has determined that the proposed action will either not affect or is not likely to adversely affect listed species. On August 7, 2006, the Corps received a concurrence letter from the USFWS stating that the this project may affect, but is not likely to adversely affect the species of concern.

7.5 BALD AND GOLDEN EAGLE PROTECTION ACT OF 1940, as amended (16 U.S.C. 668)

This FEIS addresses the potential for this project to affect the bald eagle. No take of bald or golden eagles, alive or dead, or any part, nest, or egg thereof, is anticipated, regardless of which alternative is selected. All five action alternatives are expected to comply with the Bald and Golden Eagle Protection Act.

7.6 FISH AND WILDLIFE COORDINATION ACT OF 1958, as amended (16 U.S.C. 661)

The project alternatives are in compliance with the Fish and Wildlife Coordination Act. In response to the requirements of the Act, the Corps has and will continue to coordinate with both the U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department (AGFD). As part of this coordination, the USFWS provided a Planning Aid Letter on June 21, 2002, and a Coordination Act Report on June 20, 2005. These documents provide recommendations for alternative formulation and future OMRR&R activities, and state that the USFWS is unaware of any federally listed Threatened or Endangered species within the project area.

Both agencies participated as members of the HGM team, and the USFWS also conducted soil, water, and fish tissue analyses. The DEIS was sent to the USFWS and the AGFD during the public review period.

7.7 MIGRATORY BIRD TREATY ACT OF 1994, as amended

This project complies with the Migratory Bird Treaty Act, which provides legal protection for almost all breeding bird species occurring in the United States. The intent of the Act is to eliminate any commercial market for migratory birds, feathers, or bird parts. This document addresses the potential of the alternatives of the project components to affect migratory birds. The alternatives would not include the taking, killing, or possession of any migratory birds. In addition, the project would not facilitate the commercial market for any bird species.

7.8 NATIONAL HISTORIC PRESERVATION ACT

An archeological field survey of the Area of Potential Effect (APE) would need to be conducted in accordance with Section 106 of the National Historic Preservation Act of 1966 (36 CFR 800). If cultural resources were to be discovered during construction and could not be avoided, work would be suspended in that area until the finds are evaluated for eligibility for listing in the National Register of Historic Places (NRHP) in consultation with the State Historic Preservation Officer (SHPO). If resources were determined to be NRHP-eligible and avoidance is not feasible, further mitigation measures would be detailed in a Memorandum of Agreement (MOA) between all necessary parties, including the SHPO, the City of Phoenix, and the tribes. These mitigation measures would include field surveys, testing, and data recovery. The Advisory Council on Historic Preservation would be provided the opportunity to comment in accordance with 36 CFR 800.11.

7.9 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT, MAY 24, 1977, as amended

Under this Executive Order, the Corps must take action to avoid development in the base floodplain (100-year) unless it is the only practicable alternative to reduce hazards and risks associated with floods; to minimize the impact of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial value of the base floodplain. The project area is located entirely within the Salt River floodplain. The hydrologic and hydraulic analyses included as Appendix A to the Feasibility Report show that implementation of Alternative 5A would not cause a rise in water surface elevations during the 100-year flood. Incidental flood damage reduction benefits would occur if Alternative 5A was constructed. The project is in compliance with this Executive Order.

7.10 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS, 1977

In developing alternatives, the Corps considered the effects of the project on the survival and quality of wetlands. Projects are to "...avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative...." Since it is necessary to reconstruct the entire Salt River channel to implement any one of the action alternatives, avoidance of wetlands is not practicable. Essentially all wetlands within the project implementation area would be impacted by construction of Alternative 5A. However, a much larger acreage of higher quality, more sustainable wetlands would be created. There would be a short term adverse effect on wetlands until the benefits associated with the project begin to accrue. The overall effect of this project on wetlands would be beneficial.

7.11 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

On February 11, 1994, President Clinton signed an "Executive Order on Federal Action to address Environmental Justice in Minority Population and Low-Income Populations. This Order is designed to focus federal attention on actions that affect environmental and human health conditions in minority and low-income communities. The proposed project would not adversely affect minority populations or low income populations. This project would provide a geographic benefit to the area surrounding the Salt River.

7.12 ARIZONA GROUNDWATER MANAGEMENT ACT

The Arizona Groundwater Management Act was passed by the Arizona Legislature in 1980. This Act created Active Management Areas (AMAs) overseen by Arizona Department of Water Resources (ADWR). ADWR has identified the groundwater basin underlying lower Salt River Valley as the Phoenix Active Management Area. The Phoenix AMA comprises two distinct but interconnected alluvial groundwater basins: West Salt River Valley and East Salt River Valley (Section 3.2.2). The management goal of the Phoenix AMA is to attain "safe yield" by 2025. "Safe yield" means that ground-water withdrawals are balanced with natural and artificial recharge within the AMA. This is to be achieved by implementing water conservation, utilizing renewable water resources such as Colorado River water and effluent, retiring agriculture with advancing urbanization, and by purchasing and extinguishing private groundwater rights. Regardless of the water sources utilized, any alternative implemented would be expected to comply with the Arizona Groundwater Management Act.

7.13 AQUIFER PROTECTION PERMITS

The Arizona Department of Environmental Quality (ADEQ) administers an Aquifer Protection Permit (APP) program to safeguard the groundwater supply from pollutants that come from an identifiable source. Organizations or individuals may be required to obtain an APP if they own or operate a facility that discharges a pollutant directly to an aquifer, to the land surface, or to the

area between an aquifer and the land surface (the vadose zone) when it is likely that the pollutant will reach an aquifer (ADEQ, 2006). The APP program includes provisions for exemptions or non-applicability. An APP may be needed from ADEQ prior to project implementation.

7.14 ARIZONA NATIVE PLANT LAW

The Arizona Department of Agriculture enforces the Arizona Native Plant Law. The law provides varying levels of protection for most of the plants native to the state. Landowners have the right to destroy or remove native plants growing on their land, but 20 to 60 days prior to the removal of any protected native plants, landowners are required to notify the Arizona Department of Agriculture and to obtain permits or tags where applicable. The proposed alternatives would increase the number and diversity of native plants within the project while greatly reducing the number of non-native plants.

7.15 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.

The proposed project is in compliance with this Executive Order.

CHAPTER 8
MITIGATION MEASURES

Chapters 4 through 7 address impacts related to the proposed project implementation and future maintenance. Mitigation measures are developed for each resource to minimize project-related impacts. The following explanation details required mitigation measures for Alternative 5A, the recommended plan. For a complete comparison of mitigation measures for each alternative, please refer to Table ES-2.

8.1 GEOLOGY AND TOPOGRAPHY

No mitigation required.

8.2 HYDROLOGY AND WATER RESOURCES

No mitigation required.

8.3 WATER QUALITY

In terms of water quality, the awarded contractor would need to prepare a project-specific Notice of Intent (NOI) and a Stormwater Pollution Prevention Plan (SWPP) for construction activities. In addition, it should be noted that on November 16, 1990, EPA published regulations under the NPDES program that defined one facet of the phrase "stormwater discharges associated with industrial activity" as being discharges from construction activities (including clearing, grading and excavation activities) that result in the disturbance of five or more acres of total land area, including smaller areas that are part of a larger common plan of development or sale (40 CFR 122.26(b)(14)(x)). These are commonly referred to as Phase I construction activities. ADEQ is issuing the construction general permit that authorizes the discharge of pollutants in stormwater discharges associated with construction activity. The AZPDES rules found in the Arizona Administrative Code (A.A.C.) R18-9-A905 incorporate these and other NPDES federal regulations, by reference.

The regulation entitled "National Pollutant Discharge Elimination System – Regulation for Revision of the Water Pollution Control Program Addressing Stormwater Discharges" (64 FR 68722) was published by EPA on December 8, 1999. This regulation, which is considered Phase II of the stormwater program, expands the existing NPDES stormwater program to address discharges that result in land disturbance of equal to or greater than one and less than five acres or less than one acre if part of a larger common plan of development or sale. The Stormwater Phase II Rule automatically designates these small sites; however, this rule allows for the exclusion of certain sources from the national program based on a demonstration of the lack of impact on water quality, as well as the inclusion of others based on a higher likelihood of localized adverse impact on water quality. Exclusion from the program is available through waivers to operators of small construction activity who certify for one of the available waivers.

There may be confusion about permitting requirements for sites that are part of a larger common plan of development or sale. All large construction activity, regulated under 40 CFR 122.26(b)(14)(x), is required to obtain coverage under a stormwater permit including sites disturbing less than five acres that are part of a larger common plan of development or sale that has the potential to disturb five or more acres collectively. A similar permit requirement exists for small construction activity, regulated under 40 CFR 122.26(b)(15)(i), that disturbs less than one acre but is part of a larger common plan of development or sale having the potential to disturb at lease one, but less than five acres collectively. Examples of these would be lots in a subdivision or industrial park. Construction projects that disturb less than one acre not meeting these requirements may still be designated to be covered under this permit based on the potential for contribution to a violation of a water quality standard or for significant contribution of pollutants to waters of the U.S. (40 CFR 122.26(b)(15)(ii)).

The mitigation measures/environmental commitments are summarized in the following paragraphs.

Mitigation Measure WQ-1: Implement Erosion Control Best Management Practices (BMPs)

The Corps and its contractors shall implement erosion control measures throughout the construction period and during implementation of OMRR&R activities to minimize erosion and sediment input into the river. The Corps would oversee implementation of erosion control measures during construction. The contractor selected for the project shall:

- Conduct construction and OMRR&R 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 required clearing, grading, revegetation, or reshaping in a way that minimizes 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;
- Apply water to unpaved haul roads at a frequency adequate to maintain visible surface moisture;
- Mulch disturbed areas as appropriate and plant with appropriate species as soon as practicable after disturbance;

- Avoid operating equipment in flowing water by using temporary cofferdams or other suitable structures to diver flow around the channel and bank construction areas, and;
- If hay bales are used for erosion control during construction they must be sterile and weed-free.

Mitigation Measure WQ-2: Implement Spill Prevention BMPs

The Corps and its contractors would 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 would oversee development and implementation of a stormwater pollution prevention plan. Elements of that plan would 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 clean-up procedures employed;
- Staging and storage areas for equipment, materials, fuels, lubricants, solvents, and other possible contaminants are located at least 100-feet a way from the river's normal high-water area;
- 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).

8.4 BIOLOGICAL RESOURCES

Mitigation Measure BR-1: Re-vegetation Construction Management Practices

The Corps would remove salt cedar (*Tamarix* spp.) and giant reed (*Arundo donax*) from the restoration areas as part of the restoration process (Alternatives 4, 5, 5A, and 5B). The City of Phoenix, the non-federal sponsor, would be responsible for maintaining the restored habitat areas free of invasive plants, especially salt cedar and giant reed, throughout the life of the project (Alternatives 4, 5, 5A, and 5B).

The cleared areas would be re-vegetated with habitat of higher quality and permanence than the habitat removed. Implementation of good construction management practices, especially dust suppression with water and/or non-toxic dust-suppressing chemicals or soil binders, would minimize potential impacts from fugitive dust. Also, decreases in the vegetation population 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 to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

Mitigation Measure BR-2: Use Clean and Certified Foreign Soils

If any imported topsoil is used in the restoration project, it shall be clean and certified free of weeds, including seeds (Alternatives 2, 4, 5, 5A, and 5B). Feral or free-ranging cats and dogs shall be reported to the local of Animal Control office, and signs shall be posted prohibiting the release of pets of any kind and the use of the restoration area by unrestrained pets (Alternatives 2, 4, 5, 5A, and 5B).

Mitigation Measure BR-3: Safe Harbor Agreements, Candidate Conservation Plan and Habitat Conservation Plans

The Corps will encourage the non-Federal sponsor to enter into a Safe Harbor Agreement, Candidate Conservation Plan, or Habitat Conservation Plan as necessary for the continued O&M of the Rio Salado Oeste project. It is expected that with the development of agreements for the Rio Salado and Tres Rios restoration projects an additional agreement for the Rio Salado Oeste project will be developed.

Mitigation Measure BR-4: Consult with USFWS and AGFD prior to Ground-Disturbing Activities

Prior to ground-disturbing activities in existing riparian or wetland areas, the Corps would consult with U.S. Fish and Wildlife Service and Arizona Game and Fish Department to determine the potential for the occurrence of any sensitive wildlife species. If sensitive species are determined to be present or to have potential to occur, the schedule for invasive removal shall be revised to avoid breeding seasons of any sensitive species on site (Alternatives 4, 5, 5A, and 5B).

Mitigation Measure BR-5: Conduct Operation & Maintenance Activities on a Rotating Basis and Only During Non-Nesting Periods

Sediment removal and other activities would only be conducted during non-nesting periods of the above listed Threatened and Endangered species, and Wildlife of Special Concern. Sediment removal would be conducted on a rotating basis so that no more than 25 percent of the marsh area would be affected in any one year.

Mitigation Measure BR-6: Reinitiation of Section 7 Consultation

The estimated construction date for this project to commence is 2010, pending Congressional Authorization and subsequent funding for design and construction. Project area conditions may change by that time. Should new information become available or suitable habitat for southwester willow flycatcher or Yuma clapper rail become established prior to construction commencing, protocol surveys will be conducted and section 7 consultation reinitiated as necessary.

Mitigation Measure BR-7: Trap and Relocate Native Fish

It would be necessary to drain the lakes in the project implementation area during construction, and impacts to fish could be significant. To mitigate this impact, it is recommended that native fish be trapped and relocated prior to any major water draw-down.

8.5 CULTURAL RESOURCES

Mitigation Measures CR-1: Conclude MOA to Complete Field Surveys and Conduct Testing and Data Recovery Activities as Appropriate

Pursuant to Section 106 of the National Historic Preservation Act, 36 CFR 800.13(2), any discoveries of either human remains or archeological deposits shall result in the following process:

- Contractor shall stop work;
- Corps of Engineers Archeology Staff shall be notified of discovery;
- Corps Archeology Staff shall determine if discovered cultural mater is an isolated find, or consists of a deposit of some extent. If needed, hand excavations shall be conducted to determine if the deposit is of sufficient content and integrity to be eligibly for listing on the National Register of Historic Places, and;
- The Corps shall determine eligibility, and effect in consultation with the State Historic Preservation Officer pursuant to 36 CFR 800.

8.6 AESTHETICS

No mitigation required.

8.7 AIR QUALITY

Mitigation Measure AQ-1: Implement PM-10 - Reducing Measures during Channel Excavation and Bank Stabilization

All construction, restoration and routine maintenance 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 PM-10 - reducing construction practices in compliance with Maricopa County Rule 310 throughout the construction period:

- 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 in accordance with Maricopa County Rule 310;

- Minimize vehicle speed on unpaved roads;
- Water active storage piles at least with a frequency consistent with Maricopa County Rule 310;
- Cover or otherwise stabilize inactive storage piles where feasible;
- Cover haul trucks securely when transporting materials;
- Water all active construction areas with a frequency consistent with Maricopa County Rule 310. Frequency should be increased if wind speeds exceed 15 mph, and;
- Prohibit all grading activities during periods of high wind (i.e., winds greater than 30 mph).

Compliance with Maricopa County rules would be made a condition of the construction contract and would be enforced through weekly inspection by the Corps.

Mitigation Measure AQ-2: Promotion of Alternative Transportation and Energy Efficiency

In order to mitigate potential environmental impacts from increased traffic, recreational facilities (e.g., multipurpose trails, walk-in access points, access control, continuity with other projects) would be developed that promote alternative transportation and energy efficiency. Initial capacity of the parking facilities would be designed for not more than 500 vehicles in order to limit the potential impact of human activities upon the restoration project.

8.8 NOISE

Mitigation Measure N-1: Employ Noise-Reducing Construction Measures

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 7pm and 7am 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 a muffled 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.

8.9 SOCIAL AND ECONOMOIC RESOURCES

No mitigation required.

8.10 TRANSPORTATION

Mitigation Measure T-1: Implement Traffic Control Plan

This work shall consist of traffic control, and use of devices and flagmen or pilot cars in accordance with Section 401 of the COP Supplements and the City of Phoenix Traffic Barricade Manual, dated 1998.

All traffic and/or traffic control devices on this project shall be provided, maintained and/or controlled as specified in the City of Phoenix Traffic Barricade Manual, dated 1998.

Permission to restrict city streets, sidewalks and alleys (street closure permits) shall be requested as specified in Section III of the City of Phoenix Traffic Barricade Manual.

Unless otherwise provided for in the following General Traffic Regulations, all traffic on this project shall be regulated as specified in Section IV of the City of Phoenix Traffic Barricade Manual.

Mitigation Measure T-2: 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 over each roadway and with the intent to return the roadways to the conditions existing immediately prior to the commencement of the project.

8.11 LAND USE

No mitigation required.

8.12 RECREATION

No mitigation required.

8.13 PUBLIC HEALTH AND SAFETY

Mitigation Measure PHS-1: Implement HTRW Management Measures

Best Management Practices (BMPs) would be implemented during construction. Some examples of these BMPs follow. Construction activities should be conducted in the dry weather

season to the extent possible to minimize exposure of disturbed construction sites to rainfall and stormwater runoff. The general contractor for the project would 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. BMPs must be implemented before predicted rain events. In addition, the construction contractor would implement standard hazardous materials management practices to reduce the possibility of chemical spills or releases of contaminants in runoff.

Mitigation Measure PHS-2: Implement Construction and OMRR&R Management Measures

The Contractor shall provide temporary fencing, barricades, and/or guards, as required, to provide protection in the interest of public safety. Whenever the Contractor's operations create a condition hazardous to the public, he shall furnish at his own expense and without cost to the Government, such flagmen and guards as are necessary to give adequate warning to the public of any dangerous conditions to be encountered and he shall furnish, erect, or maintain such fences, barricades, lights, signs and other devices as are necessary to prevent accidents and avoid damage or injury to the public. Flagmen and guards, while on duty and assigned to give warning and safety devices shall conform to applicable city, county, and state requirements.

Should the Contractor appear to be neglectful or negligent in furnishing adequate warning and protection measures, the Contracting Officer may direct attention to the existence of a hazard and the necessary warning and protective measures shall be furnished and installed by the Contractor without additional cost to the Government. Should the Contracting Officer point out the inadequacy of warning and protective measures, such action of the Contracting Officer shall not relieve the Contractor from any responsibility for public safety or abrogate his obligation to furnish and pay for those devices. The installation of any general illumination shall not relieve the Contractor of his responsibility for furnishing and maintaining any protective facility.

Mitigation Measure PHS-3: Monitoring Plan, Natural Controls and Chemical Pesticides

Chemical pesticides would be avoided in favor of natural controls because chemical pesticides often adversely affect desirable fish and wildlife species, as well as humans. Restored habitat would attract some natural predators of mosquitoes, including insects such as water striders, giant water bugs, common backswimmers, dragonflies, and water boatman. Vertebrate predators, including barn swallows, black phoebes, song sparrows, and several species of bats would also potentially populate the habitat following restoration. Native insect and vertebrate predators of mosquitoes could be introduced to the habitat, but unless conditions are optimum, populations may not remain adequate for long-term mosquito control.

Large populations of mosquitoes often occur even in relatively undisturbed habitats where water is present. The Gila topminnow (*Poeciliopsis occidentalis occidentalis*), a small native fish that is federally listed as Endangered, may effectively control mosquitoes. Special protocols would be required to introduce this species to the project area due to its endangered status, but Gila topminnow may be a good option in areas where non-native predators (including mosquito fish)

are not present. Western mosquito fish (*Gambusia affinis*), a species of small fish native to the United States from eastern Mississippi to eastern Texas that feeds on mosquito larvae, are commonly stocked in ponds as an efficient and economical biological method of mosquito abatement. Mosquito fish also consume eggs and fry of native fish, as well as desirable insect species, which would be detrimental to native fish populations. In the borrow pit lakes, where fish populations consist primarily of introduced game species, mosquito fish may be an acceptable biological control, provided that they are confined to the lakes. A bacterium, *Bacillus thuringensis* var *israeliensis*, which is specific to mosquito larvae but harmless to most other organisms, is another effective biological control that may be compatible with ecological restoration.

In addition to the above possible measures, Maricopa County has a routine monitoring program county wide and a vector control program to help reduce the risk of mosquito-borne disease. Maricopa County Vector Control monitors mosquitoes along the Salt River primarily during the summer months. 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.

CHAPTER 9
PUBLIC INVOLVEMENT

9.1 SCOPING

The City of Phoenix 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 the past. Without previously available water sources and modifications that have been made to the floodplain, most of the native vegetation and wildlife cannot survive, and the Salt River is biologically quite impoverished. The objectives of the study are as follow:

- Restore native riparian, wetland and floodplain habitat and manage undesirable plan, fish and wildlife species.
- Reduce flood damages to infrastructure and structures.
- Improve passive recreation and environmental-education opportunities.

The publication of the Notice of Intent to prepare an EIS in the Federal Register on August 28, 2001 initiated the Rio Salado Oeste NEPA process, which emphasizes public involvement. The non-federal views and preferences regarding ecosystem restoration, with some recreation, were generally obtained through coordination with the non-federal sponsor and with various local and regional agencies and organizations, neighborhood associations, and the general public. Since September 2001, city staff held nearly 200 public presentations, reaching over 7,000 individuals, about Phoenix Rio Salado. The initial public meeting for Rio Salado Oeste was September 13, 2001. The final public meeting/hearing was May 18, 2006. During this timeframe, a diverse 25-member advisory committee met 27 times. The target audiences for Rio Salado Oeste included the city's Laveen Village Planning Committee, Estrella Village Planning Committee, South Mountain Village Planning Committee and the 142 city council District 7 neighborhoods. District 7 includes most of south and west Phoenix, with approximately 215,000 residents. The public meetings were advertised in The Arizona Republic, La Prenza, La Voz, Asian Sun News, Asian American Times and Arizona Informant. Announcements for public meetings, including the date, time, location, and subject matter, were made in local newspapers. A formal public scoping meeting was held with the sponsor on September 13, 2001. The purpose of the meeting was to introduce the project to the public, give individuals and agencies an opportunity to identify issues for consideration in this DEIS, and to solicit input on the project. The Corps received no written public comments during the scoping period. Comments received during the DEIS public meeting and responses can be found in Appendix E. The Corps, in conjunction with the local sponsors, held or made presentations at the following locations:

- Tres Rios Project Stakeholder Meeting at Flood Control District of Maricopa County- November 14, 2001, and;
- Rio Salado Advisory Committee Meetings - January 2004, May 2005;

Concerns expressed at the public meetings included the following:

- Vector control is an important component;
- Flood conveyance needs to be maintained;
- Utilize existing open water bodies (public fishing), and;
- Natural water course should be maintained.

9.2 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; representatives from the non-federal cost-sharing 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 Rio Salado Oeste project met to discuss baseline project area conditions and without-project results. In April, 2004, a similar group met to project future without-project conditions for the HGM models.

9.3 AGENCY COORDINATION

This FEIS 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 FEIS for the proposed action is the U.S. Army Corps of Engineers, Los Angeles District. The City of Phoenix is the non-federal sponsor for the project. The Corps 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 (FEIS) prior to rendering any decisions on the proposed action. A decision for the proposed action will be issued by the Corps in the form of a Record of Decision (ROD). 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. Thus far, 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 Department, and the City of Phoenix.

9.4 PUBLIC HEARING

A 45-day comment period on the Rio Salado Oeste, Draft Environmental Impact Statement (EIS) began with the publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register on May 12, 2006. A public hearing to discuss and receive comments on the Draft EIS was held at the Travis L Williams Family Services Community Center in Phoenix, Arizona on the evening of May 18, 2006. Notices were sent to local communities and a public notice in the *Arizona Republic* announced the public meeting.

Karen Williams of the City of Phoenix gave an introduction to Rio Salado. Colonel Dornstauder of the U.S. Army Corps of Engineers gave a briefing on the project. This presentation can be found in Appendix E of this statement. Afterward, the public was given three minutes to provide an oral comment. Eight members of the public spoke, all in favor of the project. The public hearing minutes can be found in Appendix E.

In addition, comment cards were available. We had one comment that mentioned a loss of focus on the environmental education this project would provide. That comment and response can be found in Appendix E.

Additionally, we received eleven letters of support for the project from: Sam Campana, Vice President and Executive Director of the Audubon Society of Arizona; Karen William of the City of Phoenix; Domenick Commisso, former member of the Rio Salado Advisory Committee; Congressman Ed Pastor; Donald P. Kuth, President of the Phoenix Community Alliance; Claude Mattox, Phoenix Councilman from District 5; Diana Brooks, Chairperson of the Phoenix Parks and Recreation Board; Joan Kelchner, Chairperson of the Phoenix Planning Commission; Doug Lingner, Vice Mayor of the City of Phoenix; George Young, Chairman of the South Mountain Village Planning Committee and former Chariman of the Rio Salado Advisory Committee; and, Diane Brossart, President of Valley Forward. The letters can be found in Appendix E.

We also received letters from seven different tribes, agencies and organizations: the Arizona Riparian Council, the Arizona Department of Game & Fish, the City of Phoenix, the Department of Interior, the Environmental Protection Agency, the Salt River Project and the Yavapai Tribe. These letters recommended changes or had editorial remarks as well as an offer of support for the project. The letters and our responses can be found in Appendix E.

All comments received during the comment period were considered in the preparation of the Final EIS. Comments received during the public hearing or in writing, along with responses, may be found in Appendix E of the Final EIS.

CHAPTER 10
LIST OF PREPARERS AND REVIEWERS

This EIS for the Rio Salado Oeste project was written by the U.S. Army Corps of Engineers, Los Angeles District Office (California).

Team Member Title/Area of Responsibility

Scott Estergard, *Study Manager*, Qualifications – BS. Biology.
14 years experience
Feasibility Report Coordinator

Timothy Kennedy, *Environmental Coordinator*, Qualifications - BA. Geology
12 years experience
EIS Coordinator

Richard Legere, Biologist, Qualifications – BA. Biology
13 years experience
Writer/Editor

Jeanine Divis, Biological Science Study Manager – B.S. Environmental Resources (Ecology Emphasis)
4 years experience
Writer/Editor

Pam Maxwell, *Archeologist*, Qualifications – BA. Anthropology; MA Anthropology (Archeology Emphasis);
16 years experience
Cultural Resources

Patricia A. Krueger, *Biologist*, Qualifications – MS. Biological Sciences
15 years experience
Biological Resources

Roland Tabije, *Air Quality Specialist*, Qualifications – BA. Environmental Analysis & Design
3 years experience
Air Quality

Priscilla E. Perry, *Chief, Regional Planning Section*, Qualification - BS. Civil/Environmental Engineering
25 years experience
Reviewer/Editor

Alex Watt, *Chief, Environmental Resources Branch*, Qualification - BS. Physical Geography
25 years experience
Reviewer

Lydia Lopez-Cruz, *Archaeologist*, Qualifications – BA. Anthropology
5 years experience
Writer/Editor

Michael J. Fink, *Landscape Ecologist - Environmental Manager*, Qualifications – BA. Environmental Manager, Regional Planning Section, 25 years experience
Reviewer

CHAPTER 11
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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.

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Hollender, Bob. Superintendent for Compliance of Regulatory Affairs, City of Phoenix. March 7, 2002 – telephone conversation regarding violations at 23rd Avenue Wastewater Treatment Plant.

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CHAPTER 12
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Mr. Mike Martinez
U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office
2321 W Royal Palm Road, Suite 103
Phoenix, AZ 85021-4951

Director, Office of Environmental Policy
and Compliance
Department of the Interior
Main Interior Building, MS 2342
1849 C Street NW
Washington, DC 20240

Regional Administrator
Federal Aviation Administration
Western – Pacific Region
15000 Aviation Blvd
Lawndale, CA 90261

U.S. Bureau of Reclamation
Phoenix Area Office (PXAO)
6150 West Thunderbird Road
Glendale, AZ 85306-4001

Mr. Stephen Thomas
Federal Highway Administration
400 E. Van Buren Street, Suite 410
Phoenix, AZ 85004

U.S. Army Corps of Engineers
Regulatory Branch
3636 N. Central Avenue
Phoenix, AZ 85012

Advisory Council on Historic Preservation
1100 Pennsylvania Avenue NW, Suite 809
Old Post Office Building
Washington, D.C. 20004

Native American Tribes

Ak-Chin Indian Community
Nancy Nelson, Cultural Resource Manager
Ak-Chin Him Dak Eco Museum & Archives
47685 N Eco Museum Rd
Maricopa, AZ 85239

Gila River Indian Community (GRIC)
Barnaby V. Lewis, Cultural Resource
Specialist
Gila River Indian Community
Cultural Resources Management Program
P.O. Box 2140
Sacaton, AZ 85247

Hopi Tribe
Leigh Kuwanwisiwma
Hopi Cultural Preservation Office
P.O. Box 123
Kykotsmovi, AZ 86039

Pascua Yaqui Tribe
Amalia A.M. Reyes, Language and Culture Preservation Specialist
Pascua Yaqui Tribe
7474 S Camino de Oeste
Tucson, AZ 85746

Salt River Pima-Maricopa Indian Community (SRPMIC)
Dezbah Hatathli, Cultural Programs Supervisor
Cultural and Environmental Services
Salt River Pima-Maricopa Indian Community
10,005 E Osborn Rd
Scottsdale, AZ 85256

Tohono O'odham Nation
Peter Steere, Program Manager
Cultural Affairs Department
Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634

Yavapai-Apache Nation
Don Decker, Director
Apache Cultural Program
Camp Verde Tribal Building
2400 W Datsi St
Camp Verde, AZ 86322

Yavapai-Prescott Indian Tribe
Greg Glassco, Director
Cultural Research Program
Yavapai-Prescott Tribe
530 E. Merritt St.
Prescott, AZ 86301

State Agencies

Arizona Dept. of Environmental Quality
Water Quality Division, Federal Permits Section
1110 W Washington Street
Mail Code 5415B-3
Phoenix, AZ 85007

Arizona Game and Fish Department
2221 W. Greenway Road
Phoenix, AZ 85023

State Historic Preservation Officer
Arizona State Parks
1300 W. Washington
Phoenix, AZ 85007

Arizona Department of Water Resources
Phoenix Active Management Area
3550 N. Central Avenue
Phoenix AZ 85012

Mr. Ralph Ellis
Arizona Department of Transportation
205 S. 17th Avenue
Phoenix, AZ 85007

County

John Hathaway
Watercourse Planning Manager, Planning and Project Management Division
Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, AZ 85009

Robert Kard, Director
Maricopa County Air Quality Department
1001 North Central Avenue, Suite #500
Phoenix, Arizona 85004

Chief Engineer and General Manager
Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, AZ 85009

Maricopa County Environmental Services
1001 N. Central Ave.
Phoenix, AZ 85004

Maricopa County Historical Society
21 N. Frontier Street
Wickenburg, AZ 85390-1417

Maricopa County Parks and Recreation Department
Attn: Chris Coover
234 N. Central Ave.
Suite 6400
Phoenix, AZ 85004

City of Phoenix

City of Phoenix
Karen Williams
Rio Salado Project Director
200 W. Washington St., 12th Floor
Phoenix, AZ 85003

City of Phoenix
Walt Kinsler
Rio Salado Project Manager
200 W. Washington St, 7th Floor
Phoenix, AZ 85003

City of Phoenix
Donn Stoltzfus
Office of Environmental Programs
200 W. Washington St., 14th Floor
Phoenix, AZ 85003

George Young
Chair, Rio Salado Citizens Advisory Committee
514 W. Sunland Avenue
Phoenix, AZ 85041

City of Phoenix
Parks and Recreation Director
200 W. Washington St., 16th Floor
Phoenix, AZ 85003

City of Phoenix
Water Services Director
200 W. Washington St., 5th Floor
Phoenix, AZ 85003

City of Phoenix
Planning Department
Estrella Village Planning Committee
200 W. Washington St., 6th Floor
Phoenix, AZ 85003

City of Phoenix
Planning Department
Laveen Village Planning Committee
200 W. Washington St., 6th Floor
Phoenix, AZ 85003

City of Phoenix
Planning Department
South Mountain Village Planning Committee
200 W. Washington St, 6th Floor
Phoenix, AZ 85003

Elected Officials

Honorable Janet Napolitano
Governor of Arizona
1700 West Washington Ave.
Phoenix, AZ 85007

Honorable Jon Kyl
2200 E. Camelback, Ste 120
Phoenix, AZ 85016-3455

Honorable John McCain
2400 E. Arizona Biltmore Center #1150
Phoenix, AZ 85016-2108

Honorable Ed Pastor
411 North Central Avenue
Suite 150
Phoenix, AZ 85004

Honorable John Shadegg
301 E. Bethany Home Rd.
C-178
Phoenix, AZ 85012

Fulton Brock
Supervisor, Maricopa County
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Don Stapley
Supervisor, Maricopa County
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Andrew Kunasek
Supervisor, Maricopa County
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Max Wilson
Supervisor, Maricopa County
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Mary Rose Wilcox
Supervisor, Maricopa County
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Mayor Phil Gordon
City of Phoenix
200 W. Washington St
Phoenix, AZ 85003

City of Phoenix, Vice Mayor Doug Lingner's Office
200 W. Washington St., 11th floor
Phoenix, AZ 85003

Councilman Claude Mattox
District 5
200 W. Washington St, 11th floor
Phoenix, AZ 85003

Libraries

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Arizona State University Libraries
Box 871006
Tempe, AZ 85287-1006

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Attn: Judy Smith
1019 Campus
Ft. Collins, CO 80523

Organizations

Audubon Arizona
4250 East Camelback Road
Suite 193K
Phoenix, AZ 85018

Maricopa Audubon Society
P.O. Box 15451
Phoenix, AZ 85060

Director
Sierra Club
Southwest Field Office
202 E. McDowell Road, Suite 277
Phoenix, AZ 85004

Director
Center for Biological Diversity
P.O. Box 39382
Phoenix, AZ 85069

Mr. Paul Cherrington
Salt River Project
Mail Station PAB 103
PO Box 52025
Phoenix, AZ 85072

Diane Brossart
Valley Forward Association
3800 North Central Avenue, Ste. 220
Phoenix, AZ 85012

Tim Flood
Friends of Arizona Rivers
503 E. Medlock Dr.
Phoenix, AZ 85012

Interested Party letters

Steve Brittle
Harold Hunt
Chuck Pedri
T Tompkins
Julie Stromberg
AZ Rock Products
Matthew Lord
Roland Wass
Jeff Englemann
Bill Weiss
Don Campbell
Dan DeSemple
Victor Vidales
George Miller
Karim Dada
Steve Weiner
Rich Fogarty

CHAPTER 13
ACRONYMS AND ABBREVIATIONS

AAC	Arizona Administrative Code
AAC	Average Annual Cost
AAFCU	Average Annual Functional Capacity Unit
AAQS	Ambient Air Quality Standards
ac-ft	acre-foot
ADEQ	Arizona Department of Environmental Quality
ADES	Arizona Department of Economic Security
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)
APE	Area of Potential Effect
APP	Aquifer Protection Permit
AQD	Air Quality Department
ASLD	Arizona State Land Department
AWQS	Aquifer Water Quality Standard
AZPDES	Arizona Pollution Discharge Elimination System
AZ-WIPWG	Arizona Wildlands Invasive Plant Working Group
BIA	Bureau of Indian Affairs
BMP	Best Management Plan
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CAFO	Concentrated Animal-Feeding Operation
CEA	Cost Effectiveness Analysis
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (commonly referred to as the "Superfund" Act)
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CNEL	Community noise equivalent level
CO	carbon monoxide
COP	City of Phoenix
Corps	U.S. Army Corps of Engineers
CORRACTS	Corrective Action Reports

CWA	Clean Water Act
dB	decibel
dBA	A-weighted decibel
DBCP	Dibromochloropropane
DCA	1,2 Dichloroethane
DCE	1,1 Dichloroethane
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
EDB	Ethylene Dibromide
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDC	Engineer Research and Development Center
ERNS	Emergency Response Notification System
ES	Executive Summary
ESA	Endangered Species Act/Environmental Site Assessment
ESRV	East Salt River Valley, one of two Phoenix AMA alluvial groundwater basins
FAA	Federal Aviation Administration
FCDMC	Flood Control District of Maricopa County
FCI	Functional Capacity Index
FCU	Functional Capacity Unit
FEIS	Final Environmental Impact Statement
FR	Federal Register
FWCA	Federal Wildlife Coordination Act
FWS	(U.S.) Fish and Wildlife Service
GRIC	Gila River Indian Community
HAP	Hazardous Air Pollutant
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HGM	Hydrogeomorphic Assessment
HR	House Resolution
HTRW	Hazardous, Toxic and Radioactive Waste
HUD	U.S. Department of Housing and Urban Development
ICA	Incremental Cost Analysis
kph	kilometers per hour
LAU	Lower Alluvial Unit
L_{dn}	day-night average sound level
L_{eq}	equivalent sound level
LUST	Leaking underground storage tank

µg/m3	micrograms per cubic meter
MAG	Maricopa Association of Governments
MFR	Memorandum for the Record
MAU	Middle Alluvial Unit
Mgd	millions of gallons per day
mg/l	milligrams per liter
MM	Mitigation Measure
MM	Modified Mercalli (Intensity Scale)
MNA	Museum of Northern Arizona
MOA	Memorandum of Agreement
mph	miles per hour
MS4	Municipal Separate Storm Sewer System
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFIP	National Flood Insurance Program
NHPA	National Historic Preservation Act
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
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
NSR	New Source Review
NTU	Nephelometric Turbidity Unit
O_3	ozone
OHV	Off-Highway Vehicle
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethylene (Perchloroethylene)
PM-10	Particulate Matter 10 microns or less in diameter
ppm	Parts per million
PSD	Prevention of Significant Deterioration
PVNGSWCS	Palo Verde Nuclear Generating Station Wastewater Conveyance System
RCRA	Resource Conservation and Recovery Act
RID	Roosevelt Irrigation District
ROD	Record of Decision
ROG	Reactive Organic Gases

RTP	Regional Transportation Plan
SCC	Sacramento Canal Company
sf	Square Foot
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SR	State Route
SRP	Salt River Project
SRPMIC	Salt River Pima Maricopa Indian Community
SWMP	Stormwater Management Plan
SWPPP	Stormwater Pollution Prevention Plan
sy	Square Yard
TAC	Toxic air contaminant
TCA	1,1,1 Trichloroethane
TCE	Trichloroethene
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
TY	Target Year
UAU	Upper Alluvial Unit
USBR	U.S. Bureau of Reclamation
UST	Underground Storage Tank
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WQARF	Arizona Water Quality Assurance Revolving Fund
WQTC	Water Quality Technical Committee
WSC	Wildlife of Special Concern
WSRV	West Salt River Valley, one of two Phoenix AMA alluvial groundwater basins
WWTP	Wastewater treatment plant

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APPENDIX A
CLEAN WATER ACT, SECTION 404 (B)(1)
COMPLIANCE EVALUATION

Rio Salado Oeste

Salt River- Phoenix, Arizona

APPENDIX A.

CLEAN WATER ACT, SECTION 404 (B)(1) COMPLIANCE EVALUATION

I. INTRODUCTION

This appendix evaluates compliance of the recommended plan, Alternative 5A, 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, 33 U.S.C. 1251 et seq.

The Clean Water Act sets national goals and policies to eliminate the discharge of water pollutants into waters of the U.S. 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 § 230. These guidelines, referred to as the Section 404(b)(1) Guidelines (the "Guidelines") are the substantive criteria used in evaluating discharges of dredged or fill material under Section 404 of the Clean Water Act.

The Rio Salado Oeste project would require the discharge of dredged and fill material into the Salt River and its tributaries. These waterways are considered to be Waters of the U.S. as defined in 33 CFR § 328.3 and, as such, are subject to regulation under Section 404. The lateral limit of jurisdiction in non-tidal waters such as the Salt River is defined in 33 CFR § 328.4(c)(1) as the ordinary high water mark (OHWM), provided the jurisdiction is not extended by the presence of wetlands (see below). Title 33 CFR § 328.3(e) defines the OHWM as that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

Wetlands are one of the Special Aquatic Sites identified in 40 CFR § 230 Subpart E. The list of special aquatic sites also includes sanctuaries and refuges, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes. Special aquatic sites are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region (40 CFR § 230.3[q-1]).

The Regulatory Branch, US Army Corps of Engineers, Los Angeles District completed a Clean Water Act Section 404 jurisdictional determination for the project implementation area on February 22, 2006, attached. The total area within the jurisdiction of Section 404 is defined primarily by the location of the OHWM, and consists of 1,700 acres. The only type of special

aquatic located in the project area is wetlands. Wetlands are defined as, "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR § 328.3). These wetlands consist of small areas dependent upon stormwater, effluent and irrigation discharges, and a few larger areas associated with abandoned aggregate mining activities. These wetlands are transitional in nature, changing with fluctuations in the volume of stormwater flows, delivery of effluent, flood events, and management of active and abandoned aggregate mining operations.

With the exception of the "No-Action" Alternative, all alternatives receiving final consideration include restoration of the Salt River channel through the entire length of the study area. This work would include modifications to the river channel, banks and terraces, installation of water harvesting features and irrigation infrastructure, planting of vegetation, and soil amendment/ restoration activities. Three of the five action alternatives under consideration would also entail modifications to aggregate mining (sand/gravel) pits located along the river. All five action alternatives would have a similar range of impacts to Waters of the U.S., both for initial construction work, and during future operation, maintenance, repair, replacement and rehabilitation (OMRR&R) activities completed by the non-federal sponsor (City of Phoenix).

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, and;

- 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 Final Environmental Impact Statement (FEIS) to which this Appendix is attached.

II. PROJECT DESCRIPTION

A. Study Authority

The study was conducted under two separate authorities provided by Congress. The first authority is given by Public Law 761, Seventy-fifth Congress, dated June 28, 1938, known as Section 6 of the Flood Control Act of 1938, which reads in part as follows:

> *"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."*

The second and most recent authority is provided by House Resolution 2425 (HR 2425), dated May 17, 1994, which states:

> *"...the Secretary of the Army is requested to review the 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. Project Purpose and Need

The Salt River was once a perennial watercourse in the project area, characterized by meandering flows throughout the river system. The river once supported substantial growth of cottonwoods, willows, and mesquites. The river channel carried abundant water that supported early irrigation projects. Increasing appropriation of surface and groundwater to support expansion of agriculture and growing urban populations, coupled with construction of dams upstream, transformed the Salt River to a dry river that flows only ephemerally in response to storm runoff and effluent discharge.

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 have been disturbed by intensive sand and gravel mining.

Flood control, in-river mining, and water supply projects (dams and groundwater withdrawal) 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 most of the native cottonwood/ willow, mesquite bosque, and freshwater marsh habitat types. Destruction of native riparian habitat facilitates an increase in invasive plant species that are more tolerant of disturbed conditions. Invasive plants consume more water than native vegetation because of their ability to occupy a greater areal extent on the landscape, placing additional strains on the already limited water supply. Within the study area, the river is now a highly disturbed riverbed with minimal native vegetation.

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.

This project is also 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 recreational opportunities by increasing the area of open space that is available to recreationists.

Without restoration, habitat values in the project implementation area (see below) are expected to remain essentially unchanged from their highly degraded condition over the next 50 years. This would not allow establishment of habitat for the endangered Yuma clapper rail, southwestern willow flycatcher, or other sensitive wildlife species. There would also be no opportunity to provide recreation, or an ecological connection between the Rio Salado Phoenix and Tres Rios projects.

C. Study Area Location

The study area for the project consists of an eight mile reach of the Salt River and adjacent lands in and near southwestern Phoenix, Maricopa County, Arizona. More specifically, the study area consists of the Salt River corridor from 19th Avenue downstream (west) to 83rd Avenue, between Lower Buckeye Road and Baseline Road. This study area is three miles wide and encompasses approximately 23.5 square miles. The riparian zone averages 300 feet in width and runs the entire length of the study area (FEIS, Figure 1.6-2). The study area lies between two other U.S. Army Corps of Engineers ecosystem restoration projects; Rio Salado Phoenix upstream, and Tres Rios downstream.

While this is a large study area extending beyond the riverbanks, any implementation of project features would be associated with the river floodplain in an area referred to as the project implementation area. The project implementation area extends from 19th Avenue on the east to 83rd Avenue on the west, and is the area within the 100-year floodplain of the Salt River. The project implementation area averages two-thirds of a mile in width, and consists of approximately 3,315 acres.

D. General Description

An initial array of 20 alternatives (including the No-Action Alternative) was formulated by the Corps and the City of Phoenix during the alternative formulation process. These alternatives represented varying combinations of restoration treatments (e.g., vegetation types, channel and sand/gravel pit 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 Rio Salado Oeste project, and project-specific opportunities and

constraints for implementing restoration activities. The specific planning objectives listed below reflect the problems and opportunities and represent desired positive changes along the Rio Salado Oeste reach:

- Restore native riparian, wetland and floodplain habitats, and manage undesirable plant, fish, and wildlife species;
- Reduce flood damages to infrastructure and structures, and;
- Improve passive recreation and environmental-education opportunities.

The initial array of alternatives was 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 and plant community characteristics), and evaluates and quantifies future changes in these characteristics and associated habitat benefits resulting from implementation of the restoration alternatives (refer to the Feasibility Report, Appendix I for a discussion of the HGM methodology). 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 2, Alternative 4, Alternative 5, Alternative 5A and Alternative 5B. The following ecosystem restoration features are common to all construction alternatives:

- river channel restoration;
- construction of vegetated habitat, and;
- ground reshaping to alter significant features, install irrigation systems, or create topographic and soil conditions needed to establish plantings (e.g., stormwater harvesting basins).

Alternative 4 adds the following ecosystem restoration measures:

- use of supplemental water sources, such as effluent from the City of Phoenix 23rd Avenue wastewater treatment plant (WWTP), and/or groundwater;
- water distribution systems to irrigate new vegetation (canals, diversion structures, etc.), and;
- eradication of salt cedar (*Tamarix spp.*).

In addition, Alternatives 5, 5A and 5B add the following:

- modifications to the 27th and 37th Avenue sand/gravel pits to maintain open water, create new riparian habitat, or both.

Project alternatives differ primarily in the types and amounts of vegetation that would be established, treatment of the 27th and 37th Avenue sand/gravel pits, the extent of structural components, and the amount of water that would be required. Project features would be constructed both in and adjacent to the river channel.

Operation, maintenance, repair, replacement and rehabilitation (OMRR&R) activities would be needed for all alternatives after the project is constructed in order to keep project features functioning as designed. These activities may include:

- periodic dredging to remove sediment deposited by floods, surface reshaping, or replanting of project features damaged by flood events;
- maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features;
- vector control, and;
- environmental monitoring.

III. PROJECT ALTERNATIVES

A. Regulatory Considerations

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." 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 project purpose is to restore this reach of the Salt River. 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 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 – ecosystem restoration- is water dependent, since the project purpose cannot be fulfilled without utilizing 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.

For the purpose of a 404(b)(1) alternatives analysis, practicable alternatives include:

- Offsite alternatives - i.e., discharges of dredged or fill material at other locations in waters of the United States, and;

- On-site alternatives - these include project designs that do not involve a discharge of dredged or fill material into Waters of the U.S., as well as project designs that have different impacts to Waters of the U.S.

B. 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 a non-federal sponsor, the proximity and contiguity of other restoration projects on the Salt River, and the technical feasibility of constructing a project at this location. The Rio Salado Oeste project is one of four ecosystem restoration projects that are at various stages of development by the Corps and non-federal sponsors along the Salt River downstream from Granite Reef Dam. The Rio Salado Phoenix project, just upstream from Rio Salado Oeste, is currently under construction. The Va Shly'ay Akimel project is upstream of the Rio Salado project, and is entering the design phase. The Tres Rios project, just downstream from Rio Salado Oeste, is also in the design stage. The proposed project location would provide an almost continuous series of habitat restoration projects from Granite Reef Dam to the confluence of the Salt River with the Gila River (FEIS, Figure 1.7-1). 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, and does not currently have the support of a non-federal sponsor. In addition, because of the series of upstream dams and associated legal constraints to project design, it would be much more difficult to design a functioning habitat restoration project upstream of the Granite Reef Dam. Off-site alternatives, therefore, are not practicable at this time.

C. On-Site Alternatives

Each of the five construction alternatives analyzed in detail through the NEPA process would accomplish the identified project purpose. However, they would accomplish this purpose to varying extents, with varying levels of benefits and a range of impacts to the aquatic ecosystem. The impacts would be both adverse (short term) and beneficial (long term). The types of OMRR&R activities would be similar for each alternative, although the level of effort and cost for OMRR&R activities would generally be proportional to the amount of new habitat created.

Additional discussion of the measures combined to formulate the action alternatives is provided in Chapter 2 of the FEIS, and a complete discussion of alternative can be found in Chapter V of the Feasibility Report. The following is a summary of those measures that would require the discharge of dredged or fill material into Waters of the U.S:

Channel Restoration: This measure restores the river channel to a more natural state based on hydraulics and geomorphology. It would be accomplished by grading and terracing to help restore an active channel through the entire reach. Average depth of grading is assumed to be

five feet, with a width varying from 200 to 400 feet. The average width of the river channel, including the adjacent river terrace, throughout the study area will be approximately 500 feet. The channel design passes a five-year event (~22,000 cfs) with occasional flooding on the terrace two to four feet in depth at 1-7 cfs. An estimated 660,000 cubic yards (cy) of material would be removed from the channel to implement this measure. Material removed would be native riverbed material, and would be utilized on site for terracing and construction of other project components, such as lake restoration.

Lake Restoration: There are existing features created from sand/gravel mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to better utilize the existing water and improve the functionality of these features. The existing banks would need to be reshaped for restoration and public safety. Depending on the alternative, from 3,000,000 cy to 5,384,000 cy of material would be moved to implement this measure. Due to the porous soils found in this project area, lining the site would be required for restoration. This would be accomplished through excavation and layering of a silt-clay soil substrate overlain by a mixed gravel and cobble layer. Between 64,000 and 213,000 cy of liner material would be required for this work, depending on the alternative.

Stormwater Wetlands: Existing stormwater outfalls within the project area have been identified and possible discharges from them quantified. There are eight different outfalls from which an estimated average of 2,863 ac-ft was estimated to discharge based upon a seven-inch annual rainfall. While not a reliable, constant source of project water, there are opportunities for future use of this water with proper design at the outfall locations. Various forms of habitat are currently being supported by stormwater runoff. Design of a restoration plan would include site-specific measures maximizing use of that runoff. Grading and excavation, as well as installation of a silt-clay soil substrate overlain by a mixed gravel and cobble layer, is recommended for the wetlands.

In-channel Wetlands: In addition to restoration of stormwater wetlands, several alternatives would restore emergent wetlands in the channel immediately downstream of 19th Avenue. This effort would include regrading and installation of similar substrate described above to allow restoration of emergent wetland vegetation. Depending on the alternative, the volume of material regarded to implement this measure would range from approximately 8,059 to 21,000 cy. In each case, a volume of liner material equal to the amount of material regraded would be installed to support newly planted vegetation.

Operation, Maintenance, Repair, Replacement and Rehabilitation: OMRR&R activities would occur after the project is constructed in order to keep project features functioning as designed. These activities may include: periodic removal of sediment, surface reshaping, or replanting of project features damaged by flood events; maintenance and replacement of pumps, pipelines, and other water delivery and irrigation infrastructure features; vector control, and; environmental monitoring. The types of OMRR&R 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.

Sediment Removal: During high flows, 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. For features within the floodplain, regrading and excavation was assumed to be needed once every ten years. It was assumed that for the stormwater outfalls, 50 percent of the construction quantity would need to be regraded in this period. The restored wetlands at existing lakes (gravel pits) would require regrading and excavation once every 20 years of up to one foot of material over the wetlands. The active channel would require regrading up to once every 20 years for up to 50 percent of the estimated construction quantity, or 330,000 cubic yards.

D. Description of the Project Alternatives

Although numerous other alternatives were considered in the study, the following alternatives have been carried though to the final array:

No Action: No federal action would be conducted and no habitat restored. This is the future Without-Project condition.

Alternative 2. Storm Water and Channel: This alternative includes the modification of existing stormwater outfall areas to improve retention and water spreading, as well as increase the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th Avenue to 83rd Avenue. No additional water source is included in this alternative other than temporary irrigation to establish vegetation.

Alternative 4. Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent: This alternative includes the features described in Alternative 2, and adds supplemental water supply in the form of effluent. It also includes restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue. At locations identified as suitable throughout the project area, cottonwood/willow and mesquite cover types would be restored. This alternative would also address the management, control, and removal of invasive species within the study area.

Alternative 5. Storm Water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake: This alternative includes the features described in Alternative 4, and adds lake restoration at the 27th and 37th Avenue sand/gravel pits.

Alternative 5A. Wetland restoration in lieu of permanent open water and lakes: In lieu of lake restoration, this alternative includes regrading both of the sand/gravel pits to restore them to the floodplain. Emergent wetland and riparian habitats would be created in both of these areas.

Alternative 5B. Hybrid of Alternatives 5 and 5A with one sand/gravel pit restored to a lake and the other a wetland/ riparian complex: This alternative includes restoration of one sand/gravel pit to a wetland/riparian complex, and the other to a lake.

E. Comparison of Alternatives

The No-Action Alternative is not considered practicable because it does not meet the primary project objective to restore degraded habitat. The No-Action alternative does not provide a permanent gain in the ecosystem benefit within the project area, specifically, to increase the amount (area) of native riparian habitat. Whereas there would be no disturbance of existing vegetation under this alternative, it provides no impetus to prevent further environmental degradation of existing riparian and wetland habitat. As such, the No-Action alternative is not the least damaging practicable alternative.

All five action alternatives would include restoration of the Salt River channel through the entire length of the project implementation area. This work is necessary to ensure hydraulic continuity for conveyance of flood flows, and for habitat connectivity with the adjacent Rio Salado Phoenix and Tres Rios ecosystem restoration projects. Channel restoration would require removal of 660,000 cy of material from the existing riverbed and terraces. This work would result in creation of 170 acres of low flow channel, in addition to associated terraces. The excavated material would be used as necessary to construct other project features. Every action alternative would include modifications to eight existing stormwater outfalls to utilize runoff as a water source for riparian habitats. These modifications would entail excavation of an additional 149,890 cy of material, followed by discharge of 45,128 cy of material to form an impermeable liner at each outfall. A total area of 28 acres would be directly impacted by this measure for all action alternatives.

Alternative 2 would be limited to the channel restoration and construction at each stormwater outfall discussed above, with no supplemental source of water. This alternative would require the least impacts to Waters of the U.S., but also produces the smallest amount of desirable riparian habitats and functional lift. A total of 737 acres of riparian habitats would be restored. However, only 154 acres of the highly desirable cottonwood/willow, mesquite and wetland habitats (including existing habitat) would result from this alternative. Alternative 2 has a functional output, expressed in terms of Average Annual Functional Capacity Units (AAFCUs), of 51 (a complete discussion of the functional assessment methodology can be found in Appendix I to the Feasibility Report). The single greatest impact to Waters of the U.S. for the five action alternatives consists of the river channel restoration. For this reason, Alternative 2 would require almost as much impacts to Waters of the U.S. as Alternatives 4, 5, 5A and 5B, despite its much lower outputs.

Alternative 4 would incorporate the features described in Alternative 2, and add supplemental water supply in the form of effluent. It would also include restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue. This measure would require regrading of approximately 8,059 cy, and installation of the same volume of clay liner material to create five acres of in-channel wetlands. At locations identified as suitable throughout the project area, cottonwood/willow and mesquite cover types would be restored. This alternative would also address the management, control, and removal of invasive species within the study area. Direct impacts to Waters of the U.S. for Alternative 4 would be greater than those associated with Alternative 2. However, Alternative 4 would establish 1,356 acres of riparian habitats, including 824 acres of the highly desirable cottonwood/willow, mesquite and

wetland habitats. The functional output of 165 AAFCUs would also far exceed those of Alternative 2.

Alternatives 5, 5A and 5B would augment the area of wetland creation at the existing lake downstream of 19th Avenue. The larger wetland area would require regrading of 20,952 cy of material, followed by installation of the same volume of clay liner. Alternatives 2 and 4 would not utilize the existing sand/gravel pits located at 27th and 37th Avenues. However, Alternatives 5, 5A and 5B include combinations of additional measures to reconnect these pits to the floodplain while creating permanent lakes, riparian habitats, or both. Alternative 5 would require 5,384,072 cy of cut and fill, followed by discharge of 212,747 cy of lining material to convert both of these pits into two 20-acre lakes. Alternative 5A would require 3,000,000 cy of cut and fill, followed by discharge of 64,469 cy of lining material to convert both of these sand/gravel pits to emergent wetlands with associated riparian habitats. Finally, Alternative 5B would require 2,692,036 cy of cut and fill, followed by discharge of 106,373 cy of lining material to convert one of the sand/gravel pits to a lake. Conversion of the remaining sand/gravel pit to emergent wetland and riparian habitat for Alternative 5B would require 1,500,000 cy of cut and fill, and discharge of 64,469 cy of lining material.

By incorporating the 27th and 37th Avenue sand/gravel pits, direct impacts to Waters of the U.S. for Alternatives 5, 5A and 5B would be greater than for Alternative 4. In return for these increased impacts, Alternatives 5, 5A, and 5B would each provide 1,466 acres of riparian habitat. A total of 902 acres, 982 acres, and 962 acres of the desirable cottonwood/willow, mesquite, and wetland habitats would be restored by Alternatives 5, 5A and 5B, respectively. The functional outputs for Alternatives 5, 5A and 5B would be 240, 267 and 253 AAFCUs, respectively. The primary difference between these three alternatives is whether or not one or both of the 27th and 37th Avenue sand/gravel pits would be converted to a permanent lake, riparian habitat, or a combination of both.

The sand/gravel pits would need to be drained for lining installation, regardless of whether or not they were filled with water to create a lake, or partially filled with soil to create emergent wetland and other riparian habitats. For this reason, Alternatives 5, 5A and 5B would all have nearly identical temporary impacts to Waters of the U.S. These alternatives would also have the greatest impact on wetlands. Since the project would increase the long-term functional value of the wetlands and other riparian areas of this ecosystem, and these elements are physically adjacent as well as functionally interrelated, alternatives that do not impact the existing wetlands would provide fewer long-term improvements in wetland and riparian habitat function.

Alternative 5A produces the greatest area of desirable riparian habitats and the highest functional output in return for the temporary impacts noted above. This alternative also provides the best combination of habitat restoration and cost, and creates ecosystem benefits that far exceed the short-term adverse effects to jurisdictional waters. With appropriate mitigation measures, this alternative would have insignificant adverse environmental impacts to the surrounding ecosystem. Furthermore, Alternative 5A does not place an excessive burden on water resources, and can also be reasonably managed by the non-federal sponsor to ensure long-term success. Alternative 5A has been selected as the tentatively Recommended Plan because it is considered

the least environmentally damaging practicable alternative that fulfills the planning objectives, and it adequately addresses the purpose and need for the project.

Table A-1. Alternative measures and associated quantities of dredged/fill material.

Alt.	Measure	Quantity (cy)	Area (acres)[1]
2	Channel Restoration	660,000	300
	Storm water outfall wetland grading	149,890	28
	Storm water outfall wetland liner	45,128	28
4	Channel Restoration	660,000	300
	Storm water outfall wetland grading	149,890	28
	Storm water outfall wetland liner	45,128	28
	Emergent wetlands (in channel)	8,059	5
	Emergent wetlands liner	8,059	5
5	Channel Restoration	660,000	300
	Storm water outfall wetland grading	149,890	28
	Storm water outfall wetland liner	45,128	28
	Emergent wetlands (in channel)	20,952	13
	Emergent wetlands liner	20,952	13
	Lake restoration cut and fill (permanent water)	5,384,072	200
	Lake liner materials	212,747	20
5A	Channel Restoration	660,000	300
	Storm water outfall wetland grading	149,890	28
	Storm water outfall wetland liner	45,128	28
	Emergent wetlands (in channel)	20,952	13
	Emergent wetlands liner	20,952	13
	Lake restoration (wetland/riparian) cut and fill	3,000,000	200
	Lake restoration liner	64,469	40
5B	Channel Restoration	660,000	300
	Storm water outfall wetland grading	149,890	28
	Storm water outfall wetland liner	45,128	28
	Emergent wetlands (in channel)	20,952	13
	Emergent wetlands liner	20,952	13
	Lake restoration cut and fill (permanent water)	2,692,036	100
	Lake restoration liner	106,373	20
	Lake restoration (wetland/riparian) cut and fill	1,500,000	100
	Lake restoration liner	64,469	20

[1] Acreages noted are not additive. They relate to the potential area affected by implementation of that measure.

Table A-2: Acres of habitat associated with each action alternative.

Alternative	Channel[2]			Cotton-wood/ Willow	Mesquite	Open Water	Scrub-Shrub[3]	Other Wetlands	TOTALS
	Low-Flow Channel	In-Channel Wetlands[4]	Riparian Scrub						
2. Stormwater and Channel	170	17	125	66	43	0	305	28	737
4. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent	170	34	165	348	409	0	63	33	1188
5. Stormwater, Channel, Water Supply, Cottowood, Mesquite, Invasive and Emergent, Lake	170	34	296	375	417	40	92	76	1466
5A. Wetland/riparian restoration in lieu of permanent open water and lakes	170	34	296	375	417	0	52	156	1466
5B. Hybrid of 5 & 5A with one sand/gravel pit restored to a lake and the other a wetland/ riparian complex	170	34	296	375	417	20	52	136	1466

[2] River channel consists of low flow, wetland or riparian scrub.
[3] Scrub shrub acres are dispersed among and between the other restored cover types within the floodplain.
[4] Alternative 2 assumes that 10% of the low-flow channel would consist of wetlands; the remaining alternatives assume that 20% of the low-flow channel would consist of wetlands.

IV. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations

1. Substrate Elevation and Slope: The study area is located within the Salt River Valley at an elevation of approximately 335 meters (1,100 feet). The project implementation area includes the river channel and overbank areas within the 100-year floodplain. The channel topographic relief is generally very low to flat (less than 1% gradient), ranging from an elevation of ~1,000 feet elevation in the Salt River bed at 19th Avenue to ~960 feet at 83rd Avenue.

The usually dry, sandy Salt River bottom is highly disturbed by both natural processes and human activities. Substrate materials include water-rounded gravel, cobble, and principally fine sand. Since these materials are unconsolidated and easily transported by water, the channel is reconfigured by high flows during flood events. The channel substrate is also continuously altered by aggregate (sand/gravel) mining, and uncontrolled motorcycle and all-terrain-vehicle travel. Alteration of the river bottom and terraces by construction equipment would occur during project implementation. This work would be necessary to construct a low flow channel, create stable side slopes and terraces, and to transport excess excavated materials to locations where needed. Mostly minor changes in topography would occur along the length of the project area. These changes in topography would be more significant in areas where sand/gravel pits are being restored and reconnected to the floodplain. For instance, the sand/gravel pits at 27th and 37th Avenues would be reshaped and partially filled with native material for riparian restoration. However, the overall elevations of the channel bottom and the historic flood plain would not be significantly altered.

Substantial quantities of material would be discharged into the jurisdictional limits of Waters of the U.S. (in this instance, a typically dry condition) during reconstruction of the river channel, regrading of channel banks and terraces, construction of water harvesting basins, installation of water distribution and irrigation systems, and preparing the ground surface for planting. Construction material would consist of native alluvial soils from the project area, as well as clay, rock from nearby quarries, and possibly soil amendments. In terms of volume, the vast majority of dredged and fill material would originate on site. No significant quantities of inadvertently discharged earth materials would remain above existing channel bottom elevations. However, in some locations affected by aggregate mining, increased ground elevation would be part of the project design. The approximate pre-construction channel bottom contour would be reestablished to eliminate any potential changes in flooding characteristics. Excess excavated materials would be incorporated into final grades for the project. The disposal of excavated materials outside the project area is thus not anticipated.

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 area soils are often sandy to gravelly, may include lenses of finer particles, and are often redistributed by water flows associated with active channels. 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 having low relief. No exposed bedrock is present in the project area.

Reshaping would include restoration of a low flow channel and adjacent terraces for the entire length of the project area. On site soils would be redistributed to fill depressions or remove unwanted mounds, reconnect the 27th and 37th Avenue sand/gravel pits to the floodplain, and to create new riparian habitats. Where existing sediments are used, sediment types would not be changed by the project. However, materials other than existing sediment types would be used in various areas to provide the necessary environment for new vegetation. Clay, mixed gravel, and cobble layers would be used to line areas of proposed wetland/riparian habitats at eight stormwater outfalls, and at the active and abandoned sand/gravel pits at 19th, 27th, and 37th Avenues. This work would serve to make these basins impermeable, and would armor the surface against anticipated high flows. Most of the materials needed for this work would be imported to the site. Soil amendments may also be necessary to create conditions suitable for the establishment of native vegetation.

3. <u>Dredged/Fill Material Movement</u>: With the exception of pits excavated for aggregate mining, and areas affected by effluent discharges from the 23rd Avenue WWTP, the Salt River is typically dry. Construction activities (e.g., river channel restoration, creation of stormwater detention basins and vegetated areas, removal of invasive species) would result in incidental movement of local soils and sediments into downstream areas during runoff events. The channel substrates are generally unconsolidated, natural embankments are highly unstable, and human-induced perturbations have been both extensive and continuous. Therefore, it is unlikely that construction of the selected restoration alternative would significantly increase erosion in or along the Salt River channel. The potential for increases in erosion would be further minimized by limiting the area of exposed soils during construction, completing earth-disturbing activities during the dry season, rapid revegetation of exposed soil areas, and implementation of an erosion and sedimentation control plan that identifies best management practices (BMPs) appropriate for the study area. Adherence to an erosion and sedimentation control plan, as required by the storm water pollution prevention plan (SWPPP) mandated by the National Pollutant Discharge Elimination System (NPDES) permit, would control storm water discharges associated with construction activities.

Following construction, substantial movement of fill material placed for this project would be expected to occur only under high flow conditions. OMRR&R 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. These activities would include repair work after major flooding events. Dredging and reconstruction may be required in the restoration areas. This would temporarily change substrate elevations and compaction as the substrate is restored to design configurations. Implementation of mitigation measure WQ-1 would minimize unintended movement of fill material. Discharges of dredged or fill material into Waters of the U.S. for future OMRR&R activities by the non-federal sponsor would require separate authorization pursuant to the Clean Water Act.

4. Physical Effects on Benthic Macroinvertebrate Communities: Benthic organisms (organisms that live at the bottom of a water body) may occur in the project area where there is permanent or semi-permanent standing water - presently at the 19th, 27th and 37th Avenue sand/gravel pits. Although effluent is discharged into the river at two locations (near 35th and 41st Avenues), the volume of this effluent is dependent on agricultural needs by the Roosevelt Irrigation District. Daily effluent discharge varies on a generally annual cycle from nothing to nearly 50 mgd. This fluctuation in water availability, coupled with rapid infiltration rates, greatly limits the suitability of the Salt River channel for benthic organisms. Construction work for the project would directly affect the sand/gravel pits, as well as the effluent-supplied portions of the river bottom. The potential of these habitats to support viable benthic communities is low, though some species are probably present in the sand/gravel pits. Undesirable, non-native fish species are known to be present when hydrologic conditions allow.

Site preparation for channel restoration, establishment of riparian habitat, etc., is likely to result in temporary discharges of soil and sediment into the river channel. Due to the usual lack of a water column, soil discharged into the river channel would be unlikely to increase turbidity, stimulate algal growth, increase sediment deposition, or adversely affect benthic organisms. This would be a potentially significant impact in the event of heavy rainfall, but few (if any) benthic organisms are present to be affected. In addition, this impact can be mitigated through the implementation of Mitigation Measure WQ-1.

The sand/gravel pits would need to be pumped dry for reshaping prior to installation of clay lining overlain with gravel and cobble. This short term adverse effect would be expected to result in the complete loss of all aquatic organisms present, with the possible exception of some amphibians. If native fish are found to be present, the Arizona Game and Fish Department may elect to trap and relocate any desirable species. Water pumped from the sand/gravel pits would infiltrate into the bed of the Salt River downstream. Over the long term, these pits would be reconnected to the floodplain and restored with riparian habitat more appropriate for the area.

Construction of the selected restoration alternative would not result in perennial channel flow. With the exception of newly constructed emergent wetland areas, no new habitat for benthic organisms would be created. New benthic communities consisting of more desirable species would likely become established in these wetland areas, with a long term net benefit. Future OMRR&R activities such as sediment removal would have the potential to affect any newly established benthic organisms. Since the purpose of these activities would be to maintain habitat values, including water column depth in emergent wetlands, their effect would be temporary and minor.

5. Other Effects: OMRR&R activities to ensure adequate flood flow would require periodic inspections, removal of sediments and invasive vegetation, gabion replacement and repair, and channel side slope repair to maintain structural integrity and to preserve newly vegetated areas. These effects would be similar to those expected during construction, but on a substantially reduced level because they would be limited in both areal extent and duration.

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 WQ-2.

6. Actions Taken to Minimize Impacts: An Erosion and Sedimentation Control Plan would be prepared for project construction. The plan would also address BMPs for operation and maintenance activities. The BMPs identified in the Erosion and Sedimentation Control Plan would incorporate measures to minimize erosion. With implementation of the plan and the mitigation measures listed below, potential impacts to water resources are presumed to be insignificant.

Mitigation Measure WQ-1: Implement Erosion Control Best Management Practices (BMPs)

The Corps and its contractors shall implement erosion control measures throughout the construction period and during implementation of OMRR&R activities to minimize erosion and sediment input into the river. The Corps would oversee implementation of erosion control measures during construction. The contractor selected for the project shall:

- Conduct construction and OMRR&R 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 required clearing, grading, revegetation, or reshaping in a way that minimizes 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;
- Apply water to unpaved haul roads at a frequency adequate to maintain visible surface moisture;
- Mulch disturbed areas as appropriate and plant with appropriate species as soon as practicable after disturbance;
- Avoid operating equipment in flowing water by using temporary cofferdams or other suitable structures to diver flow around the channel and bank construction areas, and;
- If hay bales are used for erosion control during construction, they must be sterile and weed-free.

Mitigation Measure WQ-2: Implement Spill Prevention BMPs

The Corps and its contractors would 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 would oversee development and implementation of a stormwater pollution prevention plan. Elements of that 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 clean-up 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 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-1: Re-vegetation Construction Management Practices

The Corps would remove salt cedar (*Tamarix* spp.) and giant reed (*Arundo donax*) from the restoration areas as part of the restoration process (Alternatives 4, 5, 5A, and 5B). The City of Phoenix would be responsible for maintaining the restored habitat areas free of invasive plants, especially salt cedar and giant reed, throughout the life of the project (Alternatives 4, 5, 5A, and 5B).

The cleared areas would be re-vegetated with habitat of higher quality and permanence than the habitat removed. Implementation of good construction management practices, especially dust suppression with water and/or non-toxic dust-suppressing chemicals or soil binders, would minimize potential impacts from fugitive dust. Also, decreases in the cover of desirable vegetation 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 to ensure adequate time for a majority of the avian offspring to disperse prior to construction activities.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. <u>Effects on Water Quality</u>: Potential water sources for the project include stormwater, Salt River flood flows, irrigation return flows (tailwater and surplus water), irrigation drains, effluent from the 23rd Avenue WWTP, groundwater (in situ and pumped), releases from sand/gravel mining operations, and residual water from the Rio Salado Phoenix project. With the possible exception of sediment loads, most of the surface water sources listed above are suitable for ecosystem restoration. However, only effluent and groundwater (both in situ and pumped) are considered to be dependable.

The 23rd Avenue WWTP effluent undergoes tertiary treatment and is released at wastewater class A+. Arizona Administrative Code, Title 18, Environmental Quality defines the classification of A+ as, "...wastewater that has undergone secondary treatment, filtration, nitrogen removal treatment, and disinfection..." This reliable water source is considered to be suitable for ecosystem restoration.

Groundwater and stormwater have potential water quality issues requiring further consideration. Groundwater testing in the vicinity of the project area has indicated the presence of nitrates, volatile organic compounds (VOCs), metals, and pesticides. With few exceptions, these contaminants have been below detection levels or detected at concentrations below numeric groundwater quality standards. Both in situ and pumped groundwater is generally suitable for agricultural purposes, and is expected to be adequate for ecosystem restoration.

Due to infrequent rainfall, stormwater is considered a supplemental water source for the restoration effort. Because stormwater discharges represent runoff from residential, commercial, industrial and agricultural areas, water quality varies greatly based on land use and the magnitude, duration, and timing of storm events. Stormwater quality data are very limited for this reach of the Salt River due to the lack of precipitation. Between rainstorms, sediment and pollutants tend to accumulate, and the highest concentrations of pollutants are often washed into rivers, creeks, and streams during "first flush" events. Despite the limited water quality data, a total of 21 parameters are known to have exceeded numeric surface water quality criteria in the study area (URS, 2002). These parameters include pesticides, metals, chlorinated hydrocarbons, the water quality parameters pH and turbidity, and bacteriological parameters. In general, based on analysis of available data versus the numeric water quality standards, stormwater is a vehicle by which surface water quality appears to degrade within the Salt River (URS, 2002).

The water quality issues already present in the project area will exist regardless of whether or not a project is constructed. Although the project would affect land uses in the immediate environs of the Salt River, overall land use in the watershed is not expected to be affected. Thus, this project would not change the quantity or quality of groundwater or stormwater available for the restoration. Alternative 5A would not be expected to cause or contribute to violations of water quality standards unless a spill occurs during construction.

An AZPDES permit, administered by the Arizona Department of Environmental Quality, would be required for any proposed construction activity, and Storm water Pollution Prevention Plan (SWPPP) would be required, developed, and implemented as part of the permit. The SWPPP, along with other measures discussed in the FEIS, would reduce construction-related water quality impacts to a less than significant level. A separate AZPDES permit may be required for the removal and/or control of invasive vegetation as part of long-term maintenance of the project. The need for this additional permit would be determined through consultation with the Arizona Department of Environmental Quality before construction. [5]

As stated above, the potential exists for impacts to surface and groundwater from minor, chronic, or large scale spills of hazardous and toxic materials during construction from both equipment and storage areas established for the project. The aforementioned SWPPP would also contain provisions for spill prevention that properly identifies storage location, spill containment, and remediation measures for clean up. Mitigation measures WQ-1 and WQ-2 would be employed during construction to minimize the potential for significant impacts to water quality.

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[5] There is currently litigation pending that challenged the authority of the State of Arizona to issue these permits. Should that litigation be resolved in a manner adverse to the State's authority, a permit may have to be issued by the EPA.

The addition of wetlands and other riparian habitats to the Salt River has the potential to increase the retention of nutrients carried in by fine sediments, which would improve water quality. The wetland plants would also act as filters by taking up nutrients (such as nitrogen and phosphorus), which can cause algal blooms and fish kills in streams and lakes. Wetland vegetation would provide additional water quality benefits, such as removing additional nitrogen through the action of soil bacteria, binding to metal pollutants such as lead, zinc and cadmium, removing some kinds of pesticides bound to sediments, retaining other pesticides long enough for them to break down into less harmful components, and preventing stormwater runoff from causing destructive downstream soil erosion by holding water after a storm and releasing it slowly (Ohio EPA Fact Sheets and Publications, 2006).

2. Effects on Current Drainage Patterns and Circulation: The proposed project would not substantially alter the surface water hydraulics or drainage patterns within or into the Salt River. Proposed restoration measures would more closely mimic historical conditions and promote establishment of native vegetation. Stormwater outfalls would be modified to utilize stormwater flows as a supplemental water source for some of this vegetation. The location of stormwater outfalls and irrigation drains would not be changed by the project. Hydraulic modeling (see Appendix A of the Feasibility Report) for the with-project conditions shows that the conveyance capacity of the channel and affected tributaries would not be significantly affected. Utilization of effluent for planted vegetation would likely reduce the amount of water in the low flow channel between 35th and 51st Avenues. Since the availability of this effluent varies widely depending on irrigation needs and distance from the discharge points, it is not a perennial water source supporting high value plant and animal communities.

3. Effects on Normal Water Level Fluctuations: The frequency and duration of flooding along the Salt River would not be altered by construction of an ecosystem restoration project. Hydraulic modeling for Alternative 5A indicates that water surface elevations for the 100-year flood would not increase from the present condition, and would decrease slightly in some areas. Establishment of vegetation within the active area of conveyance would be compensated for by a hydraulically designed channel and reduced surface roughness.

Implementation of Alternative 5A would require reliable sources providing up to 9,293 ac-ft of water per year (8.3 mgd). For this reason, a water supply and distribution system is essential for the success of the project. Providing water to newly established riparian communities at the times and locations needed would require redistribution and reallocation of existing water supplies in the project area.

The primary water sources identified for the project are effluent from the 23rd Avenue WWTP, and both in situ and pumped groundwater. Pumped groundwater would consist of effluent that has infiltrated into the Upper Alluvial Unit (UAU). Effluent not used for other purposes is currently discharged to the Salt River at 35th and 43rd Avenues. Effluent is also available at the 27th Avenue discharge structure, though it is not discharged to the river at this location. Water requirements for the project would likely affect the volume and duration of effluent discharges to the Salt River. This effluent would be distributed to locations as needed using the reclaimed

water system, the distribution system for agricultural water, or indirectly used as groundwater pumped from the UAU.

With the exception of flood flows, construction work proposed for the Salt River channel, stormwater outfalls, and the sand/gravel pits would permanently alter existing water level fluctuations. This is especially true for the 19th, 27th, and 37th Avenue sand/gravel pits, where the existing water column and associated habitats would be adversely affected by draining, reshaping, and installation of clay liners. When combined with the anticipated changes in effluent distribution and availability, project construction would have an adverse effect on water level fluctuations.

Following completion of construction, there would be a long term stabilization of water fluctuations in the project area. The volume of stormwater and flood water entering the Salt River along the project area would not be changed. However, water from these less reliable sources would be retained on site for longer periods by the installation of clay liners at outfall structures, and beneath some restored riparian habitats (former sand/gravel pits). Construction of a continuous low flow channel would also stabilize water availability along the Salt River as flood flows attenuate, and for conveyance of excess water applied for irrigation.

The temporary adverse impacts on plants caused by changes in water level fluctuations would be ameliorated because much of the affected vegetation consists of invasive species that would be removed. The project design incorporates water supplies for existing desirable vegetation that would be retained. The Rio Salado Phoenix and Tres Rios projects would provide refuge for some wildlife disturbed by construction activity and changes in water availability in the Rio Salado Oeste reach. Over the long term, wildlife would find more stable conditions in restored habitats and their associated water supplies.

4. Action Taken to Minimize Impacts: An erosion and sedimentation control plan would be prepared for project activities. This plan would also address Best management Practices (BMPs) for OMRR&R activities.

C. Suspended Particulate/Turbidity Determinations at the Disposal Site

1. Expected Change in Suspended Particulate and Turbidity Levels in the Vicinity of the Disposal Site: Short-term increases in suspended particulate and turbidity levels may occur during construction, if water is flowing. Water pumped from the 27th and 37th Avenue sand/gravel pits while they are drained would increase suspended particulate and turbidity levels in the Salt River until this water infiltrates into the riverbed. Following construction, vegetation establishment would be expected to reduce suspended particulate and turbidity levels during the smaller flow events, but would have little effect during major floods. No long-term effects are anticipated.

2. Effects on Chemical and Physical Properties of the Water Column: The Salt River is typically dry except while effluent is being discharged from the 23rd Avenue WWTP. The existing water column in the sand/gravel pits would be eliminated, then replaced with emergent wetlands. This effect would be adverse but temporary. 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. The SWPPP developed for this project would contain a spill prevention, control, and clean-up plan that would specify proper storage, handling, containment, and clean-up techniques and measures for potentially hazardous materials during construction. These measures are designed to minimize the probability of a spill and any resulting impacts. This impact is considered potentially significant, but can be mitigated through the implementation of Mitigation Measure WQ-2.

3. Effects of Turbidity on Biota: The Salt River rarely flows, and construction activities would generally be carried out during dry conditions. Soil discharged into the river channel due to project construction is unlikely to significantly increase turbidity. The ephemeral and highly turbid flows in the Salt River are generally of short duration and do not, during flow periods, support aquatic biota. With implementation of BMPs for sediment and erosion control, no adverse impacts are expected.

4. Actions Taken to Minimize Impacts: Refer to the three previous subsections for mitigation measures.

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 (Sections 3.13, 4.13 and 8.13 of the FEIS, and Appendix F of the Feasibility Report). Buried materials found during construction would be evaluated and disposed of in accordance with local, state and federal regulations.

E. Effect on Aquatic Ecosystem and Organism Determination

Alternative 5A would result in a substantial increase in the cottonwood/willow, mesquite bosque, new river bottom (including freshwater marsh), wetland, and associated riparian communities compared to future conditions without the project. It would result in the creation of 375 acres of cottonwood/willow, 417 acres of mesquite, 170 acres of river bottom (including 34 acres of wetlands), 156 acres of additional wetlands, 296 acres of riparian scrub, and 52 acres of Sonoran desert scrub-shrub, for a total of 1,466 acres. It would also entail the physical removal of non-native salt cedar habitat in areas where the new habitat cells would be created.

The only special aquatic site type in the project area consists of wetlands. These wetlands are transitional in nature, changing with fluctuations in the delivery of effluent, volume of stormwater flows, flood events, and management of active and abandoned aggregate mining operations. Most of the area within the jurisdiction of Section 404, including these wetland areas, would be disturbed during project construction. However, a much larger acreage of higher quality, more sustainable wetlands would be created. With implementation of erosion control measures and other measures identified in the FEIS, no significant long-term adverse effects on the aquatic ecosystem or aquatic organisms are anticipated. There would be a short term adverse

effect on wetlands until the benefits associated with the project begin to accrue. The overall effect of this project on special aquatic sites would be beneficial.

Implementation of Alternative 5A would also result in substantial short-term impacts on vegetation. The major disruption would be to salt cedar 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 would be mitigated through implementation of Mitigation Measure BR-1.

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 5A, 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 5A is expected to increase foraging habitat for sensitive raptor species such as the peregrine falcon and the bald eagle. In summary, the project would have a net, long-term beneficial effect on the habitat value of the aquatic ecosystem.

F. Proposed Disposal Site Determinations

The area to be affected during construction of this project would be confined to the minimum area necessary to construct the project features. The project is expected to comply with applicable water quality standards. Implementation of the proposed mitigation measures would ensure that adverse impacts to jurisdictional Waters of the U.S. are minimized.

G. Determination of Cumulative Effects of Disposal of Fill on the Aquatic Ecosystem

The Salt River is a highly modified and degraded ecosystem. That degradation has occurred over decades of development and impacts to the river ecosystem from both private and public projects. The Feasibility Report and EIS associated with this evaluation describe past activities in detail, EIS Chapter 3 Affected Environment and Feasibility Report Chapters III and IV. Ongoing projects include aggregate mining operations which occur throughout the project area and are anticipated to continue. As described in the reports there are several projects planned in the reasonably foreseeable future. Those include expansion of the 35th Avenue Bridge, proposed South Mountain Freeway and Rio Salado Marsh.

With implementation of appropriate mitigation measures, this project would not significantly contribute to adverse cumulative effects on the aquatic ecosystem of the Salt River. Instead, it would directly contribute to the cumulative beneficial effects on the aquatic ecosystem anticipated to result from implementation of this and other ecosystem restoration projects on the Salt River, including Va Shly'ay Akimel, Rio Salado (Phoenix and Tempe reaches), and Tres

Rios. Coupled 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.

Most of the adverse effects are associated with project construction, with beneficial effects usually following as vegetation is established and benefits begin to accrue. Information on the timing of the construction phase for each of the Salt River projects is provided in Table 5.1-1 in the FEIS. Both the Rio Salado and Tres Rios projects will be constructed and providing ecosystem benefits before Va Shly'ay Akimel and Rio Salado Oeste would begin construction. Thus, the cumulative effects would be spread out over a longer time frame while the benefits associated with the earlier projects would already begin to offset those effects.

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 restored areas. No increase in flood surface water elevations is anticipated as a result of project construction. The indirect effects of this project are generally beneficial. Adequate mitigation is provided for the adverse impacts that may occur.

V. 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.

JURISDICTIONAL DELINEATION

CESPL-CO-RA February 22, 2006

MEMORANDUM FOR Los Angeles District Planning Section C

SUBJECT: Jurisdictional Delineation for Rio Salado Oeste

Regulatory File #2006-00553-SDM

A preliminary jurisdictional delineation has been performed for the Salt River, within the Rio Salado Oeste study area located in Phoenix, Maricopa County, Arizona (Sections 20, 21, 22, 23, 24, 27, 28, 29 and 30 T1N, R2E and Sections 25, 26 and 35, T1N, R1E). The study area is approximately 8 miles long, and extends from 19th Avenue (the eastern boundary) to 83rd Avenue (the western boundary).

This is a preliminary, planning level jurisdictional delineation. The Salt River within the study area is primarily an ephemeral watercourses. A preliminary calculation shows that approximately 1,700 acres of jurisdictional waters occur within the study area. A few wetlands have previously been delineated within the study area. The study area includes several sand and gravel mines with pits that fill with water. Additionally, stormwater and agricultural tail water enter the river at various point, sometimes resulting in the development of wetlands. Due to the preliminary nature of this jurisdictional delineation decision, no estimate of jurisdictional waters can be made. Further field work and/or research could identify wetlands within the study area. This preliminary jurisdictional determination will remain in effect for five years from the date of this memorandum unless an unusual flood event occurs. After this five-year period or after an unusual flood event alters stream conditions, the Corps of Engineers reserves the authority to retain the original jurisdictional limits or to establish new jurisdictional limits as conditions warrant.

The Salt River is tributary to the Gila River. The Gila River is tributary to the Colorado River, which is an interstate, navigable waterway. The Section 404 jurisdictional limit for a water of the United States is defined at 33 CFR 328. The jurisdictional limit for a non-tidal water of the United States is determined by the jurisdictional wetland boundary and/or the ordinary high water mark. The presence of the indicators stated in the definition of ordinary high mark (33CFR 328.3(e)) are used to establish the jurisdictional limit of a water of the United States. This preliminary jurisdictional delineation is based on the following:

- Aerial photography interpretation: Aerial photos were provided, dated 2003. They were plotted at a scale of 1"-155' and 1"-300' (approximately). The location of the ordinary high water mark was based on the appearance of scoured areas of the Salt River (i.e. areas that do not show any vegetation on the aerial photo). Other areas that supported some limited vegetation (as interpreted from the aerial photo) were included within the ordinary high water mark.

- Comparison of previously accepted delineations of the area:
    - 2001-01363 – Jurisdictional delineations for wetlands located within the Salt River.
    - 2005-00798 – Individual permit issued for widening of the 35th Avenue bridge crossing the Salt River. No formal jurisdictional delineation was completed.
    - 2003-01303 – Jurisdictional delineation (not field checked) of a portion of the Salt River within the study area.
    - 2005-00023 – Jurisdictional delineation (not field checked) for a portion of the Salt River upstream of 67th Avenue.
    - 2003-01288 – Jurisdictional delineation, confirmed in the field, for a portion of the Salt River upstream of 59th Avenue.
- Phoenix Metropolitan Street Atlas, 2002 Edition, Phoenix Mapping Service
- Aerial photos dated 2005 obtained from the Maricopa County assessor's office website: www.maricopa.gov/Assessor/GIS/Maps/assessor.mwf. These photos also indicated the delineated floodway in the project area.
- Staff knowledge of precipitation and fluvial dynamics of the region: Senior Project Manager has over 8 years experience in the Arizona Regulatory office. During this time she has performed over 400 jurisdictional delineations in Arizona's ephemeral systems, many of which included field work.

\signed by\

Sallie D. McGuire

Project Manager

FINAL

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX B

Biological Resources and Correspondence

Rio Salado Oeste
Salt River – Phoenix, Arizona

Rio Salado Oeste Final Environmental Impact Statement Appendix B

The following are included in this appendix:

- ☐ Table B-1 List of Plant and Animal Species Mentioned in the Text
- ☐ Federally Listed Threatened and Endangered Species listed as occurring within Maricopa County, USFWS. Downloaded March 8, 2006 http://www.fws.gov/arizonaes/Documents/CountyLists/Maricopa.pdf
- ☐ USFWS Planning Aid Letter Dated June 21, 2002
- ☐ USFWS Fish and Wildlife Coordination Act Report Dated June 20, 2005
- ☐ Biological Assessment Dated April 2006
- ☐ USFWS Section 7 Consultation Concurrence Letter Dated August 7, 2006

Table B-1. List of Plant and Animal Species Mentioned in the Text

Common Name	Scientific Name
Plants	
Acacia	*Acacia greggii*
Bermuda grass	*Cynodon dactylon*
Paloverde	*Cercidium floridum* var. *floridum*
Cheesebush/burrobush	*Hymenoclea salsola*
Cattail	*Typha* spp.
Cottonwood	*Populus fremontii* ssp. *fremontii*
Creosote bush	*Larrea tridentata*
Desert broom	*Baccharis sarothroides*
Desert willow	*Chilopsis linearis*
Gooddings willow	*Salix gooddingii*
London rocket	*Sisymbrium irio*
Marsh fleabane	*Pluchea purpurascens* var. *purpurascens*
Mesquite	*Prosopis velutina*
Willow	*Salix* spp.
Quailbush	*Atriplex lentiformis* ssp. *lentiformis*
Rabbitbrush	*Chrysothamnus* spp.
Filaree	*Erodium cicutarium*
Russian thistle	*Salsola tragus*
Salt Heliotrope	*Heliotropium curassavicum*
Saltbush	*Atriplex* spp.
Saltcedar	*Tamarix* spp.
Sedges	*Cyperus* spp.
Tree tobacco	*Nicotiana glauca*
Reptiles and Amphibians	
Banded Gecko	*Coleonyx variegatus*
Banded Sand Snake	*Chilomeniscus cinctus*
Common Kingsnake	*Lampropeltis getulus*
Desert Black-headed snake	*Tantilla nigriceps*
Desert Tortoise	*Gopherus agassizii*
Earless Lizard	*Holbrookia texana*
Lowland Leopard Frog	*Rana yavapaiensis*

Table B-1. Continued

Common Name	Scientific Name
Mexican Garter Snake	*Thamnophis eques*
Side-blotched Lizard	*Uta stansburiana*
Desert Spiny Lizard	*Sceloporus magister*
Tree Lizard	*Urosaurus ornatus*
Western Diamondback Rattlesnake	*Crotalus atrox*
Western Whiptail	*Cnemidophorous tigris*
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*
Belted Kingfisher	*Ceryle alcyon*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-throated Sparrow	*Amphispiza bilineata*
Cactus Ferruginous Pygmy Owl	*Glaucidium brasilianum cactorum*
Cactus Wren	*Campylorhynchus brunneicapillus*
Canyon Towhee	*Pipilo fuscus*
Cattle Egret	*Bubulcus ibis*
Cinnamon Teal	*Anas cyanoptera*
Common Merganser	*Mergus merganser*
Curve-billed Thrasher	*Toxostoma curvirostre*
Double-crested Cormorant	*Phalacrocorax auritus*
Dusky Flycatcher	*Empidonax oberholseri*
Elf Owl	*Micrathene whitneyi*
European Starling	*Sturnus vulgarus*
Gambel's Quail	*Callipepla gambelii*
Gila Woodpecker	*Melanerpes uropygialis*

Table B-1. Continued

Common Name	Scientific Name
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Great horned Owl	*Bubo virginianus*
Greater Roadrunner	*Geococcyx californianus*
House Finch	*Carpodacus mexicanus*
House Sparrow (I)	*Passer domesticus*
House Wren	*Troglodytes aedon*
Bell's Vireo	*Vireo belli*
Loggerhead Shrike	*Lanius ludovicianus*
Lucy's Warbler	*Vermivora luciae*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Peregrine Falcon	*Falco peregrinus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Rock Dove (I)	*Columba livia*
Snowy Egret	*Egretta thula*
Southwestern Willow Flycatcher	*Empidonax traillii extimus*
Tree Swallow	*Tachycineta bicolor*
Verdin	*Auriparus flaviceps*
Western Burrowing Owl	*Athene cunicularia*
Western Kingbird	*Tyrannus verticalis*
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*

Table B-1. Continued

Common Name	Scientific Name
Mammals	
Lesser Long-nosed Bat	*Leptonycteris curasoae yerbabuenae*
Pocket Gopher	*Pappogeomys castanops*
Coyote	*Canis latrans*
Gray Fox	*Urocyon cinereoargenteus*
Bobcat	*Lynx rufus*
Cactus Mouse	*Peromyscus eremicus*
Deer Mouse	*Peromyscus maniculatus*
Western Harvest Mouse	*Reithrodontomys magalotis*
Whitethroat Wood Rat	*Neotoma albigula*
Hispid Cotton Rat	*Sigmodon hispidus*
Blacktail Jack Rabbit	*Lepus californicus*
Desert Cottontail	*Sylvilagus auduboni*
Striped Skunk	*Mephitis mephitis*
Opossum	*Didelphis virginianus*

Maricopa County

COMMON NAME	SCIENTIFIC NAME	STATUS	DESCRIPTION	COUNTY	ELEVATION	HABITAT	COMMENTS
Arizona agave	*Agave arizonica*	Endangered	Has attractive rosettes of bright green leaves with dark mahogany margins. Flower: Borne on sub-umbellate inflorescences.	Gila, Maricopa, Yavapai	3000-6000 ft	Transition zone between oak-juniper woodland & mountain mahogany-oak scrub.	Scattered clones in New River mountains and Sierra Ancha. Usually found on steep, rocky slopes. Possibly Mazatal mountains. Should be looked for wherever the ranges of Agave toumeyana var. bella and Agave chrysantha overlap.
Arizona cliffrose	*Purshia subintegra*	Endangered	Evergreen shrub of the rose family (Roseaceae). Bark pale shreddy. Young twigs with dense hairs. Leaves 1-5 lobes and edges curl downward (revolute). Flowers: 5 white or yellow petals <0.5 inches long.	Graham, Maricopa, Mohave, Yavapai	< 4,000 ft	Characteristic white soils of tertiary limestone lakebed deposits.	White soils of teritiary limestone lakebed deposits can be seen from a distance.
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Large, adults have white head and tail. Height 28-38 inches; wingspan 66-96 inches. Dark with varying degrees of mottled brown plumage. Feet bare of feathers.	Apache, Cochise, Coconino, Gila, Graham, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, Santa Cruz, Yavapai, Yuma	Varies	Large trees or cliffs near water (reservoirs, rivers, and streams) with abundant prey.	Some birds are nesting residents while a larger number winters along rivers and reservoirs. An estimated 200 to 300 birds winter in Arizona. Once endangered (32 FR 4001, 03-11-1967; 43 FR 6233, 02-14-78) because of reproductive failures from pesticide poisoning and loss of habitat, this species was down listed to threatened on August 11, 1995. Illegal shooting, disturbance, and loss of habitat continues to be a problem. Species has been proposed for delisting (64 FR 36454) but still receives full protection under the ESA.
Cactus ferruginous pygmy-owl	*Glaucidium brasilianum cactorum*	Endangered	Small (Approx. 7inches), diurnal owl reddish brown overall with cream-colored belly streaked with reddish brown. Some individuals are grayish brown.	Cochise, Gila, Graham, Greenlee, Maricopa, Pima, Pinal, Santa Cruz, Yuma	<4000 ft	Mature cottonwood/willow, mesquite bosques, and Sonoran desertscrub.	Historical distribution in Arizona is from New River (North) to Gila Box (East) to Cabeza Prieta Mountains (West). Only a few documented sites where this species persists are known, additional surveys are needed. Species has been proposed for delisting (70 FR 44547) but still receives full protection under the ESA.

COMMON NAME	SCIENTIFIC NAME	STATUS	DESCRIPTION	COUNTY	ELEVATION	HABITAT	COMMENTS
California Brown pelican	*Pelecanus occidentalis californicus*	Endangered	Large dark gray-brown water bird with a pouch underneath long bill and webbed feet. Adults have a white head and neck, brownish black breast, and silver gray upper parts.	Apache, Cochise, Coconino, Gila, Graham, Greenlee, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, Santa Cruz, Yavapai, Yuma	Varies	Coastal land and islands; species found around many Arizona lakes and rivers.	Subspecies is found on Pacific Coast and is endangered due to pesticides. It is an uncommon transient in Arizona on many Arizona lakes and rivers. Individuals wander up from Mexico in summer and fall. No breeding records in Arizona.
Desert pupfish	*Cyprinodon macularius*	Endangered	Small (2 inches) smoothly rounded body shape with narrow vertical bars on the sides. Breeding males blue on head and sides with yellow on tail. Females and juveniles tan to olive colored back and silvery sides.	Graham, La Paz, Maricopa, Pima, Pinal, Santa Cruz, Yavapai	< 5,000 ft	Shallow springs, small streams, and marshes. Tolerates saline and warm water.	Critical habitat includes Quitobaquito Springs, Pima County, portions of San Felipe Creek, Carrizo Wash, and Fish Creek Wash, Imperial County, California. Two subspeices are recognized: Desert Pupfish (C.m.macularis) and Quitobaquito Pupfish (C.m.eremus).
Gila chub	*Gila intermedia*	Endangered	Deep compressed body, flat head. Dark olive-gray color above, silver sides. Endemic to Gila River Basin.	Cochise, Gila, Graham, Greenlee, Maricopa, Pima, Pinal, Santa Cruz, Yavapai	2,000 - 5,500 ft	Pools, springs, cienegas, and streams.	Found on multiple private lands, including the Nature Conservancy, the Audubon Society, and others. Also occurs on Federal and state lands and in Sonora, Mexico. Critical habitat occurs in Cochise, Gila, Graham, Greenlee, Pima, Pinal, Santa Cruz and Yavapai counties.
Gila topminnow	*Poeciliopsis occidentalis occidentalis*	Endangered	Small (2 inches), guppy-like, live bearing, lacks dark spots on its fins. Breeding males are jet black with yellow fins.	Gila, Graham, La Paz, Maricopa, Pima, Pinal, Santa Cruz, Yavapai	< 4,500 ft	Small streams, springs, and cienegas vegetated shallows.	Species historically occurred in backwaters of large rivers but is currently isolated to small streams and springs.
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	Endangered	Elongated muzzle, small leaf nose, and long tongue. Yellowish brown or gray above and cinnamon brown below. Tail minute and appears to be lacking. Easily disturbed.	Cochise, Gila, Graham, Greenlee, Pima, Pinal, Maricopa, Santa Cruz	< 6000 ft	Desert scrub habitat with agave and columnar cacti present as food plants.	Day roosts in caves and abandoned tunnels. Forages at night on nectar, pollen, and fruit of paniculate agaves and columnar cacti. This species is migratory and is present in Arizona usually from April to September and south of the border the remainder of the year.

COMMON NAME	SCIENTIFIC NAME	STATUS	DESCRIPTION	COUNTY	ELEVATION	HABITAT	COMMENTS
Mexican spotted owl	*Strix occidentalis lucida*	Threatened	Medium sized with dark eyes and no ear tufts. Brownish and heavily spotted with white or beige.	Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Mohave, Navajo, Pima, Pinal, Santa Cruz, Yavapai	4100-9000 ft	Nests in canyons and dense forests with multi-layered foliage structure.	Generally nest in older forests of mixed conifer or ponderosa pine/gambel oak type, in canyons, and use variety of habitats for foraging. Sites with cool microclimates appear to be of importance or are preferred. Critical habitat was finalized on August 31, 2004 (69 FR 53182). Critical habitat in Arizona occurs in Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Navajo, Pima, Pinal, Santa Cruz, and Yavapai counties.
Razorback sucker	*Xyrauchen texanus*	Endangered	Large, up to 3 feet long and up to 6 lbs. high sharp-edged keel-like hump behind the head. Head flattened on top. Olive-brown above to yellowish below.	Coconino, Gila, Graham, Greenlee, La Paz, Maricopa, Mohave, Pinal, Yavapai, Yuma	< 6000 ft	Riverine and lacustrine areas, generally not in fast moving water and may use backwaters.	Species is also found in Horseshoe reservoir (Maricopa County). Critical habitat includes the 100-year floodplain of the river through the Grand Canyon from confluence with Paria River to Hoover Dam; Hoover Dam to Davis Dam; Parker Dam to Imperial Dam. Also Gila River from Arizon/New Mexico border to Coolidge Dam; and Salt River from Hwy 60/SR77 Bridge to Roosevelt Dam; Verde River from FS boundary to Horseshoe Lake.
Sonoran pronghorn	*Antilocapra americana sonoriensis*	Endangered	Buff on back and white below, hoofed with slightly curved black horns having a single prong. Smallest and palest of the pronghorn subspecies	Maricopa, Pima, Yuma	500 - 2,000 ft	Broad intermountain alluvial valleys with creosote-bursage and palo verde-mixed cacti associations.	Typically, bajadas are used as fawning areas and sandy dune areas provide food seasonally. Historical range was probably larger than exists today. This subspecies also occurs in Mexico.
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Small passerine (about 6 inches) grayish-green back and wings, whitish throat, light olive-gray breast and pale yellowish belly. Two wingbars visible. Eye-ring faint or absent.	Apache, Cochise, Coconino, Gila, Graham, Greenlee, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, Santa Cruz, Yavapai, Yuma	<8500 ft	Cottonwood/willow and tamarisk vegetation communities along rivers and streams.	Migratory riparian-obligate species that occupies breeding habitat from late April to September. Distribution within its range is restricted to riparian corridors. Difficult to distinguish from other members of the Empidonax complex by sight alone. Training seminar required for those conducting flycatcher surveys. Critical habitat was finalized on October 19, 2005 (50 CFR 60886) and can be viewed at http://arizonaes.fws.gov. In Arizona there are critical habitat segments in Apache, Cochise, Gila, Graham, Greenlee, Maricopa, Mohave, Pima, Pinal, and Yavapai counties.

COMMON NAME	SCIENTIFIC NAME	STATUS	DESCRIPTION	COUNTY	ELEVATION	HABITAT	COMMENTS
Yuma clapper rail	*Rallus longirostris yumanensis*	Endangered	Water bird with long legs and short tail. Long, slender decurved bill. Mottled brown or gray on its rump. Flanks and undersides are dark gray with narrow vertical stripes producing a barring effect.	Gila, La Paz, Maricopa, Mohave, Pinal, Yuma	< 4,500 ft	Fresh water and brackish marshes.	Species is associated with dense emergent riparian vegetation. Requires wet substrate (mudflat, sandbar) with dense herbaceous or woody vegetation for nesting and foraging. Channelization and marsh destruction are primary sources of habitat loss.
Yellow-billed cuckoo	*Coccyzus americanus*	Candidate	Medium-sized bird with a slender, long-tailed profile, slightly down-curved bill, which is blue-black with yellow on the lower half of the bill. Plumage is grayish-brown above and white below, with rufous primary flight feathers.	Apache, Cochise, Coconino, Gila, Graham, Greenlee, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, Santa Cruz, Yavapai, Yuma	< 6,500 ft	Large blocks of riparain woodlands (cottonwood, willow, or tamarisk galleries).	Listing was found warranted, but precluded as a distinct vertebrate population segment in the western U.S. on July 25, 2001. This finding indicates that the Service has sufficient information to list the bird, but other, higher priority listing actions prevent the Service from addressing the listing of the cuckoo at this time.

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

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June 21, 2002

Ms. Ruth Villalobos
Chief, Planning Division
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 presents the Fish and Wildlife Service's (Service) preliminary evaluation of potential environmental effects and habitat benefits associated with the U.S. Army Corps of Engineers' Rio Salado Oeste Feasibility Study. 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 the Service report under Section 2(B) of the FWCA. This planning aid letter is based on coordination with the Arizona Game and Fish Department, literature research, file reviews, and information provided by the Corps. A more detailed evaluation of the Hydrogeomorphic Functional Analysis, existing conditions, and future without project scenario will be incorporated into the 2(B) report.

PROJECT DESCRIPTION

The proposed project would provide ecosystem restoration, flood damage reduction, and public recreation within the portion of the Salt River that runs through Phoenix between 19th and 83rd Avenues, 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 Phoenix would be the local non-Federal sponsor.

EXISTING ENVIRONMENT

Due to dams and diversions, water flow in this portion of the Salt River is not perennial and is limited to summer or fall flood events. This has caused significant changes to the biotic communities historically found along the Salt River. The dense multi-storied cottonwood and willow gallery forests that once dominated the project area are gone. Scattered vegetation currently found in the project area includes velvet mesquite (*Prosopsis velutina*), Fremont's cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), seepwillow (*Baccharis*

salicifolia), desert broom (*B. sarothroides*), burrobush (*Hymenoclea salsola*), rabbitbush (*Chrysothamnus* sp.), creosote (*Larrea tridentata*), and the non-native salt cedar (*Tamarix* sp.). Sand and gravel mining operations exist within the project area. Mining has created a number of open water areas that support limited cottonwood, willow, cattail (*Typha* sp.), and bulrush (*Scirpus* sp.) vegetation.

Native wildlife species likely found in the project area include coyote (*Canis latrans*), black-tailed jackrabbit (*Lepus californicus*), tree lizard (*Urosaurus ornatus*), garter snake (*Thamnophis* sp.), great blue heron (*Ardea herodias*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), Gambel's quail (*Callipepla gambelii*), killdeer (*Charadrius vociferus*), black-necked stilt (*Himantopus mexicanus*), mourning dove (*Zenaida macroura*), and red-winged blackbird (*Agelaius phoeniceus*) to name a few. We are unaware of the occurrence any federally threatened or endangered species within the project area.

ALTERNATIVES

Specific planning alternatives have yet to be developed. However, management measures to address planning objectives have been identified. These include the development of a water supply, creation of a mesquite bosque, establishment of a cottonwood/willow gallery forest, creation of emergent wetlands, incorporation of existing ponds, creation of perennial base flow, vector control, implementation of sanitation program, construction of levee or other flood control features, and development of a recreational corridor.

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, it is unlikely that this stretch of the Salt River would ever be characterized by perennial flow. Water would flow in the project area only during periods of flood release from the dam or storm water runoff from storm drains.

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 diversity of fish and wildlife, particularly native species.

The Service is pleased to participate in the planning process for a riparian restoration project. Riparian biotic communities within the State of Arizona have experienced dramatic degradation and decline over the past century. This has, unfortunately, had detrimental effects on wildlife resources, as the vast majority of native wildlife depend upon riparian areas to satisfy some portion of their life cycle. The Rio Salado Oeste project not only offers a tremendous opportunity to restore native biotic communities along the Salt River, but also offers the unique opportunity to provide a link between two other restoration projects, specifically Rio Salado and Tres Rios. We expect the resultant habitat contiguity and connectivity provided by the combined projects to substantially enhance the biological functions and values along the lower Salt River.

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 that should be used to describe proper hydrologic conditions, include hydroperiod, water depth, and seasonal flood pulses. Accordingly, significant attention should be focused on securing a permanent and sufficient source of water. A combination of effluent, groundwater, and storm water may be beneficial.

Riparian restoration has the potential to benefit a diversity of native wildlife species by restoring critically important habitats, particularly within riverine systems severely degraded by urbanization. For example, most native bird species have not done particularly well in urban environments. Cities are typically dominated by the abundance of a few bird species, in contrast to relatively undisturbed environments that are characterized by high species richness and balanced evenness. Vegetation in urban landscapes often lack the structural components sought by native wildlife. For this reason we suggest the Corps and sponsor consider restoring a mosaic of heterogeneous vegetative cover types juxtapositioned to provide substantial edge and habitat diversity. Within this framework, we believe incorporation of dense multistoried patches with relatively tall canopies would be critical.

Prior to active restoration, assessments should be conducted to ensure that chosen sites 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.

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The proposed project could eventually result in the establishment of habitats suitable for a [illegible] species including those listed as threatened and endangered or those that are [illegible] listing. We encourage the local non-Federal sponsor to explore the opportunity to develop a Safe Harbor Agreement, Candidate Conservation Agreement, or Habitat Conservation Plan, as appropriate, to complete future operation and maintenance activities while providing assurance against additional Endangered Species Act restrictions.

PRELIMINARY RECOMMENDATIONS

1) Focus significant attention on securing a permanent and sufficient source of water, perhaps through a combination of effluent, groundwater, and storm water.

2) Evaluate opportunities to restore a mosaic of heterogeneous vegetative cover types that maximizes structural habitat complexity.

3) Conduct assessments to ensure that site specific microhabitat conditions would be conducive to establishment and growth of native riparian plants especially cottonwood, willow, and mesquite.

4) Encourage the non-Federal sponsor to explore the need for a Safe Harbor Agreement, Candidate Conservation Agreement, or Habitat Conservation Plan for operation and maintenance activities.

We appreciate the opportunity to provide planning assistance for the proposed project. We look forward to working with you on continued project development. If we can be of further assistance or you have questions, please contact Mike Martinez (x224).

Sincerely,

David L. Harlow

David L. Harlow
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Scott Estergard, Planning Branch, Army Corps of Engineers, Phoenix, AZ

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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

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June 20, 2005

Ms. Ruth Villalobos
Chief, Planning Division
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 Rio Salado Oeste Feasibility Study. This report represents our evaluation of the Rio Salado Oeste 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.). This report is based on coordination with the Arizona Game and Fish Department, literature research, file reviews, and information provided by the Corps.

PROJECT DESCRIPTION

The proposed project would provide ecosystem restoration, flood damage reduction, and public recreation within the portion of the Salt River that runs through Phoenix between 19th and 83rd Avenues, 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 Phoenix would be the local non-Federal sponsor.

EXISTING ENVIRONMENT

Due to dams and diversions, water flow in this portion of the Salt River is not perennial and is limited to summer or fall flood events. This has caused significant changes to the biotic communities historically found along the Salt River. The dense multi-storied cottonwood and willow gallery forests that once dominated the project area are gone. Scattered vegetation currently found in the project area includes velvet mesquite (*Prosopsis velutina*), Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), seepwillow (*Baccharis salicifolia*), desert broom (*B. sarothroides*), burrobush (*Hymenoclea salsola*), rabbitbush (*Chrysothamnus* sp.), creosote (*Larrea tridentata*), and non-native salt cedar (*Tamarix* sp.). Substantial sand and gravel mining operations exist within the project area. Mining has created a

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number of open water areas that support limited cottonwood, willow, cattail (*Typha* sp.), and
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Native wildlife species likely found in the project area include coyote (*Canis latrans*), black-tailed jackrabbit (*Lepus californicus*), tree lizard (*Urosaurus ornatus*), garter snake (*Thamnophis* sp.), great blue heron (*Ardea herodias*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), Gambel's quail (*Callipepla gambelii*), killdeer (*Charadrius vociferus*), black-necked stilt (*Himantopus mexicanus*), mourning dove (*Zenaida macroura*), and red-winged blackbird (*Agelaius phoeniceus*). We have no information on the occurrence of federally-listed threatened or endangered species within the project area.

ALTERNATIVES

General Features Alternatives

Channel Restoration: This would provide a flow connection through the study reach and be accomplished by grading and terracing to restore an active channel. Average depth would be five ft with a width of 200-400 ft. Due to a drop in the channel downstream of the 35th Avenue Bridge, a grade control structure is recommended in that vicinity. At this time erosion and scour do not appear to be a concern with project features or infrastructure. An estimated 660,000 c.y. would be removed from the channel to implement this measure. Material removed would be utilized onsite for terracing and construction of other project components, such as lake restoration.

Stormwater outfalls: There are stormwater outfalls throughout the study area supporting wetland habitat. In most cases it is dominated by invasive and exotic species, although conditions appear to be suitable for native riparian vegetation. Existing outfalls would be modified to discharge to a concrete/stone channel through the river terrace and directed toward the low-flow channel. Within that channel there would be a low weir to capture the low flows and allow floodwaters to pass. The weir would direct flows to a stormwater wetland constructed for the purpose of harvesting stormwater and supporting adjacent habitat.

Cottonwood/Willow: This would include restoration of riparian cottonwood/willow stands adjacent to water sources and low terraces throughout the study area. Cottonwood-willow would be dominated by Fremont cottonwood and Goodding's willow. In addition to cottonwood and willow, other plants species may include are *Baccharis* sp., arrowweed (*Pluchea sericea*), and ash (*Fraxinus* sp.). Other understory species would be planted, depending upon individual site conditions, including arrowweed, elderberry (*Sambucus mexicana*), or burrobush. The cottonwood-willow areas would be planted with a combination of pole plantings and container plants with a density of approximately 50 cottonwoods, 50 willows, and 25 understory brush species per acre. Understory forbes would also be planted using a seed mix. It is assumed five years of irrigation would be required for establishment.

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Mesquite: This habitat would be restored over a potentially large portion of the project area and [illegible] watering for five years. Watering could be discontinued after five years or when [illegible] oundwater or during rainfall. Mesquite bosques would be dominated by velvet mesquite intermixed with honey mesquite (*Prosopsis glandulosa*), understory shrubs such as desert thorn (*Lycium spp.*), palo verde (*Parkinsonia floridia*), and brittlebush (*Encelia farinosa*).

Mesquite bosques would be planted with a density of approximately 100 velvet mesquite, ten honey mesquite, and 40 understory shrubs per acre. Understory forbes would also be planted using a seed mix. In locations throughout the study area with less water supply, xeric stands of mesquite would be established. Planting densities would be less with approximately 25 velvet mesquite, five honey mesquite, and ten understory shrubs per acre.

Wetland: Wetlands can consist of open water, submerged vegetation, or mud flats; all requiring a high water table level at or near the surface. Due to porous soils in the project area, lining would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate approximately 12 inches thick would be sufficient. Emergent wetlands contain primarily cattails, tule (*Scirpus acutus*), and sedges (*Carex* sp.). In addition to wetlands included in the stormwater outfall measure, wetland restoration would be included in several alternatives at various locations throughout the study area, mainly in existing gravel pits or open water bodies within the floodplain.

Lakes: There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to restore the floodplain landscape and improve functionality: The existing banks would need to be reshaped for public safety and restoration; possible aeration of the existing water bodies; and potential substrate modification to reduce the annual fluctuation in the lake levels. This measure would be implemented through grading and filling with material excavated for other project features and onsite materials.

Invasive Control: Invasive species such as salt cedar and giant reed (*Arundo donax*) would require removal and management through the project life. Salt cedar is currently found in stands throughout the study area. Arundo, although not yet a significant problem in Arizona, is a problem in neighboring California. A stand of arundo can be found on the south side of the river near a stormwater outfall at 43rd Avenue.

Water Supply: In addition to the stormwater runoff that would be harvested, additional water would be required. Effluent from the 23rd Avenue Waste water Treatment Plant is available. The City of Phoenix estimates that approximately eight MGD (8,964 acre feet) is available. This would require construction of a pump and piping system to deliver water throughout the project area.

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Alternative 1 - No Action: Under this alternative the Corps and local sponsor would not pursue environmental restoration in the study area.

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Alternative 2 - Stormwater and Channel: This alternative would include the modification of existing stormwater outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls. It also would include modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th avenue to 83rd avenue. No additional water source would be included in this alternative.

Alternative 3 - Stormwater, Channel, Water Supply, Cottonwood, Mesquite, Invasive Species: This alternative would include the features described in alternative 2 and add a supplemental water supply in the form of effluent. At locations identified as suitable throughout the project area, cottonwood/willow and mesquite cover types would be restored. This alternative would also address the management, control, and removal of invasive species within the study area.

Alternative 4 - Stormwater, Channel, Water Supply, Cottonwood, Mesquite, Invasive Species, Emergent Wetlands: This alternative would add restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue.

Alternative 5 - Stormwater, Channel, Water Supply, Cottonwood, Mesquite, Invasive Species, Emergent Wetlands, Lake: Added to this alternative would be lake restoration at the existing gravel pits at 29th and 37th Avenues.

Alternative 5A - Wetland Restoration in lieu of Permanent Open Water and Lakes: In lieu of lake restoration this would include regrading of the existing gravel pits to restore them to the floodplain and restoration of emergent wetland and riparian areas.

Alternative 5B - Hybrid of 5 and 5A: This would include restoration of one gravel pit to a wetland/riparian complex and the other to include the lake.

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, it is unlikely that this stretch of the Salt River would ever be characterized by perennial flow. Water would flow in the project area only during periods of flood releases or stormwater runoff.

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n of the proposed project could restore water and native vegetation to an otherwise barren stretch of the Salt River. Each alternative would provide habitat for a diversity of fish and wildlife, particularly native species.

Alternative 2: This alternative would restore 66 acres of cottonwood/willow, 43 acres of mesquite, 28 acres of wetland at outfalls, and 17 acres of wetland in the low-flow channel.

Alternative 3: This alternative would restore 348 acres of cottonwood/willow, 409 acres of mesquite, 28 acres of wetland at outfalls, and 34 acres of wetland in the low-flow channel.

Alternative 4: This alternative would restore 348 acres of cottonwood/willow, 409 acres of mesquite, 33 acres of wetland at outfalls, and 34 acres of wetland in the low-flow channel.

Alternative 5: This alternative would restore 375 acres of cottonwood/willow, 417 acres of mesquite, 76 acres of wetland at outfalls and lakes, 34 acres of wetland in the low-flow channel, and 40 acres of open water.

Alternative 5A: This alternative would restore 375 acres of cottonwood/willow, 417 acres of mesquite, 156 acres of wetland at outfalls and lakes, and 34 acres of wetland in the low-flow channel.

Alternative 5B: This alternative would restore 375 acres of cottonwood/willow, 417 acres of mesquite, 136 acres of wetland at outfalls and lakes, 34 acres of wetland in the low-flow channel, and 20 acres of open water.

DISCUSSION

We are pleased to participate in the development of your riparian restoration project. Riparian biotic communities within the State of Arizona have experienced dramatic degradation and decline over the past century. This has had detrimental effects on wildlife resources as the vast majority of native wildlife depend upon riparian areas to satisfy some portion of their life cycle. The Rio Salado Oeste project not only offers a tremendous opportunity to restore native biotic communities along the Salt River, but also offers the unique opportunity to provide a link between two other restoration projects, specifically Rio Salado and Tres Rios. We expect the resultant habitat contiguity and connectivity provided by the combined projects to substantially enhance the biological functions and values along the lower Salt River.

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 that should be used to describe proper hydrologic conditions include hydroperiod, water depth, and seasonal flood pulses. Accordingly, significant attention

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should be focused on securing a permanent and sufficient source of water. A combination of
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Riparian restoration has the potential to benefit a diversity of native wildlife species by restoring critically important habitats, particularly within riverine systems severely degraded by urbanization. For example, most native bird species have not done particularly well in urban environments. Cities are typically dominated by an abundance of a few bird species, in contrast to relatively undisturbed environments that are characterized by high species richness. Vegetation in urban landscapes often lacks the structural components needed by native wildlife. For this reason, we suggest that the Corps and sponsor consider restoring a mosaic of heterogeneous vegetative cover types juxtapositioned to provide substantial edge and habitat diversity. Within this framework, we believe incorporation of dense multistoried patches with relatively tall canopies would be critical.

Assessments should be conducted prior to active restoration to ensure that chosen sites 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.

This proposed project could eventually result in establishment of habitats suitable for a number of native species including those listed as threatened and endangered or those that are candidates for listing. We encourage the local non-Federal sponsor to consider developing a Safe Harbor Agreement, Candidate Conservation Agreement, or Habitat Conservation Plan, as appropriate, to avoid additional Endangered Species Act restrictions. We offer our assistance in exploring these options.

RECOMMENDATIONS

1) Focus significant attention on securing a permanent and sufficient source of water, perhaps through a combination of effluent, groundwater, and stormwater.

2) Maximize opportunities to restore a mosaic of heterogeneous vegetative cover types that maximizes structural habitat complexity.

3) Ensure that site-specific microhabitat conditions would be conducive to establishment and growth of native riparian plants, especially cottonwood, willow, and mesquite.

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4) Encourage the non-Federal sponsor to evaluate Safe Harbor Agreements, Candidate
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Conservation Agreements, or Habitat Conservation Plans.

We appreciate the opportunity to provide planning assistance for this proposed project. If we can be of further assistance or you have questions, please contact Mike Martinez (x224).

Sincerely,

Thomas A. Gatz
Deputy Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ARD-ES)
Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Scott Estergard, Planning Branch, Army Corps of Engineers, Phoenix, AZ

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April 2006

Biological Assessment
Rio Salado Oeste Feasibility Study
Salt River, Phoenix, Arizona

INTRODUCTION

In accordance with Section 7 (a) of the Endangered Species Act of 1973, as amended, this Biological Assessment (BA) evaluates the potential effects of the tentatively recommended plan in the Rio Salado Oeste Feasibility Study. 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 Rio Salado Oeste Study is being conducted by the U.S. Army Corps of Engineers (USACE), Los Angeles District and the City of Phoenix, with the cooperation of the Flood Control District of Maricopa County (FCDMC). The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix. The City of Phoenix, as the non-Federal sponsor, supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The Proposed Action involves the restoration of four significant habitat types throughout the project area. These are habitats that are scarce and ecologically significant in the desert southwest, including cottonwood/willow (375 acres), mesquite (417 acres), wetlands including within the river channel (190 acres), and restoration of 8 miles of river channel made up of approximately 500 acres of active channel and riparian scrub. Multiple measures make up the restoration plan, including, water supply and distribution, channel restoration, revegetation, and invasive-species removal. Major recreation features include multipurpose trails, shelters, signage, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and five smaller access points for walk-in use.

PROPOSED ACTION

Project Location

The study area is geographically located in Maricopa County, Arizona, and is entirely within the City of Phoenix (see Figure 1). The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west, and from Lower Buckeye Road on the north to Dobbins Road on the south. While this is a large study area extending beyond the riverbanks, any implementation of project features would be associated with the river floodplain. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west, and is the area within the 100-year floodplain of the Salt River.

Purpose and Need

The City of Phoenix 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 groundwater 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 and effluent discharge.

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. The Nature Conservancy lists desert riparian woodland as a very rare although significantly important cover type and describes restoration of riparian systems in the Sonoran Desert as critical. (Marshall et al 2000).

Southwest riparian areas represent less than 1% of the regions area (Knopf, F. L., 1989), yet 80-90% of vertebrate wildlife species depend on them for food, water, cover and migration (Gillis, 1991). As a direct consequence of the extent of the lost or degraded riparian habitat, the study area has experienced a major reduction in species diversity and in the populations 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 is land available for restoration. As long as these conditions remain unchanged, there is 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 region. In addition to restoration there are opportunities to reduce future flood damages and improve recreation opportunities associated with the restored floodplain.

EXISTING CONDITIONS

The project area is located in a rapidly developing and changing area of metro Phoenix. Land uses range from industrial and commercial to residential and agriculture. The majority of the area has been highly modified by development or the past modifications to the Salt River. The major cover type within the 100 year floodplain is scrub-shrub, with minimal cottonwood/willow and wetlands scattered throughout.

Aggregate Mining

Since the construction of upstream dams began controlling the flows in the Salt River, sand and gravel mining operations moved into the riverbed and surrounding floodplain to mine the natural resource. The materials extracted from the river have been used extensively throughout the development of the Phoenix Metropolitan area and have contributed to geomorphic changes to the floodplain and adjacent over bank. Removal of sediments also removes materials that would normally be redeposited during flood events.

There are an estimated 671 acres of sand and gravel mining operations within the 100-year floodplain of the project area. Between 19th and 35th Avenues, the river is lined with operations and is nearly 100 percent modified. South of the river between 43rd and 51st Avenues there are mining operations that cross the river just downstream of 51st and extend on the north side to near 63rd Avenue. It is assumed that the existing mining operations will continue operating until resources and demand dictate that they are no longer feasible in their existing locations. New operations will begin in previously un-mined portions of the river, close to new development.

Vegetative Habitat

Historically, the study area supported significant biological resources including extensive riparian and wetland habitats within the floodplain. 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. Included in this reach of the Salt River are a large number of open water areas, mostly the results of gravel mining. Adjacent to several of these there is dense vegetation including some cottonwood and willows as well as the occasional cattail or bulrush.

Cover Types

A classification system of cover types was developed for the feasibility study and is mainly based upon vegetation cover. Cover types were mapped for the length of the study reach and 1 mile on either side of the thalweg, or center of the river channel. Scattered remnants of natural vegetation remain; those cover types include cotton-willow forest, mesquite, scrub-shrub lands, and emergent wetlands. Of those cover types, scrub-shrub lands are the most dominant in the study area, covering approximately 1,200 acres. The scarcest is cottonwood/willow forest, extant within merely 10.5 acres, not including an additional 120 acres in which salt cedar dominates.

Cottonwood/Willow Forest: 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 salt cedar. Of the 10.5 acres referenced above most is scattered throughout the study area and associated with water sources including storm water outfalls or gravel pits. The salt cedar referenced in the 120 acres above is associated with gravel pits at approximately 19th Avenue, 37th Avenue, and the majority at 83rd Avenue near the upstream limit of the Tres Rios Project Area.

Scrub-Shrub Lands: Scrub-shrub lands are common and are present within the active channel of the river. They are dominated by various combinations of burrobush, rabbitbush, quailbush, saltbush, and occasionally by creosotebush. Many of these areas have been highly disturbed from off-highway vehicle (OHV) traffic and gravel mining activities and contain little or no vegetative cover.

Wetlands (Low-Flow Channels): Low-flow channels in the Salt River have been almost entirely eliminated and mostly associated with effluent or storm water discharges These features are characterized by either seasonal or perennial open water, and are generally unvegetated when present. Vegetation, when present, consists of scattered patches of Bermuda grass, salt heliotrope, and sedges. Although most of the wetland vegetation was removed with flows during the Winter 2005, the cover is regenerating in suitable locations.

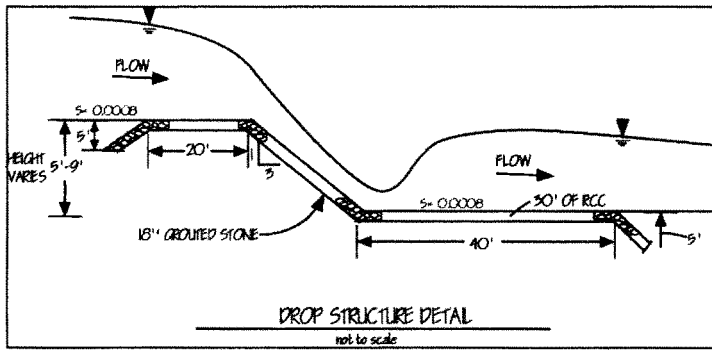
DESCRIPTION OF PROPOSED ACTION

Based on the results of the analyses conducted and described in the feasibility study the proposed action (tentatively recommended plan, Alternative 5A) includes the following features. Figure 2 displays the tentatively recommended plan.

River Channel Restoration

Restoring the river channel to a more natural state would be accomplished by grading and terracing to help restore an active channel through the entire 8-mile reach. Average depth would be 5 feet, with a width varying from 200 to 400 feet. The channel design passes a 5-year event (~22,000 cfs) with occasional flooding on the terrace 2 to 4 feet depth at 1-7 cfs. An estimated 660,000 c.y. would be removed from the channel to implement this measure. Material removed would be native riverbed material and would be used on site for terracing and construction of other project components, such as reshaping of the two "lakes" within the project area.

> **Grade Control Structure:** Due to a drop in grade downstream of the 35th Avenue Bridge, a grade-control structure is recommended within that vicinity. This structure would be similar to those installed in the upstream Rio Salado Project, and would consist of roller-compacted concrete and grouted stone. Although at a feasibility level of detail the following graphic depicts the general dimensions of the grade control structure.



River Channel Habitats: The habitats restored within the active channel will include a combination of dry river bottom, emergent wetland, riparian scrub or desert scrub, depending on the specific site. Total acreage of the active river channel is assumed to be nearly 500 acres comprised of a 170 acre low flow channel, 34 acres of emergent wetland and the remainder riparian scrub.

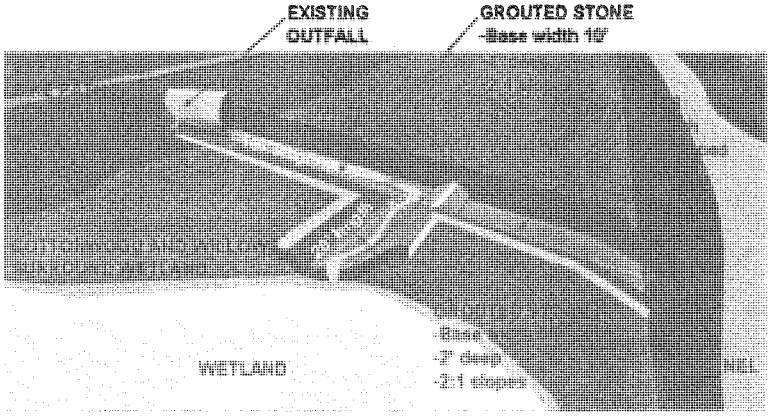
Stormwater Wetlands

Stormwater outfalls within the project area have been identified and average discharges from them quantified, with an estimated 2,863 ac-ft available for use in restoration. The following table describes the location of existing storm water outfalls, estimated runoff and recommended habitat restoration in the vicinity of each outfall.

Location and Estimated Runoff (ac-ft)			Acreage of Habitat		
	Estimated	1/2	Cottonwood /Willow	Mesquite	Wetland
19th Ave NW	79	39.5		13	
19th Ave SW	231	115.5	10		4
27th Ave SE	196	98	8		4
35th Ave NW	224	112	14		
43rd Ave N	274	137	11		5
43rd Ave S	Unknown			x	x
51st Ave NW	274	137		30	5
67th Ave N	558	279	23		10

Note: Assumed water demand (ac-ft/acre): Cottonwood/willow = 8, Mesquite = 3 , Wetland = 9.

This measure includes the addition of grouted rock channels extending from the banks into the channel from existing pipe outfalls. The grouted rock would extend approximately 100 feet from the existing pipe outfall and would vary from 2 to 4 feet in height. The required grout is approximately thirty percent of the needed rock. Each outfall would require 221 c.y. of rock and 67 c.y. of grout. The outfall sites would require a total of 1989 c.y. of rock and 603 c.y. of grout. Large storm flows would be conveyed to the channel while smaller discharges would be directed into adjacent wetland and riparian habitat areas. Techniques would be site-specific and would include grading or excavation, removal of exotics, and planting of suitable vegetation for the site conditions. Supplemental water would be required via an irrigation source, and structures would be installed to contain high-energy inputs and avoid erosion during storm events. It was assumed that approximatley 28 acres of wetlands would be associated with the outfalls within the study area.



Revegetation

Planting of riparian vegetation to restore the various cover types is included in the plan.

Cottonwood/Willow: Cottonwood/willow would be dominated by Fremont's cottonwood (*Populus fremontii*) and Gooding's willow (*Salix gooddingii*). Other understory species would be planted, depending upon individual site conditions, but may include arrowweed (*Pluchea sericea*), elderberry (*Sambucus mexicana*) or burrobush (*Hymenoclea spp.*). The feasibility design includes approximately 60 to 100 trees and 5 shrubs per acre, with a combination of pole and containerized plantings. Hydroseeding of ground cover and additional shrubs is also included in the design.

Mesquite: This habitat would be restored over a potentially large portion of the project area. It would require periodic watering for the first five years after planting, though with

less frequency than cottonwood/willow. Watering could possibly be discontinued after five years or when roots are expected to reach groundwater. Mesquite bosques would be dominated by velvet mesquite (*Prosopis velutina*), with scattered honey mesquite, and some understory shrubs, such as desert thorn (Lycium spp.), palo verde (*Cercidium floridum*), brittlebush (*Encelia farinose*), and forbs.

> **Bosque**: Mesquite bosques are commonly found 5 to 20 feet above the river channel where water is adequate. They require a water table or semi-saturated soil conditions 10 to 30 feet below the surface elevation, and rely on occasional saturated conditions 1 to 3 feet below the surface. Soil requirements range from fine to gravelly with some rocky areas. The mesquite bosques would be planted with a density of approximately 100 velvet mesquite, 10 honey mesquite, and 40 understory shrubs per acre. Understory forbs would also be planted using a seed mix.
> **Xeric**: In locations throughout the study with less water supply, xeric stands of mesquite would be established. It is assumed that mesquite would survive under drier conditions and on higher terraces than mesquite bosques. Planting densities would be less, with approximately 25 velvet mesquite, 5 honey mesquite, and 10 understory shrubs per acre.

Riparian Scrub: It is assumed that some portions maintained will remain a more xeric desert scrub but others adjacent to the wetter riparian habitats will develop into more distinctive riparian cover containing species such as Seepwillow, desert broom, or Desert willow. Approximately 296 acres of the active river channel will be riparian scrub.

Wetlands: A total of approximately 156 acres of wetlands would be restored with Alternative 5A. This would include the stormwater wetlands described above, in the vicinity of the "lakes," and within the restored channel. Wetlands could consist of open water, submerged vegetation, or mud flats, all requiring a high water table at or near the surface. Due to the porous soils found in this project area, lining the site would be required to maintain surface water. Excavation and layering of a silt-clay soil substrate overlain by a mixed gravel, and finally, cobble layer, is 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. Emergent wetlands contain primarily cattails (*Typha domingensis*), tule (*Scirpus acutus*), and sedges (Carex spp.). Because the river will not flow year round, the wetlands would need to be constructed specifically to retain water. In addition to grading and excavation, an impermeable layer would be added to retain water on site.

Lake Restoration

There are existing lake features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. Under Alternative 5A, the proposed measures include significant regrading to restore the lake features into a more natural state coinciding with the floodplain environment. This would include the movement of approximately 3 million c.y. of materials mostly with cut and fil

onsite but would also include materials removed in restoring the channel throuhgout the eight mile reach (660,000 cy). With the reshaping of the two areas, additional measures described above would be incorporated, including the wetland and riparian habitat restoration that would be carried out within them. The two gravel pit lakes and proposed restoration can be seen no Figure 2.

Invasive Species Management

Invasive species such as saltcedar and Arundo would require removal and management with project implementation. This would likely require physical removal and ongoing maintenance through the life of the project as part of a management plan. Saltcedar is currently found in stands throughout the study area. Arundo, although not yet a significant problem in Arizona, is a problem in neighboring California and some stands are found within the project area (43rd Avenue storm water outfall). It was assumed that up to 120 acres would require invasive-species eradication and control measures prior to restoration. The management of invasive species under this Biological Assessment includes the constructoin period and following 5 years of Monitoring and Adaptive Management, cost shared between the Corps and Local Sponsor (City of Phoenix). Maintenance activities following that initial 5 year period after construction, it is presumed will fall within a Safe Harbor Agreement.

Water Supply and Distribution

The City of Phoenix developed the water supply and distribution plan for the project. The primary water supply for the Rio Salado Oeste project would be effluent obtained directly from the 23rd Avenue WWTP with supplemental water (if necessary) potentially from several sources. An estimated 8 mgd is available from the 23rd Avenue Plant.
The sustainable water supply and distribution system would consist of the following features: 20 mgd pump station, supply well, monitoring wells, electronic flow regulated valves, reservoirs, pump stations, open channel canals, irrigation system, pressurized distribution piping. A combination of irrigation approaches could be implemented in the project and would be determined in detail during design. These could include temporary drip systems for establishment of vegetation, subsurface liners to create an artificially perched aquifer, and canal or rill (ditch or flood) irrigation, as well as water-harvesting polymer, or polymer-type products, planted with vegetation.

Maintenance Considerations

Operation and Maintenance activities would occur after project construction in order for project features to function as designed. The following are the currently assumed major maintenance activities that would occur over the life of the project. Project life and period of analysis in the feasibility study are 50 years. Specific maintenance activities and requirements following construction and initial 5 year Monitoring and Adaptive Management period will be defined during design and construction and at this time will be presumed to fall within a Safe Harbor Agreement to be developed in the future.

Replacement Costs. Up to 25 percent of vegetation could require replacement following a flood event at some time during the project life.

Invasive Species Control. Annual removal of exotic species was assumed to be necessary. This would include removal of non-native species that threaten to overtake an area and become a monoculture. This wouldn't necessarily include removal of 100 percent of non-natives through the project area.

Stormwater Wetlands. Regrading and excavation was assumed to be necessary once every 10 years. It was assumed that 50 percent of the construction quantity would need to be regraded in this period.

Irrigation System. Maintenance of the irrigation infrastructure, including replacement of infrastructure, would occur annually. Costs were estimated on a per-acre basis for those acres planted to vegetation.

Lakes/Wetlands. The restored wetlands at existing lakes (gravel pits) would require regrading and excavation once every 20 years of up to 1 foot of material over the 40 acres of wetlands.

Channel. The active channel would require regrading up to once every 20 years for up to 50 percent of the estimated construction quantity or 330,000 c.y.

Water Supply. The water supply and distribution system would require periodic maintenance and inspection of pumps and pipelines. Inspection, repair, and replacement would be necessary for the irrigation system and infrastructure.

Recreation Plan

The City of Phoenix developed the recreation plan for the project. The plan is consistent with Corps policy on development of recreation at ecosystem restoration projects, as outlined in Policy Guidance Letter No. 59, USACE 1998. Major recreation features include multipurpose trails, shelters, signage, utilities, park furniture, and interpretive media. Access points are identified in the plan, with four drive-in points with parking facilities and five smaller access points for walk-in use. Additionally, nine minor points for walk-in access from adjacent neighborhoods will be completed. Although an environmental-education center is included in the estimate below, it is not a cost-shareable portion of the project and would be a local sponsor cost.

Monitoring and Adaptive Management Plan

The Monitoring and Adaptive Management Plan is an essential element for the overall implementation of the proposed plan. It would provide 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. The plan includes monitoring

and adaptive management actions during the first five years after initial project implementation.

SPECIES ACCOUNT

The following list of federally threatened, endangered, or proposed species listed for Maricopa County was obtained from the USFWS, Arizona Ecological Services website and is dated March 8, 2006 (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
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*) –endangered

Plant Species
Arizona agave (*Agave arizonica*) - endangered
Arizona cliffrose (*Purshia subintegra*) - endangered

PLANT SPECIES

There are two listed plant species occur within Maricopa County: Arizona agave (*Agave arizonica*) and Arizona cliffrose (*Purshia subintegra*).

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 Mazatzal 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 1000 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.

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.

WILDLIFE 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*), 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 Gila chub (*Gila intermedia*).

Birds

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). The USFWS announced in the Federal Register on February 16, 2006 the reopening of the comment period on the 1999 proposal to delist the Bald eagle "due to new information related to the nesting management guidelines and the regulatory definition of disturb along with updated population numbers and status information received since the 1999 proposed delisting."

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). A perched bald eagle was observed at a gravel pit in the vicinity of

51st Avenue in February 2003 and one recently reported flying upstream at the Central Avenue Bridge, (Estergard).

There are large areas of open water known to contain fish (tilapia, large mouth bass, carp) throughout the study area. These include gravel pits at 27th and 37th Avenues as well as downstream near 57th and 83rd Avenues. The two upstream pits are known to contain fish and are frequented by herons, egrets and other shorebirds. Although they have been observed wintering here, the dry portion of the Salt River downstream of Granite Reef Dam is not likely suitable foraging habitat for the species.

The proposed restoration features including lake and wetland restoration will increase the potential foraging habitat for bald eagle, providing a beneficial effect. Once mature and established the cottonwood/willow forest may provide more suitable perching locations as well. The may be temporary disturbance during construction associated with the existing open water areas. The project proposes to restore the two gravel pit lakes at 27th and 37th Avenues to a more natural floodplain riparian habitat with a combination of wetland and riparian habitats. Restoration of the large acreage of wetland and riparian habitat within the project should be beneficial to any winter avian visitors foraging along the Salt River. The proposed project may affect but is not likely to adversely affect any potentially existing bald eagles.

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). Although the proposed project will restore riparian habitat significantly increasing the suitable habitat for this species the extent of development and urbanization surrounding the site indicate that this project will have no effect on the cactus ferruginous pygmy-owl. On April 13, 2006 the USFWS announced that it is removing the species from Endangered Species Act protection, effective May 15. The rule was published in the April 14, 2006 Federal Register.

California brown pelican – No effect

The California Brown pelican is considered an uncommon transient in Arizona on many Arizona lakes and rivers. Brown pelican have been observed on Tempe Town Lake but since they are an uncommon transient it can be determined that the proposed action will have no effect on this species.

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 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.

Southwestern willow flycatcher – May affect, not likely to adversely affect

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 salt cedar 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 study area has approximately 130 acres classified as cottonwood/willow and salt cedar habitat. Of that acreage it is estimated that up to 110 acres of salt cedar throughout the area would be removed or thinned to allow restoration of cottonwood/willow and mesquite habitats. The largest existing stand of potentially suitable habitat (73 acres) is at the downstream end of the study area in the vicinity of 83rd Avenue. Additional stand of salt cedar mixed with cottonwood and willow can be found just downstream of 19th

Avenue (30 acres) associated with a settling basin at the aggregate mining operation there. Other strands of mixed cottonwood and willow, salt cedar and various exotics mainly associated with storm water and effluent discharge were located throughout the floodway. Examples of these are shown below in Figures 3-4. However, much of that was washed away during winter 2005 discharges. It can be assumed that without further disturbance those stands of vegetation will return prior to construction.

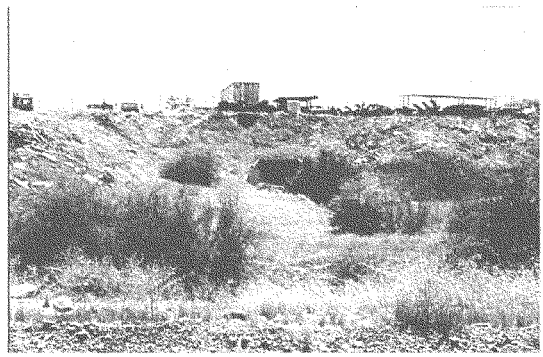


Figure 3. Salt cedar near storm water outfall at 27th Avenue.

Figure 4. Example of floodway vegetation with riparian strand at 67th Avenue, note that this has since been entirely scoured to cobble by 2005 flooding.

The proposed project assumes that up to 110 acres of salt cedar and other exotics will require removal and/or thinning to allow restoration of native cottonwood/willow or mesquite cover types. This does not include the large 70 plus acre stand at 83rd Avenue. Removal of exotics (salt cedar) would be conducted outside the migration/nesting period for Federally listed neo tropical migrants.

While it has been assumed that up to 110 acres may be modified with project construction most were either scoured during 2005 dam releases or have been cleared by private activities in recent months. Remaining stands of vegetation is immature and not tall or dense enough to be potential habitat for willow flycatcher. However, should this habitat change prior to construction, any areas potentially supporting Southwest willow flycatcher habitats will be surveyed according to existing protocols and results coordinated with the Service. If necessary, Formal Section 7 Consultation would be reinitiated at that time.

Although existing cover of salt cedar will be removed with project implementation, the proposed project will increase the cottonwood/willow habitat by approximately 375 acres, creating a significant positive benefit for this species. Due to the proposed increase in cottonwood/willow habitat associated with the restoration the proposed project may affect, but not likely adversely affect the Southwestern willow flycatcher.

Yuma clapper rail – May affect, not likely to adversely affect

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).

Existing wetland habitat with emergent vegetation throughout the project area is ephemeral and scarce, and not likely suitable for the species. Yuma clapper rail is known to be present in wetland marsh habitats downstream of the project area within the Tres Rios Project Area (USACE 2000). If suitable wetland habitat develops in the project area prior to construction surveys will be conducted and Consultation with the Service reinitiated at that time. Restoration of the river channel and associated wetlands (190 acres) throughout the project area will increase the suitable habitat therefore the project may affect, but not likely adversely affect the species.

Mammals

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.

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 1000 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.

Fish

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. (USACE, 2004)

Water within the project area is ephemeral and existing water bodies are associated with aggregate mining, effluent discharge, storm water and agricultural tail waters. There is no suitable habitat within the project area and the project will have no effect on the desert pupfish.

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).

Water within the project area is ephemeral and existing water bodies are associated with aggregate mining, effluent discharge, storm water and agricultural tail waters. Rare releases from upstream dams return flows to this reach of the Salt River but habitat for the species doesn't exist within the area and therefore the project will not effect the Gila topminnow.

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.

Water within the project area is ephemeral and existing water bodies are associated with aggregate mining, effluent discharge, storm water and agricultural tail waters. Rare releases from upstream dams return flows to this reach of the Salt River but habitat for the species doesn't exist within the area and therefore the project will not effect the Razorback sucker.

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).

Since the Gila chub has not been recorded in Maricopa County and its lowest habitat elevation range is approximately 1000 feet above the elevation of the proposed project, it can be determined that there will be no effect on this species.

CONSERVATION MEASURES

1. The estimated construction date for this project is 2010, pending Congressional Authorization and subsequent funding for design and construction. It is assumed that the project area conditions may change by that time. Should new information become available or suitable habitat become established for Southwest willow flycatcher or Yuma clapper rail prior to construction protocol surveys will be conducted and Formal Section 7 Consultation reinitiated as necessary.

2. The Corps will encourage the non Federal sponsor to enter into a Safe Harbor Agreements, Candidate Conservation Plans, or Habitat Conservation Plans for the Rio Salado Oeste project. It is expected that with construction of the Rio Salado and Tres

Rios projects and agreements developed for those projects that an additional agreement for the Rio Salado Oeste project will also be developed.

CONCLUSIONS

Given the rarity of riparian ecosystems within the arid southwest, the proposed project attempted to establish as many acres of native riparian habitat as was practicably feasible, given the limitations of available surface water and current land use. The Proposed Action involves the restoration of approximately 375 acres cottonwood/willow, 417 acres mesquite, 190 acres wetlands including within the river channel, and restoration of 8 miles of river channel made up of 500 acres of active channel and riparian scrub.

Determinations of effect are summarized as follows. The proposed action may affect, but not likely adversely affect the following species:

Bald eagle (*Halieaetus leucocephalus*) – threatened
Yuma clapper rail (*Rallus longirostris yumanensis*) – endangered
Southwestern willow flycatcher (*Empidonax traillii extimus*) – endangered

The proposed action will have no effect on the following species:

Cactus ferruginois pygmy-owl (*Glaucidium brasilianum cactorum*) – endangered
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*) –endangered
Arizona agave (*Agave arizonica*) - endangered
Arizona cliffrose (*Purshia subintegra*) - endangered

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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/SE
02-21-04-I-0137

August 7, 2006

Daniel E. Sulzer
Acting Chief, Planning Division
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2352

Dear Mr. Sulzer:

Thank you for your April 24, 2006, letter requesting consultation under section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531-1544), as amended, for the proposed Rio Salado Oeste Feasibility Study located along the Salt River in Maricopa County, Arizona. We received this letter via electronic mail on July 17, 2006. We have also received the April, 2006, Biological Assessment (BA) and March, 2006, draft Feasibility Report and Environmental Impact Statement (DEIS). Your office has determined that the proposed action may affect, but is not likely to adversely affect these species, as discussed below.

Based on our review of the proposed action and conservation measures, we concur that the Rio Salado Oeste Feasibility Study may affect, but is not likely to adversely affect, the bald eagle Yuma clapper rail, and southwestern willow flycatcher.

Background

We have reviewed the BA, DEIS, our Fish and Wildlife Coordination Act 2(B) Report dated June 20, 2005. The project description is contained in those documents and need not be repeated in this letter. 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 19th Avenue to 83rd Avenue between Buckeye Road and Dobbins Road. The life of the project for which this consultation pertains is five years, beginning with construction and including initial operation and maintenance (O&M). The Corps would turn responsibility for O&M over to the City of Phoenix, the local non-Federal sponsor, after the fifth year following completion of construction.

The following summarizes relevant information on each species:

Yuma clapper rail: Existing wetland habitat with emergent vegetation throughout the project area is ephemeral and scarce, and is unsuitable for the species. If suitable habitat develops in the project area prior to construction, protocol surveys will be conducted and consultation reinitiated, if necessary. Restoration of the river channel and associated wetlands (190 acres) throughout the project area should provide suitable habitat for the Yuma clapper rail in the future.

Southwestern willow flycatcher: The study area has approximately 130 acres classified as cottonwood/willow and salt cedar habitat. While up to 110 acres may be modified with project construction, much of that has already been scoured by flooding in 2005 or cleared by private activities in recent months. Remaining stands of vegetation are largely immature and not tall or dense enough to be suitable habitat for willow flycatcher. However, should habitat become suitable prior to construction, protocol surveys will be conducted and consultation reinitiated if necessary. The proposed project will increase the cottonwood/willow habitat by approximately 375 acres, potentially resulting in the establishment of suitable habitat.

Bald eagle: Bald eagles have been observed foraging and perching within the project area. However, nesting does not occur in the project area and there is a general lack of suitable nesting trees. Restoration of cottonwood/willow gallery forests may eventually provide suitable nesting habitat for bald eagle.

Additionally, the following mitigation and conservations measures have been identified in the BA and DEIS as part of the proposed action. We assume full implementation of these measures.

1. The estimated construction date for this project to commence is 2010, pending Congressional Authorization and subsequent funding for design and construction. Project area conditions may change by that time. Should new information become available or suitable habitat for southwestern willow flycatcher or Yuma clapper rail become established prior to construction commencing, protocol surveys will be conducted and section 7 consultation reinitiated as necessary.

2. The Corps will encourage the non-Federal sponsor to enter into a Safe Harbor Agreement, Candidate Conservation Plan, or Habitat Conservation Plan, as necessary for the continued O&M of the Rio Salado Oeste project. It is expected that, with the development of agreements for the Rio Salado and Tres Rios restoration projects, an additional agreement for the Rio Salado Oeste project will be developed.

3. Prior to ground-disturbing activities in existing riparian or wetland areas, the Corps would consult with the Fish and Wildlife Service and Arizona Game and Fish Department to determine the potential for the occurrence of any sensitive wildlife species. If sensitive species are determined to be present or the have the potential to occur, the schedule for invasive vegetation removal shall be revised to avoid breeding seasons of any sensitive species on site.

4. Sediment removal and other (O&M) activities will only be conducted during non-nesting periods of threatened and endangered species and wildlife of special concern. Sediment removal will be conducted on a rotating basis so that no more than 25 percent of marsh area will be affected in any one year.

Where discretionary agency involvement or control over the action is exercised by the Corps Planning Division, reinitiation of consultation will be 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 reasonably certain to occur.

We appreciate your efforts to protect threatened and endangered species. As a final note, copies of survey protocols and recovery plans for listed species are available from our web page at http://www.fws.gov/arizonaes/. We applaud the Corps and the City of Phoenix for engaging in this habitat restoration effort. We 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) or Debra Bills (x239).

Sincerely,

Debra T. Bills

for Steven L. Spangle
Field Supervisor

cc: Supervisor, Project Evaluation Program, Arizona Game and Fish Department, Phoenix, AZ
Scott Estergard, Planning Branch, U.S. Army Corps of Engineers, Phoenix, AZ

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FINAL

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX C

Cultural Resources and Correspondence

Rio Salado Oeste
Salt River – Phoenix, Arizona

The following are included in this appendix.

- Memorandum for Record and Attachments 1-3 dated August 10, 2005
- Notices to Ak-Chin Community, Gila River Indian Community, The Hopi Tribe, Pascua Yaqui Tribe, Salt River Pima-Maricopa Indian Community, Yavapai-Apache Nation, Tohono O'odham Nation, and Apache Tribe dated July 6, 2005
- Notice to State Historic Preservation Office dated July 6, 2005
- Correspondence received from State Historic Preservation Office dated August 10, 2005
- Correspondence to State Historic Preservation Office dated October 6, 2005
- Correspondence received from State Historic Preservation Office dated November 18, 2005

CESPL-PD-RL (Maxwell) 10 August 2005

MEMORANDUM FOR RECORD

SUBJECT: Reconnaissance survey of selected portions of the Rio Salado Oeste Environmental Restoration Project, conducted by Corps of Engineers staff archeologist, Pamela Maxwell.

1. The proposed project is located along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2).

2. General conditions affecting access and potential level of disturbance of the project area include aggregate mining. Within the 100-year flood plain of the project area there are an estimated 671 acres of sand and gravel mining operations. The river between 19th and 35th Avenues is lined with operations and nearly 100% modified. Again south of the river between 43rd Avenue and 51st Avenue are mining operations which cross the river just downstream of 51st Avenue and extend on the north side to near 63rd Avenue. Two new operations are in the permitting process between 51st and 67th Avenues. It is assumed that the existing mining operations will continue operating until resources and demand dictate that they are no longer feasible in their existing locations.

3. Although storm water runoff is seasonally inconsistent, observations in the study area indicate that there is sufficient runoff to support wetland vegetation. The outfalls recommended for potential wetland restoration, and potential impacts, were selected for field visits as noted below.

4. Field visits were made to the following outfall sites on March 10th and 11th, 2004. Trash and debris occupy significant portions of the outfalls visited. Due to ground surfaces and access, the reconnaissance consisted of varying widths and lengths of informal transects. The size of the areas surveyed varied from site-to-site, and were not measured.

- 19th Avenue NW. Site consists of a concrete culvert with a trash screen situated on the north side of the Salt River channel immediately upstream from the 19th Avenue Bridge. At the time of the site visit, a small amount of flowing water from the outfall supported a stand of cattails immediately below the concrete apron of the outfall. (Attachment 3, Photo 1)

  Surface visibility was good to moderate with ground cover of unidentified grasses. Primarily sandy soil was observed with some areas of gravel and cobbles. No cultural material was observed.

- 19th Avenue SW. Site consists of a concrete culvert with a trash screen, located on the south side of the Salt River channel near 19th Avenue Below the outfall was a small pool of open water approximately. Mesquite, salt cedar and palm trees were observed. (Attachment 3, Photos 2 & 3)

  Surface visibility was poor due to vegetation. The few sandy areas observed contained no cultural material.

- 27th Avenue SE. Site consists of a USGS gauge site (flow and quality) and a largeconcrete culvert with a trash screen located on the south side of the Salt River channelnear 27th Avenue. Minimal standing water was visible at the site. Salt cedar dominated the vegetation. (Attachment 3, Photo 4)

  Visibility was good to moderate with the main soil types of sand and gravel/cobble. No cultural material was observed.

- 35th Avenue NW. Site consists of a cement culvert located on the north side of the Salt River channel, northwest of the 35th Avenue Bridge. At the time of the visit a small pool existed below the outfall structure. Cottonwood, willow, Palm, and Paloverde were present. (Attachment 3, Photos 5 & 6)

  Surface visibility was good to poor, with the dominant soil type of gravel/cobble. No cultural material was observed.

- 43rd Avenue N. Site consists of a concrete culvert flowing into an unlined canal on the north side of the Salt River channel, near 43rd Avenue. At the time of the site visit, both standing and flowing water were visible and flow is routed into a common, large pool of water in the river channel. Cattail, salt cedar sunflower, and several grasses in and around the water were present. 3 Great Egrets, several Snowy Egrets and a Great Blue Heron were also observed. (Attachment 3, Photo 7)

  Surface visibility was good to poor, with soil types including sand and gravel/cobble. No cultural material was observed.

- 51st Avenue NW. Site consists of a concrete culvert without a trash screen on the north side of the Salt River channel near 51st Avenue. A small pond of standing water deep was present directly below the outfall. Cattail, willow, mesquite and sunflower were present. (Attachment 3, Photos 8 & 9)

  Surface visibility was moderate to poor, with soil types primarily of gravel/cobble. No cultural material was observed.

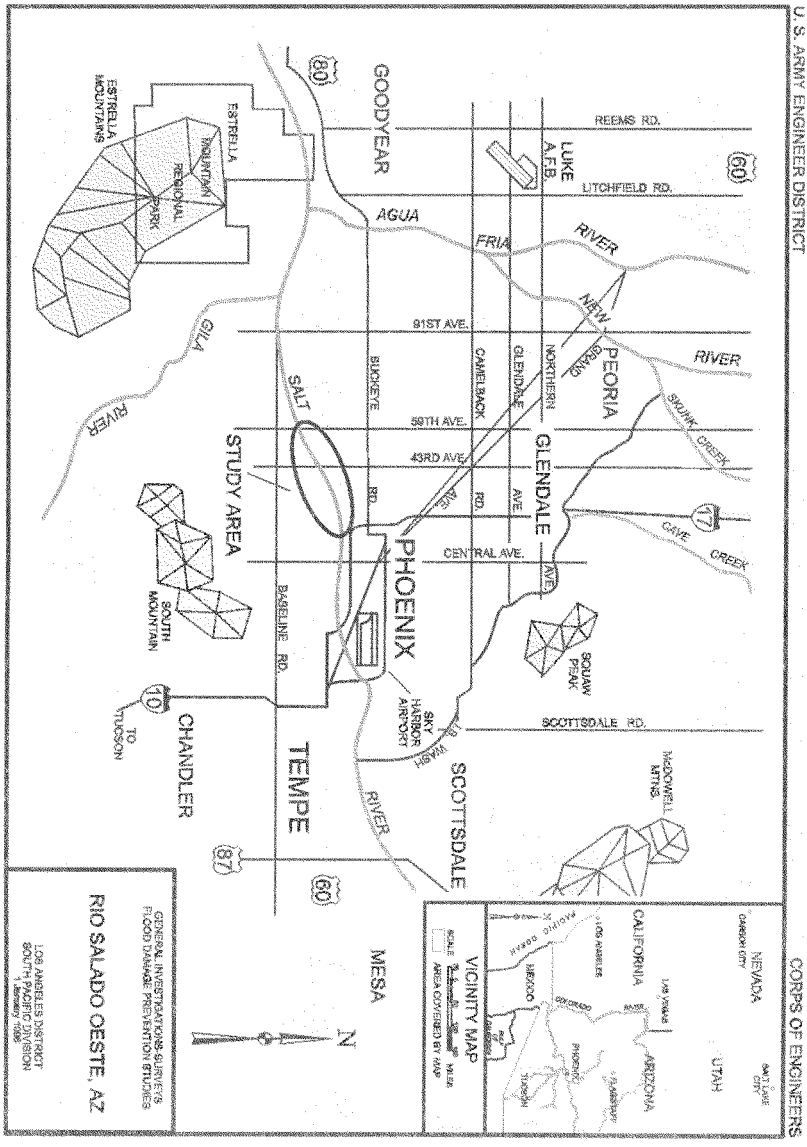
- 67th Avenue N. Site consists of two open, concrete-lined channels leading from concrete culverts on the north side of the Salt River channel near 67th Avenue. Both channels empty into a standing pool of water on the west side of 67th Avenue. Salt cedar and paloverde were present. (Attachment 3, Photos 10, 11 & 12).

  Surface visibility was good to poor, with the sandy/silty soil. No cultural material was observed.

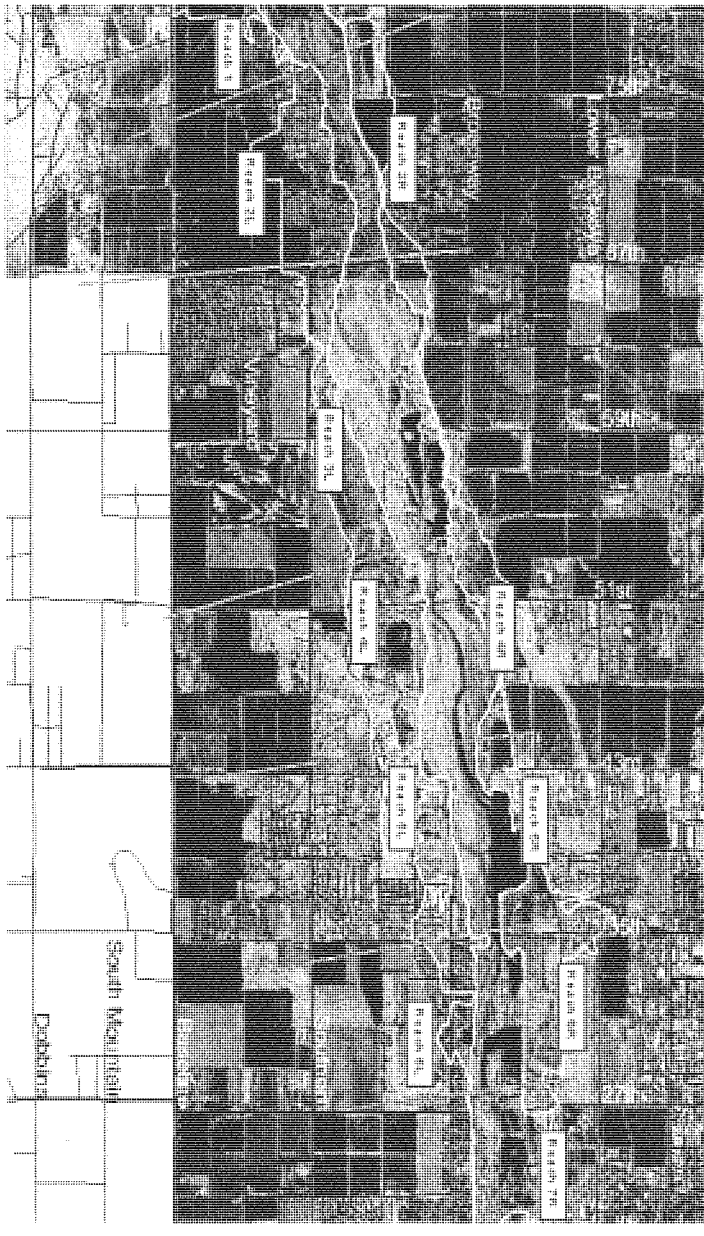
6. The entire length of the Salt River within the Oeste project boundary appears to have been highly disturbed, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping. Based on the level of disturbance, and on what was observed during the survey described here, the Corps believes that the potential for buried archeological resources within the project area is low.

7. Once the preferred project alternative is selected, additional inventory and evaluation efforts may be required. After consideration of potential for buried cultural resources within the project Area of Potential Effect (APE), a determination of effect will be made in consultation with tribes, City of Phoenix, and the Arizona State Historic Preservation Officer.

Pamela J. Maxwell
Staff Archeologist
Environmental Resources Branch
U.S. Army Corps of Engineers, Los Angeles District



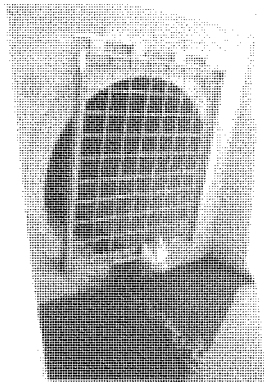
Attachment 1



Attachment 2

Photo 1: North bank west of 19th Avenue

Photos 2 & 3 (left to right):
South bank west of 19th Avenue



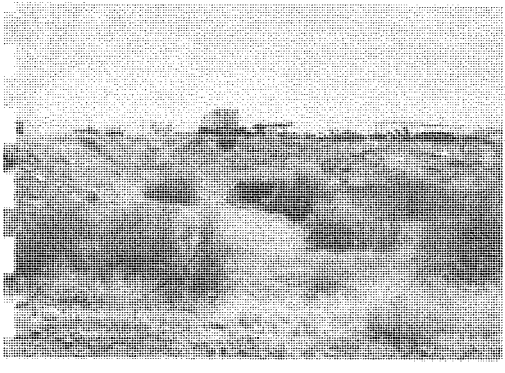
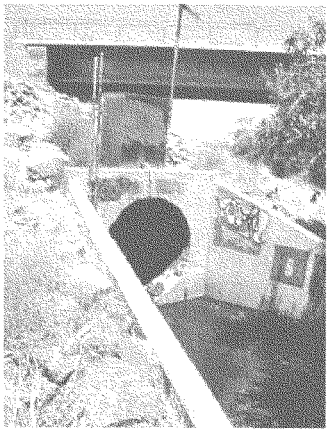
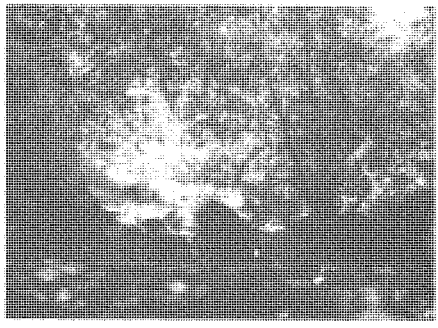


Photo 4: South bank east of 27th Avenue

Attachment 3





Photos 5 & 6 (left and above): North bank west of 35th Avenue

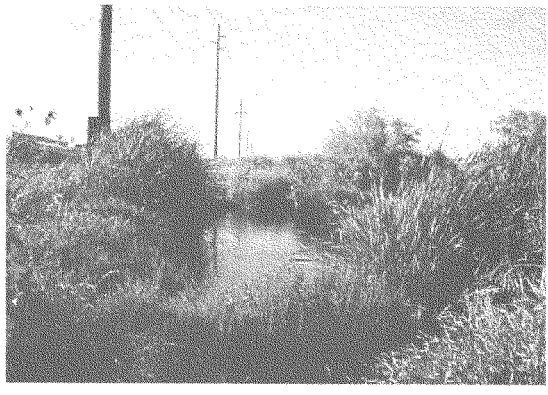
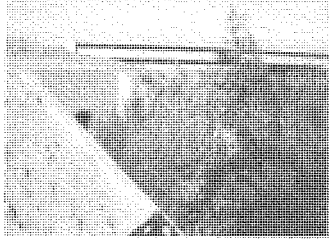
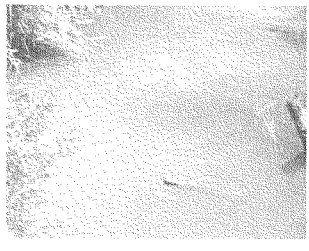


Photo 7: North bank at 43rd Avenue





Photos 8 & 9 (left to right): North bank west of 51st Avenue

Attachment 3

Photo 10: North bank west of 67th Avenue

Photo 11: SRP Avenue Drain: North bank east of 67th Avenue

Photo 12: Both channels above drain into standing pool of water on west side of 67th Avenue.

Attachment 3

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Delia Carlisle, Chair
Ak-Chin Indian Community Council
42507 W. Peters & Nall Rd.
Maricopa, AZ 85239

Dear Ms. Carlisle:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments1and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

An example of one early alternative proposal is illustrated in Attachment 3. Alternatives could include variations of the following:

- Storm water and channel modification
- Storm water, channel modification, water supply, cottonwood, mesquite and invasive species removal
- Storm water, channel modification, water supply, cottonwood, mesquite, invasive species removal and emergent wetlands

- Storm water, channel, water supply, cottonwood, mesquite, invasive species removal, emergent wetlands and lake restoration
- Wetland restoration in lieu of permanent open water and lakes

The Rio Salado Oeste project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction (Attachment 4). The projects are being conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam.

A literature search of the proposed project APE was performed through the Arizona State Museum, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed within the proposed project APE.

A Corps of Engineers survey conducted for the Tres Rios project, beginning at 91st Avenue, just downstream of this project, resulted in the location of the historic St. John's Canal, and a possible Hohokam habitation site. While higher ground is often preferred for habitation sites, farming hamlets and canal maintenance camps may be located in the floodplain. Geoarchaeological investigations were conducted for the Tres Rios project (Onken et al. 2004), which provide a very good reconstruction of the floodplain history just west (downstream) of the Rio Salado Oeste Project, at the junction of the Salt and Agua Fria Rivers with the Gila River. The results of the Tres Rios geomorphological investigation suggest that 94% of that project area has no or low sensitivity for buried prehistoric sites.

Given the Oeste project's location upstream of Tres Rios, it is reasonable to conclude that the alluvial stratigraphy of the lower Salt River might be comparable. The entire length of the Salt River within the Oeste project boundary appears to have been more disturbed than downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys may be conducted as alternatives are refined.

If unanticipated discoveries are made during future investigations, your Nation will be consulted in accordance with 36 CFR 800.13. Per 36 CFR § 800.4(b) and § 800.4(c).

Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Elaine Peters, Director
Nancy Nelson, Cultural Resource Manager
Ak-Chin Him Dak Eco Museum and Archives
47685 N. Eco Museum Rd.
Maricopa, AZ 85239

Dear Ms. Peters:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

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Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Enclosures

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Donald R. Anton, Governor
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85247

Dear Mr. Anton:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

for Ruth B. Villallobos
Chief, Planning Division

Enclosures

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Barnaby V. Lewis, Cultural
Resource Specialist
Gila River Indian Community
Cultural Resources Management Program
P.O. Box 2140
Sacaton, AZ 85247

Dear Mr. Lewis:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

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Sincerely,

for Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Mr. Wayne Taylor, Jr., Chair
The Hopi Tribe
P.O. Box 123
Kykotsmovi, Arizona 86039
Attention: Mr. Leigh Kuwanisiwma

Dear Mr. Taylor, Jr.:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Benito F. Valencia, Chair
Pascua Yaqui Tribe
7474 S Camino de Oeste
Tucson, AZ 85746

Dear Mr. Valencia:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Amalia A.M. Reyes,
Language and Culture Preservation Specialist
Pascua Yaqui Tribe
7474 S Camino de Oeste
Tucson, AZ 85746

Dear Ms. Reyes:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. . Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys may be conducted as alternatives are refined.

If unanticipated discoveries are made during future investigations, your Nation will be consulted in accordance with 36 CFR 800.13. Per 36 CFR § 800.4(b) and § 800.4(c).

Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attacchments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 632711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Ivan Makil, President
Salt River Pima-Maricopa Indian Community
10005 E. Osborn Rd.
Scottsdale, Arizona 85256

Dear Mr. Makil:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

An example of one early alternative proposal is illustrated in Attachment 3. Alternatives could include variations of the following:

- Storm water and channel modification
- Storm water, channel modification, water supply, cottonwood, mesquite and invasive species removal
- Storm water, channel modification, water supply, cottonwood, mesquite, invasive species removal and emergent wetlands

- Storm water, channel, water supply, cottonwood, mesquite, invasive species removal, emergent wetlands and lake restoration
- Wetland restoration in lieu of permanent open water and lakes

The Rio Salado Oeste project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction (Attachment 4). The projects are being conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam.

A literature search of the proposed project APE was performed through the Arizona State Museum, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed within the proposed project APE.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

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Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Gary Gilbert, Cultural Resources Specialist
Cultural and Environmental Services
Salt River Pima-Maricopa Indian Community
10005 E. Osborn Rd.
Scottsdale, Arizona 85256

Dear Mr. Gilbert:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Aaron Russell, Chair
Yavapai-Apache Nation
2400 W. Datsi St.
Camp Verde, AZ 86322

Dear Mr. Russell:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

An example of one early alternative proposal is illustrated in Attachment 3. Alternatives could include variations of the following:

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If unanticipated discoveries are made during future investigations, your Nation will be consulted in accordance with 36 CFR 800.13. Per 36 CFR § 800.4(b) and § 800.4(c).

Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

For Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Katherine Marquez, Director
Yavapai Cultural Program
Tribal Building
P.O. Box 1143
Clarkdale, AZ 86324

Dear Ms. Marquez:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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The Rio Salado Oeste project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction (Attachment 4). The projects are being conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam.

A literature search of the proposed project APE was performed through the Arizona State Museum, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed within the proposed project APE.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

for Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Edward Manuel, Chair
Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634

Dear Mr. Manuel:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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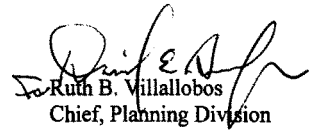
Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,



Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Peter Steere, Program Manager
Cultural Affairs Department
Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634

Dear Mr.Steere:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

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Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

for Ruth B. Villallobos
Chief, Planning Division

Attachments

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

July 6, 2005

REPLY TO
ATTENTION OF:

Office of the Chief
Planning Division

Don Deker, Director
Apache Cultura Program
Camp Verde Tribal Building
2400 W. Datsi St.
Camp Verdi, AZ 86322

Dear Mr. Decker:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

An example of one early alternative proposal is illustrated in Attachment 3. Alternatives could include variations of the following:

- Storm water and channel modification
- Storm water, channel modification, water supply, cottonwood, mesquite and invasive species removal
- Storm water, channel modification, water supply, cottonwood, mesquite, invasive species removal and emergent wetlands

- Storm water, channel, water supply, cottonwood, mesquite, invasive species removal, emergent wetlands and lake restoration
- Wetland restoration in lieu of permanent open water and lakes

The Rio Salado Oeste project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction (Attachment 4). The projects are being conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam.

A literature search of the proposed project APE was performed through the Arizona State Museum, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed within the proposed project APE.

A Corps of Engineers survey conducted for the Tres Rios project, beginning at 91st Avenue, just downstream of this project, resulted in the location of the historic St. John's Canal, and a possible Hohokam habitation site. While higher ground is often preferred for habitation sites, farming hamlets and canal maintenance camps may be located in the floodplain. Geoarchaeological investigations were conducted for the Tres Rios project (Onken et al. 2004), which provide a very good reconstruction of the floodplain history just west (downstream) of the Rio Salado Oeste Project, at the junction of the Salt and Agua Fria Rivers with the Gila River. The results of the Tres Rios geomorphological investigation suggest that 94% of that project area has no or low sensitivity for buried prehistoric sites.

Given the Oeste project's location upstream of Tres Rios, it is reasonable to conclude that the alluvial stratigraphy of the lower Salt River might be comparable. The entire length of the Salt River within the Oeste project boundary appears to have been more disturbed than downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. . Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys may be conducted as alternatives are refined.

If unanticipated discoveries are made during future investigations, your Nation will be consulted in accordance with 36 CFR 800.13. Per 36 CFR § 800.4(b) and § 800.4(c).

Please send correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Attention: Pamela Maxwell (CESPL-PD-RL)
P.O. Box 532711
Los Angeles, CA 90053-2325

If you have any questions or need further information, please call Ms. Pamela Maxwell, Staff Archeologist, at (213) 452-3877.

Sincerely,

Ruth B. Villallobos
Chief, Planning Division

Attachment

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

REPLY TO
ATTENTION OF:

July 6, 2005

Office of the Chief
Planning Division

Mr. James Garrison
State Historic Preservation Officer
Arizona State Parks
1300 West Washington
Phoenix, Arizona 85007

Dear Mr. Garrison:

This letter is in regards the Rio Salado Oeste Study, which is being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Phoenix with cooperation of The Flood Control District of Maricopa County. The purpose of this study is to identify whether there is a Federal interest in implementing a project along the Salt River from 19th to 83rd Avenues in Phoenix (Attachments 1 and 2). This study identifies feasible flood damage reduction and ecosystem restoration alternatives that are technically feasible, economically practicable, sound with respect to environmental considerations, and publicly acceptable. The City of Phoenix, as non Federal sponsor supports the proposed project purpose to provide flood damage reduction, ecosystem restoration, passive recreation, and other related outputs.

The study area is geographically located in Maricopa County, Arizona and entirely within the City of Phoenix. The study area is approximately 8 miles long extending from 19th Avenue on the east to 83rd Avenue on the west and from Lower Buckeye Road on the north to Dobbins Road on the south. The project implementation area extends from 19th Avenue on the east and 83rd Avenue on the west and is the area within the 100-year floodplain of the Salt River. The study area is approximately 4-miles wide and consists of approximately 20,480 acres. The project Area of Potential Effect (APE) is on average approximately 1-mile wide and consists of approximately 3,315 acres.

An example of one early alternative proposal is illustrated in Attachment 3. Alternatives could include variations of the following:

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- Storm water, channel, water supply, cottonwood, mesquite, invasive species removal, emergent wetlands and lake restoration
- Wetland restoration in lieu of permanent open water and lakes

The Rio Salado Oeste project is one of four ecosystem restoration projects that are in various stages of progress, from the planning phase to construction (Attachment 4). The projects are being conducted by the Corps and various local sponsors along the Salt River downstream of Granite Reef Dam.

A literature search of the proposed project APE was performed through the Arizona State Museum, the City of Phoenix, and Corps of Engineers files. This search indicated that archeologists had never surveyed within the proposed project APE.

A Corps of Engineers survey conducted for the Tres Rios project, beginning at 91st Avenue, just downstream of this project, resulted in the location of the historic St. John's Canal, and a possible Hohokam habitation site. While higher ground is often preferred for habitation sites, farming hamlets and canal maintenance camps may be located in the floodplain. Geoarchaeological investigations were conducted for the Tres Rios project (Onken et al. 2004), which provide a very good reconstruction of the floodplain history just west (downstream) of the Rio Salado Oeste Project, at the junction of the Salt and Agua Fria Rivers with the Gila River. The results of the Tres Rios geomorphological investigation suggest that 94% of that project area has no or low sensitivity for buried prehistoric sites.

Given the Oeste project's location upstream of Tres Rios, it is reasonable to conclude that the alluvial stratigraphy of the lower Salt River might be comparable. The entire length of the Salt River within the Oeste project boundary appears to have been more disturbed than downstream, and has been modified through natural scouring action of periodic flooding, sand and gravel mining, and dumping.

Surveys of selected portions of the river, at all outfalls and adjacent or nearest terrace, were conducted by a Corps of Engineers staff archeologist. No cultural material was observed at any of these areas. The effects of the above mentioned impacts on the river are evident at the outfalls and surrounding areas. Based on the reconnaissance survey, level of disturbance, and data provided by the Tres Rios geological assessment, the Corps believes that the potential for buried archeological resources within the project area is low. Additional surveys may be conducted as alternatives are refined.

Invitations to comment on the project were sent with the project description and including a request for comment to the Ak-Chin Indian Community, Hopi, Pascua Yaqui Tribe, Salt River Pima-Maricopa Indian Community, Gila River Indian Community, Tohono O'odham Nation, Yavapai Cultural Program, and the Apache Cultural Program.

We request that this submittal be considered as an expedited consultation under 36 CFR 800.3(g). We look forward to your response within thirty days.

Please send Correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Ms. Ruth B. Villalobos
Chief, Planning Division
Attention: (CESPL-PD-RL, Maxwell)
P.O. Box 532711
Los Angeles, CA 90053-2325

Questions regarding this evaluation may be referred to Pamela Maxwell, Staff Archeologist, at (213) 452-3877, or via email at pamela.j.maxwell@usace.army.mil.

Sincerely,

Ruth B. Villalobos
Chief, Planning Division

Attachments

"Managing and conserving natural, cultural, and recreational resources"

Arizona State Parks

In reply refer to SHPO-2005-1527
More information requested

August 10, 2005

Ruth B. Villalobos
Chief, Planning Division
U.S. Army Corps of Engineers
P. O. Box 532711
Los Angeles, CA 90053-2325

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Arizona State Parks
1300 W. Washington
Phoenix, AZ 85007

Tel & TTY: 602.542.4174
www.azstateparks.com

800.285.3703 from
(520 & 928) area codes

General Fax:
602.542.4180

Director's Office Fax:
602.542.4188

Attention: Pamela Maxwell, Archaeologist

RE: Rio Salado Oeste Flood Damage Reduction and Ecosystem Restoration Study; Phoenix, AZ; DOD-Corps
SHPO-2005-1527 (24780)

Dear Ms. Villalobos:

Thank you for consulting with our office pursuant to 36 CFR 800 regarding the above referenced proposed federal undertaking.

Based in the information provided in your letter, we agree that intact cultural resources are unlikely to occur within the area of potential effect (i.e., outfalls and adjacent or nearest terraces) because of heavy ground disturbance by periodic flooding, sand and gravel mining, and modern dumping activities. However, you need to provide supporting documentation of the survey referred to in your letter to demonstrate the Corps' efforts to locate historic properties pursuant to 36 CFR 800.4(b)(1) and in order to arrive at a justified finding of effect for the undertaking.

Please inform us about the results of your consultation with Native Americans.

We look forward to continuing to consult on the undertaking, and appreciate your continuing cooperation with our office in complying with the requirements of historic preservation.

Sincerely,

Jo Anne Medley
Compliance Specialist/Archaeologist
State Historic Preservation Office

RECEIVED
AUG 23 2005
PLANNING DIVISION

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P.O BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

October 6, 2005

REPLY TO
ATTENTION OF:
Office of the Chief
Planning Division

Mr. James Garrison
State Historic Preservation Officer
Arizona State Parks
1300 West Washington
Phoenix, Arizona 85007

Dear Mr. Garrison:

Thank you for your letter of August 10, 2005 regarding the Rio Salado Oeste Study (Ref. SHPO-2005-1527. As requested, we have enclosed a Memorandum for Record (MFR) documenting the reconnaissance survey conducted in March 2004.

Copies of the MFR were also sent to the Ak-Chin Indian Community, Hopi, Pascua Yaqui Tribe, Salt River Pima-Maricopa Indian Community, Gila River Indian Community, Tohono O'odham Nation, Yavapai Cultural Program, and the Apache Cultural Program. The Corps has not yet had any response from our initial letter.

Once the preferred project alternative is selected, additional inventory and evaluation efforts may be required. After consideration of potential for buried cultural resources within the project Area of Potential Effect (APE), a determination of effect will be made in consultation with your office, tribes, and the City of Phoenix.

Please send Correspondence to:

U.S. Army Corps of Engineers
Los Angeles District
Ms. Ruth B. Villalobos, Chief
Planning Division
Attention: (CESPL-PD-RL, Maxwell)
P.O. Box 532711
Los Angeles, CA 90053-2325

Questions regarding this evaluation may be referred to Pamela Maxwell, Staff Archeologist, at (213) 452-3877, or via email at pamela.j.maxwell@usace.army.mil.

Sincerely,

For Ruth B. Villalobos,
Chief Planning Division

Enclosure

"Managing and conserving natural, cultural, and recreational resources"

Arizona State Parks

In reply refer to SHPO-2005-1527
General Comments

November 18, 2005

Ruth B. Villalobos
Chief, Planning Division
U.S. Army Corps of Engineers
P. O. Box 532711
Los Angeles, CA 90053-2325

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www.azstateparks.com

800.285.3703 from
(520 & 928) area codes

General Fax:
602.542.4180

Director's Office Fax:
602.542.4188

RE: Memorandum of Record for Rio Salado Oeste Flood Damage Reduction and Ecosystem Restoration Study; Phoenix, AZ; DOD-Corps
SHPO-2005-1527 (25925)

Dear Ms. Villalobos:

Thank you for continuing to consult with our office pursuant to 36 CFR 800 regarding the above referenced proposed federal undertaking.

Thank you for the Memorandum of Record presenting the results of a reconnaissance survey of selected portions of the proposed project and that document the Corps efforts to locate historic properties. No significant properties were recorded by the survey.

We understand that no Indian Tribes had responded to your initial consultation letter.

We look forward to continuing to consult once the preferred project alternative is chosen. and appreciate your continuing cooperation with our office in complying with the requirements of historic preservation.

Sincerely,

Jo Anne Medley
Compliance Specialist/Archaeologist
State Historic Preservation Office

Cc: Pamela Maxwell, Staff Archaeologist

FINAL

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX D

RECORD OF NON APPLICABILITY (RONA) ASSUMPTIONS FOR AIR QUALITY ANALYSIS

Rio Salado Oeste
Salt River – Phoenix, Arizona

RIO SALADO OESTE APPENDIX D

AIR QUALITY ASSUMPTIONS USED TO GENERATE AIR EMISSION ESTIMATES FOR THE RIO SALADO OESTE PROJECT

The following assumptions were used to estimate emissions associated with Rio Salado Oeste Alternative 5A. Detailed assumptions and emission factors for each calculation are presented in the attached tables. To calculate construction and OMRR&R emissions, emission factors developed by EPA's AP-42, Volume 1, Fifth Edition, January 1995, *Compilation of Air Pollutant Emission Factors*, has been used to calculate exhaust and fugitive dust emissions. The U.S. Army Corps of Engineers, Los Angeles District Environmental Resources Branch has coordinated with U.S. Environmental Protection Agency (EPA) staff for source and methodology to be used for air quality analysis. According to the EPA, AP-42 has been adopted by the South Coast Air Quality Management District's (SCAQMD) Air Quality Management Handbook, and was used to calculate emissions. Calculations are also based on earthwork quantity and import fill quantity information provided in the feasibility study. Air quality analysis is performed for each of the following activities: Channel Restoration, Lake Restoration, Revegetation, and Trails/Maintenance Roads. Channel Restoration includes four activities that may occur at the same time – the channel restoration itself, wetland restoration, grade control structure installation, and invasive species removal. The following types of air pollutant emission sources were included in the calculations:

Fugitive Dust Generated by Trucks and Vehicle Transport Activities: Fugitive dust emissions from haul trucks, off road equipment and passenger vehicles on unpaved roads within the construction site 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.

Fugitive Dust Generated by Excavation and Handling of Material: Fugitive dust emissions from excavating, loading, dumping, and spreading of bulk materials during channel excavation and bank stabilization were estimated based on the assumed earthwork volumes, using the EPA's AP-42, *Compilation of Air Pollutant Emission Factors* emission factors for surface mining operations.

Emission Generated by Construction Equipment: Emissions from construction equipment tailpipes were estimated based on the type and quantity of equipment, using recent emission factors for off-road equipment from the EPA's AP-42, *Compilation of Air Pollutant Emission Factors.*

Emission from Passenger Vehicles: Emissions from passenger vehicle traffic associated with the project were based upon the EPA's AP-42, *Compilation of Air Pollutant Emission Factors.*

1) Equipment Used for Calculations

Channel Restoration, Wetlands Restoration (storm water outfalls), Grade Control Structure Installation and Invasive Species Removal will be completed concurrently, with construction distributed evenly over the first two years.

Activity # 1: Channel Restoration – 660,000 cy grading/terracing (330,000 cy/year).

Equipment	Days/Yr	Hours/Day
o 2 Dozers	200	8
o 2 Graders	200	8
o 1 Front End Loader	100	8
o 2 Dump Trucks	200	8

Activity # 2: Wetland Restoration – 170,000 cy grading (85,000 cy/year)

Equipment	Days/Yr	Hours/Day
o 1 Dozer	100	8
o 1 Grader	100	8
o 1 Dump Truck	100	8

Activity # 3: Grade Control Structure – no excavation of material

Equipment	Days/Yr	Hours/Day
o 2 Cement Trucks	60	8

Activity # 4: Invasive Species Removal – 420,000 cy removal (210,000 cy/year)

Equipment	Days/Yr	Hours/Day
o 1 Grader	100	8
o 1 Front End Loader	100	8
o 2 Dump Trucks	100	8, 5 miles to landfill

In addition to the above equipment, each activity would include:

Equipment	Days/Yr	Hours/Day
o 2 Water Trucks	200	6
o 4 Pickup Trucks	200	4

Lake Restoration, with construction distributed evenly over years 3 and 4, after the above tasks have been completed. 3,000,000 cy material cut and fill gravel pits (1,500,000 cy/year).

- Note that haul distance is less than one mile for any movement of material by dump trucks.
- All cut and fill by dozers and graders will be onsite.
- Equipment to be used:

Equipment	Days/Yr	Hours/Day
o 4 Dozers	200	8
o 4 Graders	200	8
o 2 Front End Loaders	200	8
o 4 Dump Trucks	200	8
o 2 Water Trucks	200	6
o 2 Pickup Trucks	200	4

Revegetation, 18 months distributed evenly over years 3 and 4, concurrent with Lake Restoration. Divided 18 months in half, resulting in nine months of Revegetation work each year.

- Equipment to be used:

Equipment	Days/Yr	Hours/Day
o 4 Front End Loaders	150	6
o 4 Backhoes	150	6
o 2 Flatbed Trucks	50	2
o 4 Pickup Trucks	150	8

Trails and Maintenance Roads, year 4 (concurrent with second year of lake restoration). 91,000 cy grading/terracing for one year.

- Equipment to be used:

Equipment	Days/Yr	Hours/Day
o 1 Grader	100	8
o 1 Front End Loader	100	8
o 2 Dump Trucks	100	8
o 1 Paver	100	8

• Earth not removed off-site is redistributed locally
• Haul trucks for transporting the removed invasive species would travel for approximately one mile (two miles round trip) on the project site before reaching paved roads to transport the removed dirt.

• The mean transport truck weight in the calculations was 10 tons.
• Each piece of on-site construction equipment would generate two worker vehicle round-trips per day, and each construction worker round trip was 40 miles (20 miles one way).
• Construction, depending on Task, would occur between 100 to 300 working days per year.

2) Grading/Earthmoving – Fugitive Dust

Table 11.9-4 of the EPA's *Air Pollution Emission Factors*, AP-42 gives the emission factor of 0.058 lbs TSP (total suspended particulate) per ton of earth removed. The soil in the project area was assumed to have a density of 100-lbs/cubic foot (Chemical Engineer's Handbook, 5th Edition, 1973, p.3-90). PM-10 was assumed to be 0.6*TSP. This was taken from "Assessing Chronic Health Risks from Stationary Source Emissions in Volgograd, Russia: A Case Study in Quantitative Health Risk Assessment", September 1997, The Volgograd Health Risk Assessment Working Group and President and Fellows of Harvard College. This paper cited the PM-10 to TSP ratio of 0.6 as given by a report titled: "Particles in our air: concentrations and health effects" (Wilson and Spengler, 1996, Harvard School of Public Health, Harvard University Press). This yields 0.04698 lbs of PM-10 per cubic-yard of earth removed. The yearly amount of PM-10 generated for all tasks for Alternative 5a is as follows:

Grading/Earthmoving – Fugitive Dust	cy/yr excavated	PM-10 lbs/yr	PM-10 tons/yr
Channel Restoration	330,000	15503.4	7.75
Wetland Restoration	85,000	3993.3	1.99
Invasive Species Removal	210,000	9865.8	4.93
Lake Restoration	1,500,000	70470	35.24
Trails and Maintenance	91,000	4275.18	2.14

3) Grading/Earthmoving – Equipment Emissions

The predominant construction equipment would involve grading/earthmoving machinery. It was assumed that grading would take place over 100 to 300 working days/year, and the total work would be averaged over the specified construction periods to determine how much earth would be moved each year and each day. It is also assumed that Alternative 5A would use two water trucks. Emissions from haul trucks are discussed separately below.

Emissions for equipment were obtained from the SCAQMD CEQA Handbook 2007 Emissions, Table A9-8-A, and are listed below in **lbs per hour**:

Emission Factors (lb/hr)	CO	VOC	N0x	S0x	PM-10
Front-End Wheeled Loader	0.572	0.23	1.9	0.182	0.17
Dump Truck	1.8	0.19	4.17	0.45	0.26
Dozer	0.01	0.002	0.021	0.002	0.0005
Grader	0.151	0.0039	0.713	0.086	0.061
Back-hoe loader	0.015	0.003	0.022	0.002	0.001
Water Tank	0.008	0.005	0.017	0.002	0.0015
Paver	0.01	0.002	0.024	0.002	0.001
Pickup Truck	1.8	0.19	4.17	0.45	0.26

The emissions above were multiplied by the number of pieces of equipment, then converted from lbs to tons. Emissions in tons per year, assuming 8-hour working day, and 100-300 days per year of use, with the equipment quantities provided above, are as follows:

EQUIPMENT EMISSION TOTALS

Channel Restoration Total On Site Emissions

Tons/Year	CO	VOC	N0x	S0x	PM-10
Channel Restoration	2.65	0.33	6.94	0.75	0.48
Wetland Restoration	1.86	0.19	4.46	0.49	0.28
Grade Control Structure	0.00	0.00	0.10	0.00	0.00
Invasive Species Removal	1.73	0.25	4.38	0.47	0.30

Lake Restoration Total On Site Emissions

	CO	VOC	N0x	S0x	PM-10
Tons/Year	7.19	0.99	18.73	2.01	1.30

Revegetation Total On Site Emissions

	CO	VOC	N0x	S0x	PM-10
Tons/Year	1.40	0.45	4.27	0.42	0.36

Trails and Maintenance Total On Site Emissions

	CO	VOC	N0x	S0x	PM-10
Tons/Year	1.73	0.25	4.39	0.47	0.30

4) Off-site Earth Hauling on Paved Roads – Fugitive Dust

EPA's AP-42, section 13.2.1, March 22, 2006 - Draft:

Emissions = Vehicle Miles Traveled (VMT) x Emissions Factor

Equation 2 from AP-42, section 13.2.1 was used to calculate PM-10 emission factors for three types of roads:

(1) Roads with an ADT between 500 and 5,000;
(2) Roads with an ADT between 5,000 and 10,000; and
(3) Roads with an ADT greater than 10,000.

The emission rates for these road types are:
(1) 0.020555 lbs PM-10/VMT
(2) 0.0091523 lbs PM-10/VMT
(3) 0.005668 lbs PM-10/VMT

It was assumed that the haul trucks would primarily use Interstate 10 for transporting removed dirt. From the ADT figure in this report, most of the roads connecting the project area to the freeway carry at least 5,000-10,000 ADT, although a small amount carry between 500 and 5,000 ADT.

It was assumed that the average distance material would be exported is five miles from the project site, or a round-truck-trip of 10 miles. AP-42 states that six additional miles of road be added to the calculations for each active trackout point (area of trucks leaving the paved dirt road to paved road). It was assumed that trackout points would only be an issue for trucks leaving the project site. Using this information, the roundtrip vehicle miles traveled (per vehicle) were assumed to be as follows:

(1) 500-5,000 ADT roads 1(outbound)+1(trackout)+1(inbound) = 3 miles
(2) 5,000 – 10,000 ADT roads 2(outbound)+2(trackout)+2(inbound) = 6 miles
(3) >10,000 ADT roads 17(outbound)+3(trackout)+17(inbound) = 37 miles

The number of daily trips was calculated for Alternative 5A based on a truck capacity of 20 cy, the one or two year construction periods, and construction taking place 100-300 days each year. The paved-road vehicle miles traveled (VMT), and fugitive dust produced for Alternative 5A is as follows:

Paved Road Fugitive Dust	Daily cy Removed	Total Daily Trips	Daily VMT	Yearly VMT	PM-10 lbs/yr	PM-10 tons/yr
Channel Restoration	1650	41	410	82000	1685.51	0.84
Wetland Restoration	850	43	430	43000	883.87	0.44
Invasive Species Removal	2100	53	572*	57200	523.51	0.26
Lake Restoration	7500	94	188	37600	772.87	0.39
Trails and Maintenance	910	23	46	4600	94.55	0.47
* 6 miles added to VMT calculation to include trackout point						

5) Off-site Earth Hauling on Unpaved Roads – Fugitive Dust

EPA's AP-42, section 13.2.1, March 22, 2006 - Draft:

Emissions = Vehicle Miles Traveled x Emissions Factor

It was assumed that the haul trucks would travel for approximately one mile (two miles round trip) on the project site before reaching paved roads to transport the removed dirt. The Emissions Factor for a Sand/Gravel Plant road (which is the unpaved road type most comparable to the project site) is k(s/12)a(W/3)b([365-P]/365) in lbs PM-10/mile, where W is the mean vehicle weight in tons (assumed 10 tons); s is the silt content (mean of 4.8% for sand and gravel plant road); k, a, and b are constants of 1.5. 0.9. and 0.45, respectively, and P is the mean number of days per year with at least 0.01 inches of precipitation (53 days per NOAA data).

This results in an emissions factor of 0.9663 lbs per vehicle mile traveled. The number of daily trips (as discussed in Part 4 above) was multiplied by a round trip distance of two miles to get the vehicle miles traveled (VMT). The unpaved-road vehicle miles traveled, and fugitive dust produced for Alternative 5A is as follows:

Unpaved Road Fugitive Dust	Daily cy Removed	Total Daily Trips	Daily VMT	Yearly VMT	PM-10 lbs/yr	PM-10 tons/yr
Channel Restoration	1650	41	82	16400	15847.32	7.92
Wetland Restoration	850	43	86	8600	8310.18	4.16
Invasive Species Removal	2100	53	106	10600	10242.78	5.12
Lake Restoration	7500	94	188	37600	36332.88	18.17
Trails and Maintenance	910	23	46	4600	4444.98	2.22

6) Off-site Earth Hauling– Vehicle Emissions

Emissions were obtained from Table A9-5-K-9 from SCAQMD's Air Quality Handbook. Each haul truck-trip was assumed to be 10 miles. The revegetation work does not involve off-site hauling by dump trucks, and is not included in the heavy haul truck analysis below. The vehicle emissions for Alternative 5A in tons/year are as follows:

Channel Restoration Truck Emission Totals

Dump Trucks lbs/day	CO	VOC	N0x	PM-10
Channel Restoration	5.24	0.68	3.60	0.35
Wetland Restoration	4.92	0.64	3.60	0.37
Invasive Species Removal	6.11	0.79	4.45	0.46
Dump Trucks tons/year	**CO**	**VOC**	**N0x**	**PM-10**
Channel Restoration	0.52	0.07	0.36	0.04
Wetland Restoration	0.25	0.03	0.18	0.02
Invasive Species Removal	0.31	0.04	0.22	0.02

Lake Restoration Truck Emission Totals

Dump Trucks lbs/day	CO	VOC	N0x	PM-10
	3.03	0.45	1.81	0.16
Dump Trucks tons/year	**CO**	**VOC**	**N0x**	**PM-10**
	0.30	0.04	0.18	0.02

Trails and Maintenance Truck Emission Totals

Dump Trucks lbs/day	CO	VOC	N0x	PM-10
	0.79	0.12	0.44	0.04
Dump Trucks tons/year	**CO**	**VOC**	**N0x**	**PM-10**
	0.04	0.01	0.02	0.00

7) Construction Worker Travel

Emissions were obtained from SCAQMD's Air Quality Management Handbook. Factors for passenger vehicles from Table A9-5-J-9 were used to estimate pollutant emissions from construction workers' travel.

It was assumed that each piece of on-site construction equipment would generate two worker vehicle round-trips per day. This number was used to account for non-operator personnel, commuting, and off-site lunch trips. It was also assumed that each construction worker round-trip was 20 miles for the duration of construction. With these VMT/year figures, Alternative 5A would produce the following emissions in tons/year:

Channel Restoration

Worker Commute lbs/day	**CO**	**VOC**	**N0x**	**PM-10**
Channel Restoration	1.84	0.09	0.10	0.02
Wetland Restoration	1.36	0.06	0.08	0.02
Grade Control Structure	1.24	0.06	0.08	0.02
Invasive Species Removal	1.48	0.07	0.08	0.02
Worker Commute tons/yr	**CO**	**VOC**	**N0x**	**PM-10**
Channel Restoration	0.18	0.01	0.01	0.00
Wetland Restoration	0.07	0.00	0.00	0.00
Grade Control Structure	0.04	0.00	0.00	0.00
Invasive Species Removal	0.07	0.00	0.00	0.00

Lake Restoration

Worker Commute lbs/day	**CO**	**VOC**	**N0x**	**PM-10**
	2.91	0.14	0.14	0.02
Worker Commute tons/yr	**CO**	**VOC**	**N0x**	**PM-10**
	0.29	0.01	0.01	0.00

Revegetation Restoration

Worker Commute tons/yr	**CO**	**VOC**	**N0x**	**PM-10**
	0.15	0.01	0.01	0.00

Trails and Maintenance

Worker Commute tons/yr	**CO**	**VOC**	**N0x**	**PM-10**
	0.04	0.00	0.00	0.00

8) Load Dumping – Fugitive Dust

Table 11.9-4 of the EPA's *Compilation of Air Pollutant Emission Factors*, AP-42 gives the emission factor of 0.002 lbs TSP (total suspended particulate) per ton of "overburden" generated by bottom dump truck unloading. This emission factor was assumed to be similar to the TSP generated by dumping the excavated project soil. As discussed in Part 1 above, PM-10 was assumed to be 0.6* TSP, and the soil in the project area was assumed to have a density of 100-lbs/cubic foot. This yields 0.00162 lbs of PM-10 per cubic-yard of earth dumped. The yearly amount of PM-10 generated by dumping for Alternative 5A is as follows:

Total Fugitive Dust	PM-10 lbs/yr	PM-10 tons/yr
Channel Restoration	33570.83	16.78
Wetland Restoration	13325.05	6.66
Invasive Species Removal	20972.29	10.48
Lake Restoration	110005.75	55.02
Trails and Maintenance	8962.13	4.90

9) Total Tons/Year for All Construction Tasks

Table D-1. Total Emissions Generated By Activity

Channel Restoration Total Emissions

Tons/Year	CO	VOC	NOx	SOx	PM-10
Channel Restoration	3.35	0.41	7.31	0.75	17.30
Wetland Restoration	2.18	0.23	4.65	0.49	6.97
Grade Control Structure	0.06	0.00	0.01	0.00	0.00
Invasive Species Removal	1.83	0.25	4.39	0.47	10.79
Federal Standard (tons/yr)	**100**	**100**	**100**	**100**	**70**

Lake Restoration Total Emissions

	CO	VOC	NOx	SOx	PM-10
Tons/year	8.07	1.10	19.11	2.01	56.34
Federal Standard (tons/yr)	**100**	**100**	**100**	**100**	**70**

Revegetation Total Emissions

	CO	VOC	NOx	SOx	PM-10
Tons/Year	1.59	0.46	4.28	0.42	0.36
Federal Standard (tons/yr)	**100**	**100**	**100**	**100**	**70**

Trails and Maintenance Total Emissions

	CO	VOC	NOx	SOx	PM-10
Tons/Year	1.82	0.25	4.42	0.47	4.78
Federal Standard (tons/yr)	**100**	**100**	**100**	**100**	**70**

As identified in Table D-1, total emissions generated for each pollutant (CO, VOC, NOx, SOx and PM-10) by the implementation of Alternative 5A are below the federal thresholds for preparation of a Conformity Determination. Therefore, Conformity Determination Analysis is not required and to summarize compliance with Section 176(c) of the Clean Air Act, A Record of Non Applicability (RONA) has been prepared.

RECORD OF NON-APPLICABILITY
FOR
RIO SALADO OESTE RESTORATION PROJECT
MARICOPA COUNTY, ARIZONA

The Rio Salado Oeste Project – Final Environmental Impact Statement was completed in September, 2006. The proposed project would include the modification of existing storm-water outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th Avenue to 83rd Avenue. No additional water source is included in this alternative other than temporary irrigation to establish vegetation. The alternative also adds supplemental water supply in the form of effluent. It includes restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue. At locations identified as suitable throughout the project area, cottonwood/willow and mesquite cover types will be restored. The alternative also addresses the management, control and removal of invasive species within the study area and includes regrading of the existing gravel pits to restore them to the floodplain and restoring emergent wetland and riparian areas.

The Clean Air Act (CAA) as amended in 1990, Section 176(c), specifies that no department, agency, or instrumentality of the Federal Government shall engage in, support in any way, or provide financial assistance for, license or permit, or approve, any activity which does not conform to a State Implementation Plan (SIP). Conformity is defined in Section 176 (c) of the CAA and requires that federal actions conform to the implementation plan purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards (NAAQS) while achieving expeditious attainment of such standards. Specifically, federal actions cannot:

1. Cause or contribute to any new violation of any standard in any area; or
2. Increase the frequency or severity of any existing violation of any standard in any area; or
3. Delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

Air quality impacts of each alternative considered at Rio Salado Oeste project fall under both federal and state conformity regulation. In Arizona, the federal conformity regulation in 40 CFR Part 93, Subpart B has been adopted by reference in the Arizona Administrative Code, Section R18-2-1438.

Conformity regulations ensure that federal actions conform to the local SIP. The Arizona SIP include programs to address air pollution in the areas of the state which do not meet the federal health standards and those which have successfully reduced emissions to levels that meet the health standards (Maintenance Areas). In those areas, federal projects which will have emissions above the regulatory thresholds are subject to the conformity requirements. The Maricopa County Area is currently classified as Non-attainment for PM-10 and the 8- hour Ozone standard. In addition, the area was reclassified as a Maintenance Area for the Carbon Monoxide Standard in 2004. Table D-2 below summarizes the current air quality attainment status for the Maricopa County Area, as well as the conformity thresholds.

Table D-2. Attainment Status and Conformity Thresholds

December 2005 Maricopa County Area, Arizona			
Pollutant	Attainment Status	Federal Register Citation	Conformity Threshold
Carbon Monoxide	Maintenance Area	70 FR 11553 March 9, 2005	100 tons/yr
Ozone: VOC & NOx	**8-hr Standard** Basic Nonattainment Area	69 FR 23858 April 30, 2004	VOC: 100 tons/yr. NOx: 100 tons/yr
PM-10	Serious Nonattainment Area	June 10, 1996 (61 FR 21372)	70 tons/yr
PM-2.5	Attainment Area	70 FR 944 January 5, 2005	N/A

Estimation of air quality impacts was performed based upon EPA Guidance Document AP-42 *Compilation of Air Pollutant Emission Factors.* Calculations in this appendix show that emissions are below the federal/state conformity thresholds. Based on the air quality analysis described in this Final EIS, it has been determined that the proposed project is exempt from demonstrating conformity with State Implementation Plans. The total emissions of each applicable criteria pollutant are below *de minimus* levels as prescribed in 40 CFR 93.153(b). As a result, this project conforms to the State Implementation Plan and the Federal Clean Air Act as amended 1990.

A Record of Non-Applicability has been prepared instead of a Conformity Determination because the direct and indirect emissions do not equal or exceed the federal *de minimus* levels or the state threshold levels, which is more stringent. Therefore, the project is in conformity with the applicable State Implementation Plan

For further information, please contact Mr. Michael Fink, Environmental Coordinator, U. S. Army Corps of Engineers, Los Angeles District, at (602) 640-2001 ext. 232.

9.25.06

DATE

Alex C. Dornstauder
Colonel, US Army
District Engineer

FINAL

ENVIRONMENTAL IMPACT STATEMENT

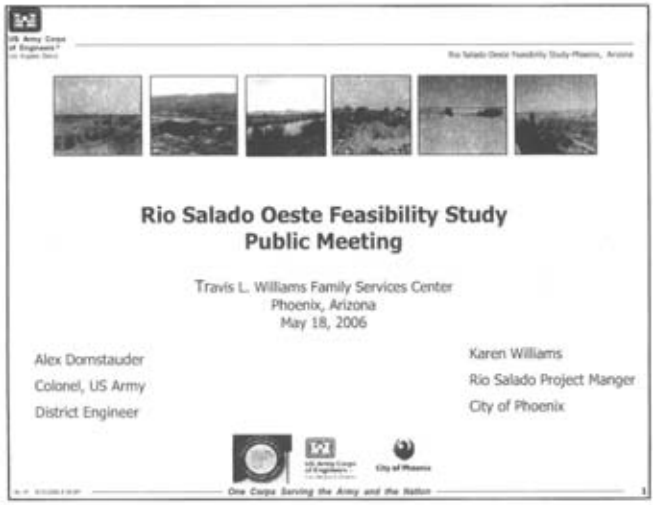
APPENDIX E

Draft EIS Public Hearing, Comments & Responses

Rio Salado Oeste
Salt River – Phoenix, Arizona

The following are included in this appendix.

- Public Meeting, May 18, 2006 Powerpoint
- Rio Salado Oeste Public Hearing Minutes, Dated May 18, 2006
- Rio Salado Oeste Hearing Notecard Comment and Response
- Letters of Support
- Tribal, Agency and Stakeholder Comment Letters and Responses


US Army Corps of Engineers
Rio Salado Oeste Feasibility Study-Phoenix, Arizona
Rio Salado Oeste Feasibility Study
Public Meeting
Travis L. Williams Family Services Center
Phoenix, Arizona
May 18, 2006
Alex Dornstauder
Colonel, US Army
District Engineer
Karen Williams
Rio Salado Project Manger
City of Phoenix
City of Phoenix
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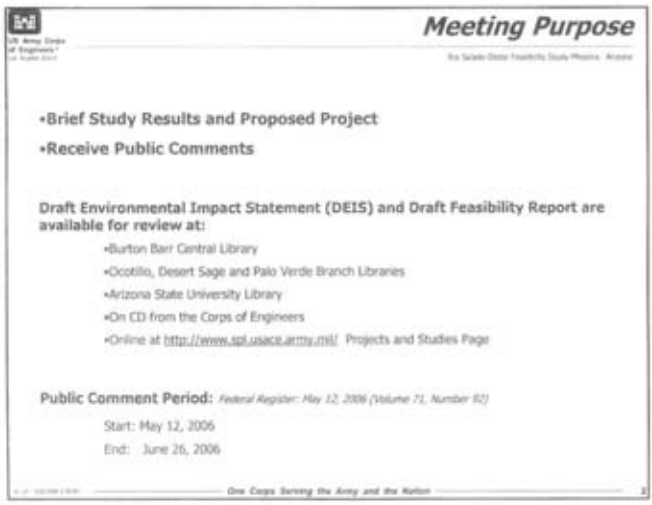
US Army Corps of Engineers
Meeting Purpose
Rio Salado Oeste Feasibility Study-Phoenix, Arizona
•Brief Study Results and Proposed Project
•Receive Public Comments
Draft Environmental Impact Statement (DEIS) and Draft Feasibility Report are available for review at:
•Burton Barr Central Library
•Ocotillo, Desert Sage and Palo Verde Branch Libraries
•Arizona State University Library
•On CD from the Corps of Engineers
•Online at http://www.spl.usace.army.mil/ Projects and Studies Page
Public Comment Period: Federal Register: May 12, 2006 (Volume 71, Number 92)
Start: May 12, 2006
End: June 26, 2006
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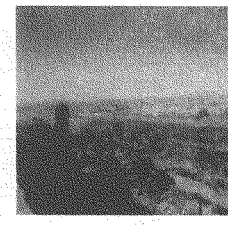
Study Authority and Process

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Study Authority: HR 2425 "*...review reports... In the interest of flood damage reduction, environmental protection and restoration, and related purposes.*"



Study Process

- Identify problems and opportunities.
- Identify baseline, or "without-project" conditions.
- Develop an array of alternatives to address problems and opportunities.
- Evaluate and compare alternatives.
- Receive public input.
- Complete Environmental Impact Statement per National Environmental Policy Act (NEPA) guidelines.
- Select plan for recommendation in compliance with Federal, State, and local policies and regulations.

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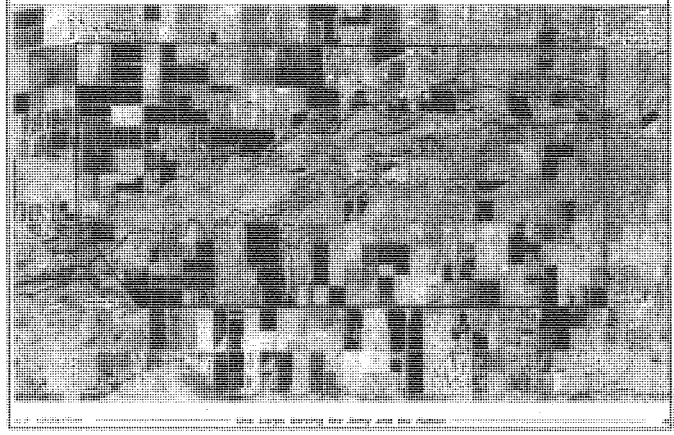
Study Area



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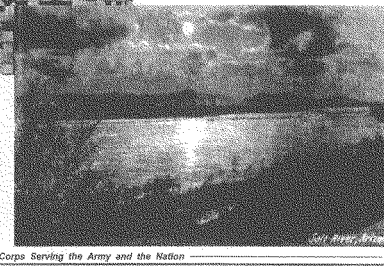
Historic Conditions

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- Perennial stream
- Shallow groundwater
- Meandering channel
- Emergent wetlands
- Cottonwood, willow and mesquite



1890's near 51st Ave

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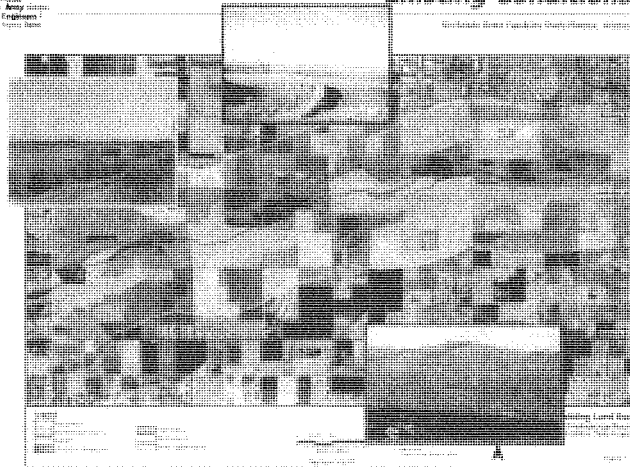
Existing Conditions



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Future Without Project Assumptions

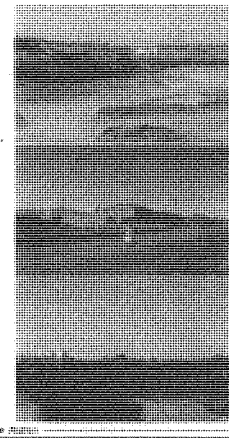
Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Land Use

- Aggregate operations will move West
- All adjacent Ag land will be residential within 5 yrs.
- Recreation needs increase

Habitat

- Surface water reduced
- 2/3 reduction in cottonwood/willow (<100 ac.)
- Slight reduction in wetlands (<30 ac.)



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Study Objectives

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- Restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish and wildlife species.
- Improve passive recreation and environmental education opportunities within the study area.
- Reduce flood damages to infrastructure and structures.

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Planning Constraints

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- Avoid contaminants/landfills
- Recognize land ownership
- Compatibility with bridges/highways
- Compliance with airport restrictions (not an issue)
- Incorporate vector control into operation and maintenance
- Maintain level of flood protection
- Prevent damage to project from flood flows
- Compatible with sand and gravel mining
- Meet water conservation requirements
- Maintain public support

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Ecosystem Restoration Assumptions

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- WATER SUPPLY
  - 23rd Ave. Effluent (9,000 af/year)
  - Storm water harvesting (2,800 af/year)
  - Low flow channel
  - Recovery well
- MINIMIZE O&M REQUIREMENTS
  - Increase sustainability by restoring river functions
  - Consider "ideal" floodplain habitat
  - Avoid large expenditures in frequently inundated locations (10-year)
- PRIORITY HABITATS
  - Cottonwood/willow
  - Mesquite
  - Emergent wetlands
  - Open water

"Restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition"

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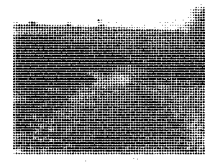
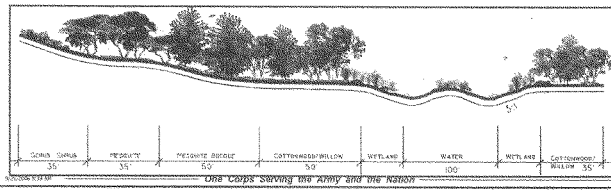
Restoration Measures

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- Revegetation
- Water Supply/Distribution
- River Channel Restoration
- Invasive Species Control
- Gravel Pit (Lake) Restoration



Initial set of 20 Alternatives Considered



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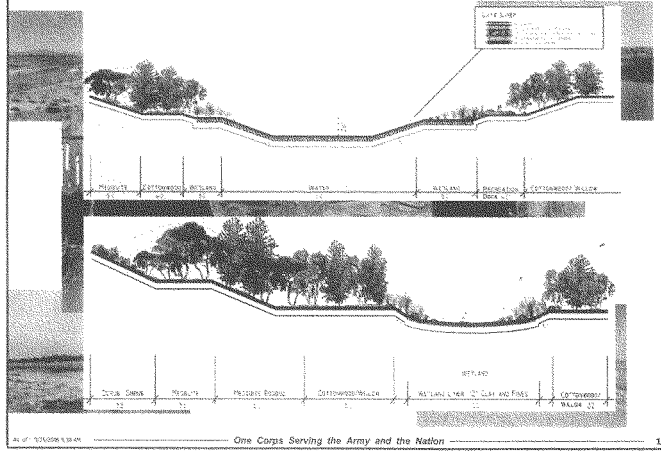
Features of Alternatives

Rio Salado Oeste Feasibility Study-Phoenix, Arizona



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Alternatives

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Riparian Habitat Restored (acres)

	Cottonwood Willow	Mesquite	Emergent Wetland	Shrub	Open water	Functional Capacity Units
No Action	-	-	-	-	-	- 580
2	66	43	45	430	0	631
4	348	409	67	228	0	745
5	375	417	110	388	40	820
5A	375	417	190	352	0	847
5B	375	417	136	348	20	833

Note: All include ~170 acres of restored channel

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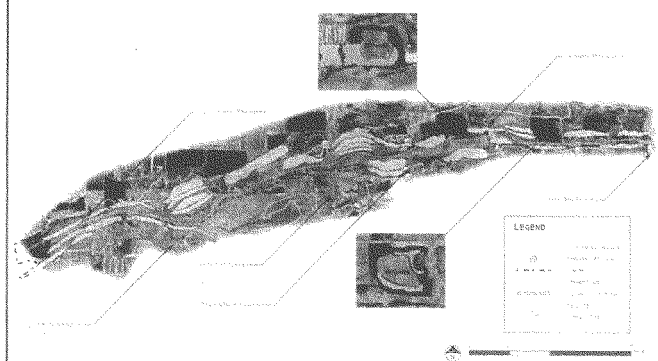
Tentatively Recommended Plan

Rio Salado Oeste Feasibility Study-Phoenix, Arizona



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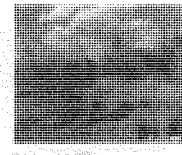
Tentatively Recommended Alternative

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Acres Restored with Alternative 5A

Cottonwood/Willow:	375
Mesquite:	417
Wetlands:	156
Channel Restoration	
Emergent wetlands:	34
Riparian Scrub:	296
Scrub shrub:	56



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Estimated Plan 5A Costs

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Item	Cost ($)
Construction & Real Estate	133,460,000
PED/EDC at 11%	8,532,000
Construction Mgmt at 6.5%	5,596,000
Monitoring & Adaptive Mgmt	3,667,000
Total First Cost	**151,254,000**
Operation and Maintenance	2,080,000
Annual Water Cost	817,000

Cost Share

Federal 65%: $98,000,000
Local 35%*: $53,000,000

** includes Real Estate*

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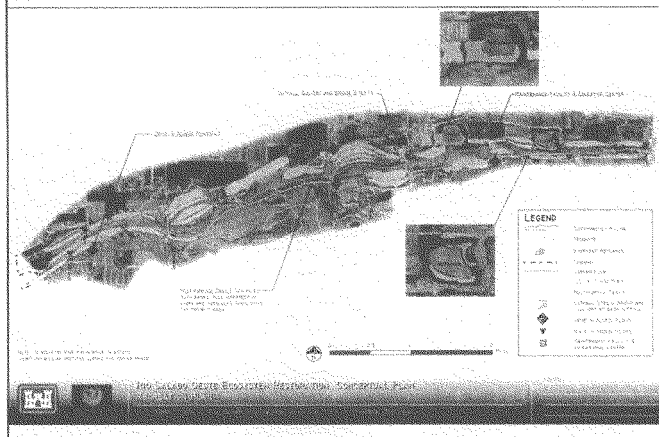
Recreation Plan

Rio Salado Oeste Feasibility Study-Phoenix, Arizona



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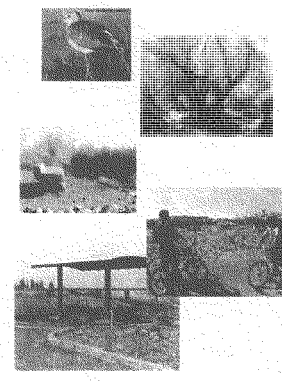
Recreation Plan Costs

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

50/50 Cost Share
$6,263,204 Each

Site Preparation
Parking Lots (500 Spaces)
Entry Roads
Sidewalks & Ramps
Multi-Use Trails
Bridges & Culverts
Minor Access Points
Access Control
Security Lighting
Signage
Picnic/Trail Shelters
Restroom Facilities
Utilities
Park Furniture
Interpretive Guidance Media



Flood Damage Reduction

Estimated flood damages through study area

- $247,000 expected annual damages
- 65% industrial area at 35th Avenue
- Most residential properties outside 100 yr. floodplain

Considered structural and non structural solutions

- Levee, channel, floodwall, relocation

Results

- Costs significantly exceed benefits
- Dropped from further consideration
- Incidental flood damage reduction with channel restoration (not quantified)

Environmental Impacts

Impacts

Temporary construction impacts

water quality, air quality, noise, aesthetics, vegetation

Long term benefits

vegetation, fish and wildlife, water quality, air quality, aesthetics

Outstanding Actions

Public and agency comments

Section 7 Consultation

Clean Water Act

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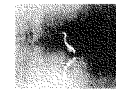
Los Angeles District

Summary

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

- 50% Increase in ecosystem function
- Riparian habitat increased
- Benefit local and migratory wildlife species
- Linkage to Rio Salado and Tres Rios
- Recreation increased
- Improved aesthetics
- Incidental flood damage reduction



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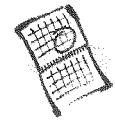
Schedule

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

End of comment period	June 26, 2006
Feasibility Report/EIS	August 06
Civil Works Review Board	October 06
Chief's Report	December 06
Congressional Authorization	Next WRDA Bill
Design Phase	2007-2008
Project Cooperation Agreement	Before construction
Construction	2010



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Public Comments

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Either fill out comment cards tonight or mail them to:

Scott K. Estergard

U.S. Army Corps of Engineers- Los Angeles District
3636 N. Central Ave, Suite 900
Phoenix, AZ 85012

Documents Available at:

- Burton Barr Central Library
- Ocotillo, Desert Sage, Palo Verde Branch Libraries
- Arizona State University Library
- On CD from the Corps of Engineers
- Online at http://www.spl.usace.army.mil/ Projects and Studies

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Public Comments

Rio Salado Oeste Feasibility Study-Phoenix, Arizona

Public Comment Period

Please speak clearly

Identify yourself

State Interest or Organization

Maximum 2 minutes person

Provide extensive comments in writing

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Rio Salado Oeste Feasibility Study
Public Hearing Meeting

Travis L. Williams Family Services Center
Phoenix, Arizona
May 18, 2006, 6:30 p.m.

Attendees that signed in:

Bruce Raden	Marty Bressor	Matt Rihs	Marcia Halsted
Bill Werner	Jeff Engelmann	John O'Donnell	Ed Demesa
Jose Rivas	Tim Flood	Lynn Timmons	Victor Vidales
Walt Kinsler	John Hathaway	Adrian Rodriguez	George Miller
Matthew Alan Lord	Susan Sargent	Don R Campbell	Karim Dada
Roland Wass	Bill Wiess	San DeSemple	George Young

OPENING COMMENTS

Karen Williams - Good evening, I am Karen Williams with the Rio Salado Project out of our City Manager's Office and I'm with the City of Phoenix' Rio Salado team tonight and the Corps of Engineers. I welcome everyone to our Rio Salado Oeste (Oeste is a Spanish word for west) so welcome to our Rio Salado West project on habitat restoration on the Salt River.

We'd like to welcome all of you to our Public Hearing. I am real excited about what we have already completed with our Rio Salado which is just right up stream from here. It surrounds Central Avenue at the Salt River and the habitat restoration includes the wetland ponds, a lot of native trees and plants, and of course a recreational trail system that goes with it.

The Oeste Project is an extension that would go then from 19th Avenue to 83rd Avenue. We are here tonight to hear about the plan for that area and the Corps of Engineers will present what is in the feasibility report and specific plans. I want to mention before we get started that we are concentrating on the improvements in the river bed itself, not beyond the banks of the river bed and specifically what we have planned for the Salt River floodplain.

Let me briefly introduce the top Corps of Engineers individual. To my left is Colonel Alex Dornstauder, he is the district commander out of the Los Angeles District. In just a moment, I will introduce some of the Corps of Engineer staff that is with him today. But I want to say thank you to the Army Corps of Engineers. They have, in fact, been financial partners right from the very beginning for two-thirds of the $100 million dollar project that 4 miles of it is open and the next mile will soon be under construction. We could not do that without our Federal partners, the Army Corps of Engineers. So I thank the Corps for the work that they have already done and specifically helping us to fulfill our long-term plan to improve the river to bring positive benefits and we have seen them in what we've already done.

We started working with the Corps of Engineers on the first stretch of the river bed in 1993. In 2007 we will complete that 5-mile stretch from 19th Avenue to 28th Street. So we know that this takes a number of years but we want to continue to give it energy and time.

We thank the Flood Control District of Maricopa County, who is represented today by John Hathaway, for being a financial partner in this Rio Salado Oeste study. We are going to keep working on it to get it authorized and eventually get federal appropriations for them to then pay two-thirds of the improvements in the river bed.

We do have a number of representatives with us today that I would like to point out. I am so glad whenever individuals from our Congressional office are able to join us. We are glad because it takes that kind of support to make things happen. We have Bruce Raden from Congressman Shadegg's office and Jose Rivas with Congressman Pastor's office. Jose will be reading a letter very soon for the public record tonight. Vice Mayor Doug Lingner is with one of our Sister Cities tonight and was not able to join us but Councilman Claude Mattox has sent a representative, Matt Rihs. We are so glad because Councilman Mattox has been a huge supporter of our Rio Salado project and has helped us get a lot of the Federal appropriations necessary to do this project.

Members of the Rio Salado team are available tonight if you do have details about the current project that is upstream or would like detailed information on the Rio Salado Oeste. Also available are the City of Phoenix Rio Salado team and a number of Corps of Engineer folks. I do want to introduce them so that you know who you can go to for further information.

Introductions:

- Walt Kinsler is our Rio Salado Project Manager from the Engineering Architectural Services Department. Walt can say a lot about what's going on in Rio Salado and help to answer questions.
- Danielle Taddy is our Rio Salado Supervisor from our Parks and Recreation Department

I am really thrilled to have them here. These are two of the core people that we meet with on a weekly basis to keep Rio Salado moving along. They are great individuals and wonderful to work with.

I also want to mention that Lynn Timmons is here from the Intergovernmental Programs office which is very important. It takes energy and time to get the Federal appropriations. Our Washington representative that we have working for us on a regular basis is John O'Donnell who is with us tonight from Washington. Mr. O'Donnell's energies have helped us do the right thing in the river bed and we appreciate that very much.

Once again thank you all for coming and at this time I would like to turn it over to Colonel Dornstauder who will do some brief introductions and a brief presentation and then we will get on to taking some public comments. Thank you.

Colonel Alex Dornstauder - Karen, thank you I appreciate that a lot. Ladies and Gentlemen thank you for having us here tonight and giving us the opportunity to share this project with you. Before I go forward with the actual presentation, can I get all of the Corps of Engineers folks to stand up one after the other? Introduce yourself and say if you are with the District or the Project so that folks can seek you out for detailed information.

Ladies and Gentlemen, these are the folks that actually know the details and know the guts of the project so seek them out if you have any questions.

Introductions:

- Ed Demesa, Planning Formulation Branch, Los Angeles District
- Scott Estergard, Planning Study Manager for the Rio Salado Oeste Project
- Eric Eldridge, Project Manager
- Major Brad Endres, Area Office
- Brian Moore, Los Angeles Chief of Programs
- Kayla Eckert, Chief of the Arizona Planning Office, Los Angeles District
- Jennie Salas, Public Relations with Los Angeles District
- Terry Lynn Padilla, Congressional Office Liaison
- Bryon Lake, Planning Study Manager
- Jeanine Divis, Planning Study Manager

I am Colonel Alex Dornstauder and have spent the last 26 years in the proud service culminating right now as the Commander of the Los Angeles District. I and the team, who just introduced themselves, take it as our high honor to serve you and that's our role. We are public servants and you are our customers. Tonight what I intend to do, at your pleasure, is to brief the results of the folks that just introduced themselves, their efforts on the study and to solicit any comments, concerns or questions that you may have to grade a paper, if you will, and to help us get better as we step along. Our purpose is to brief the results of the Study and to get comments from you to see how we did and to guide our efforts as we go forward with this project.

PowerPoint presentation (see attachment A)

PUBLIC COMMENT

Karen Williams - Let's start with Congressman Pastor's office. Josie Rivas, staff assistant for Congressman Pastor, has a letter he would like to read into the record.

Josie Rivas - Read the letter from Congressman Pastor (see attachment B).

Karen Williams - Thank you Mr. Rivas and thank the Congressman for us.

William "Wink" Wiess - 1535 E. Dobbins Road, Phoenix, AZ 85242, wiess6roud@cox.net, 602-799-3579, Past City of Phoenix Rio Salado Advisory Committee member.

Dr. Campbell from the Maricopa County College district is here and he mentioned to me just a minute ago that when he was a child, he used to fish in this river because it flowed full time. When I was a child, I worked for my parents place and we used to dump in the landfill. I think it has come full circle and now we are taking care of this beautiful riparian habitat and continuing on with this. I think it is a very good marriage of an urban setting marrying a natural riparian habitat within it. I know when I was on the Roosevelt School District Board, how important it is for our students to use the Interpretive Center for enlightenment and enjoyment for all citizens in this area. It is quite a feature, along with South Mountain and it

just gives the rural nature of our neighborhood and our community. I want to thank you and I do support this project.

John Hathaway - 2801 W. Durango, Phoenix, AZ 85009, joh@mail.maricopa.gov, 602-506-0503, Flood Control District of Maricopa County.

I am the Water Control Manager of the Flood Control District of Maricopa County. I am very pleased to see the efforts continue as we continue to build links of the desert rivers through one of the largest growing communities in the nation. As we see increasing pressures on this river, we look to the past to see the mistakes we've made and see how we are trying to correct them. As we move further to the west and try to get ahead of development, it will enable us to continue preserving as well as restoring the rivers. So I want to thank you for this opportunity to express my support and District support for the continuing efforts of our partners the City of Phoenix and the Corps of Engineers as we march our way to the west.

Karen Williams - Thank you Mr. Hathaway. I think many of you are aware the Flood District of the Maricopa County has been a financial partner not only in this Rio Salado Oeste feasibility report but also in the actual construction of the Rio Salado Project in doing the flood control elements for the low flow channel. We could not have met our 35% local match if it had not been for the Flood Control District so thank you Mr. Hathaway and thank the bosses and the supervisors for us on our behalf.

George Young - 514 W. Sunland, Phoenix, AZ 85041, gayoung@cox.net, 602-243-3162, S.M.D.P.C.

I am the former chairman of the Rio Salado Committee and one who worked on the original Rio Salado project, of which the Corps was a big asset to us. I submitted a letter to Ms. Williams to forward to you and I'm sure you will all be getting that. I wanted to thank the Corps for everything that they have done in the initial project of this river and sincerely hope that you continue to work with us, the City of Phoenix and the County, as partners to continue this on to 83rd Avenue. I can't express, from a Village Planning viewpoint, how important the Rio Salado Project is to this community as far as economic development goes. You are already seeing in a short amount of time that the river has been open and the people are using it so it has been a great asset to us, a wonderful asset to the City of Phoenix as a whole but more so for our community because it's really going to kick off a lot of economic growth that we've needed for many, many years. We appreciate that and I thank you again and keep up the good work.

Susan Sargent - 200 W. Washington, 6th Floor, Phoenix, AZ 85003, susan.sargent@phoenix.gov, 602-262-4065, City of Phoenix Planner for Rio Salado

I am very pleased to be here this evening. I would like to thank the US Army Corps of Engineers and the Rio Salado project team for this opportunity to tell you of some of the economic development that has occurred in the area near the river and along its banks in the last 4 years. As a land use Planner, I have been tracking some of the economic development that Mr. Young has just said the community so desperately needs. I am so pleased to tell you that since 2002 over $350 million dollars in new development, that's in office parks, residential new housing, and office buildings has already been developed or is presently under development for the area Rio Salado and along the banks of the river. For $100 million

dollars in public investment and over a third of a billion dollars in return, I would say that is money very well spent. I look forward to seeing even more, doubling and tripling that amount. Thank you.

Bill Werner - 3550 N. Central Avenue, Phoenix, AZ 85012, bwerner@azwater.gov, 602-771-8412, AZ Department of Water Resources

I am the Environmental Program Manager with the Arizona Department of Water Resources. I've been involved in this planning on this river for a long time. I will start with the recent past with the flooding in 1993 and the money for the reconnaissance studies that Congressman Pastor wrote the right words in the appropriation bill that gave us the opportunity to look at the Salt and Gila rivers and the issues in this area. I had been involved earlier in the late 1970's with management issues along the river. Things just happened and we worried about them and look at single purpose projects and fought over them. Now in this new era, we can look at opportunities and how to bring all these things together at once. Different reaches of the river bring different opportunities and challenges.

The Rio Salado is a highly developed area that is now completed. Tres Rios hits the downstream where this current project ends supported by effluent from the City of Phoenix and surrounding cities is now underway and is a much less developed rural setting. As John Hathaway mentioned, further west from that we have opportunities to avoid some of the development along the river. This current project is sort of an intermediary level of development but it does present a number of opportunities and it would link the other two projects which is important.

Arizona Water Protection Fund which is staffed by people at the Department of Water Resources contributed money to our pilot project in the Rio Salado Project and we contributed a million dollars toward studies and planning in the Tres Rios Project. The Department is quite interested in river restoration.

The Department is also involved in management of flooding issues in the state and it is important that we remember that these water courses can see a lot of water, they do need to convey the flood waters effectively. In fact, just shortly over a year ago we saw flooding on the Salt and Gila rivers right here in Phoenix with uncontrolled flows from the Verde River coming through. At the same time, these water courses naturally pass water, they naturally add habitat along them and if we understand how this happened in the world of nature and see how these things fit together, I think we can find opportunities to maintain open space, maintain flood conveyance at the same time. In addition have an amenity important to the citizen.

We're interested in working with entities like the City of Phoenix. We look at environmental improvements along the river here and stand ready to work with Phoenix and the other parties as this project progresses. Thank you.

Jeff Engelmann - 1030 E. Libra Drive, Tempe, AZ 85203, jengelmann@j2design.us 602-438-2221, J2 Engineering & Environmental Design

I am a landscape architect and have worked on the Rio Salado project, but more than that, as a father of two young children I have that infectious disease about being outside and enjoying

the environment. I brought my family down for one of the tree plantings. My wife and children both planted cottonwoods in the 100 acre forest. In addition to that I brought my son and his 5th grade class down for one of the first of the few educational sessions held at the Rio Salado before construction was even completed. My family has revisited the river many times since then including being able to walk and ride our bicycles along the trail systems and view the environment. So I strongly support, for both my involvement as well as being a citizen of the state of Arizona, the continued involvement of the Rio Oeste Project.

A couple other things I'd like to say is that back in the 1900's when the BOR and SRP were founded and they basically decided we needed to get a better handle on our flooding situation and the control of water for irrigation and the agricultural aspects of the state of Arizona that were and still remain very vital to the economy. That did destroy many of our riparian habitats with that control that was necessary. The reinvestment of the money on these habitats that we turned our back on so long ago back in the 1900's, it only took us 88 years to finally figure out that they are vitally important not only to the environment but also to the quality of life that we have come to expect living here in the southwest where we can enjoy outdoor environments for 12 months out of the year. Again, I very strongly encourage continued movement of this project to the west and further until we can ride from here all the way to Yuma. Thank you.

Dr. Roland Wass - 13437 N. 76th Street, Scottsdale, AZ, 85260, rwass32@aol.com, 602-625-2131, WGA, Inc.

Among other things, I am a golfer and Colonel your comments on a golf course struck me in two ways. Number 1 - it allays some fears that golf courses would be the only open space and habitat we would eventually have. Number 2 - the way that's set out offers a much more sustainable approach to the river restoration and I believe it also optimizes most of the functions and values that you can get out of these projects.

I too feel that Rio Oeste is an integral part of the efforts that you folks have started on and are continuing on through. Not only are these platforms for education and recreation, they are also platforms for appreciation of our water resources and riparian areas. And if you believe that those types of resources are a reflection upon the health of the society, I think we are headed in the right direction.

I would just like to say again that I support it. It shows that we are learning from what we've done in the past, the far past, as well as the present past. When we've done these projects, continually I have seen improvement along these corridors and I support you fully. Thank you.

Karen Williams - That is all the cards that we had turned in. Is there anyone else that would like to make any public comments? (No response)

Let me say thank you on behalf of the City of Phoenix and I'm sure the Colonel will want to make some concluding remarks but I thank you very much for taking the time and energy to come tonight.

Colonel Alex Dornstauder - Karen thanks once again. Ladies and gentlemen, thank you number 1 for the opportunity to present our efforts to you tonight. Thank you number 2 for

the opportunity to listen to what you have to say so we can only make this better. Finally number 3, thank you for the opportunity to serve you and this great nation that we call America. We are here to answer any questions if you have any.

City of Phoenix

US Army Corps of Engineers.

Rio Salado Oeste Feasibility Study
Comment Card

Name Jeff Engelmann

Address _____ City Tempe State AZ Zip _____
Email Address _____
Daytime Telephone _____

Association/Organization _____

COMMENTS:

Long-term benefits of study should include EDUCATION. It was not mentioned or listed.

Thank you for providing comments. You may also mail or fax your comments to:

Scott Estergard
U.S. Army Corps of Engineers
3636 N. Central Ave, Suite 900
Phoenix, AZ. 85012-1939

FAX: 602-640-5382

Response:

Thank you for pointing this out. Not mentioning environmental education as a benefit was an oversight during the presentation. Although the education is not a project objective there are inherent environmental education benefits will occur with the combination of ecosystem restoration and recreation. The recreation plan will have education benefits and although not a part of the cost shared project the City of Phoenix intends to have a future environmental education facility associated with this reach of the river.

Audubon ARIZONA

1250 East Camelback Road
Suite 310K
Phoenix, AZ 85014
Tel 602 468 0410
Fax 602 468 0480
www.audubonaz.org

June 6, 2006

Mr. Scott Estergard
U. S. Army Corps of Engineers
3636 N. Central Ave., Suite 900
Phoenix, AZ 85012

Dear Scott:

Although a conference out of state kept me from the recent public hearing on the Rio Salado Oeste Project, I very much want to voice my whole-hearted support, and the support of National Audubon Society, for this wonderful effort.

As you know, Audubon Arizona has taken many corporate and community leaders (as well as schoolchildren and college students) to visit the stretch of the Rio Salado habitat that is already open to the public. The response to the project has been unanimously enthusiastic. Those visitors who had seen the site before its restoration are inevitably stunned by the transformation and thrilled both by the change itself and what it means for the neighborhood's economic development.

Audubon Arizona is proud to have been chosen as the habitat's primary interpreter, and we look forward to providing environmental programs and activities to the community when the state's first Audubon Center – the Nina Mason Pulliam Rio Salado Audubon Center – opens in 2008. So important is this project to us that National Audubon Society's president, John Flicker, featured it in *Audubon* magazine last November, ensuring that news of your outstanding work has already reached, and no doubt inspired, an international audience. "[The Rio Salado] has become an example of how the most difficult environmental problems can be solved if enough people come together and take action," he wrote. "If we can heal this river, we can fix environmental problems elsewhere that also seem hopeless."

As the project moves westward to 83rd Avenue, please know that Audubon Arizona stands ready to help in any way we can. The Rio Salado habitat is destined to be one of the jewels of the City, not just a landmark but a touchstone for what we can achieve, and we are honored to be involved.

Sincerely,

Sam Campana

Sam Campana
Vice President and Executive Director

Audubon CONSERVATION CELEBRATING 100 YEARS OF CONSERVATION

City of Phoenix

OFFICE OF THE CITY MANAGER

April 21, 2006

Colonel Alex Dornstauder
United States Army Corps of Engineers
915 Wilshire Boulevard, Suite 14P00
Los Angeles, California 90017

Re: Letter of Support for the Rio Salado Oeste Recommended Plan, Salt River Ecosystem Restoration Feasibility Study

Dear Colonel Dornstauder:

The City of Phoenix, as the local sponsor, supports the recommended plan contained in the Rio Salado Oeste Ecosystem Restoration Feasibility Report, for the Salt River between 19th Avenue and 83rd Avenue through Phoenix.

This restoration plan is consistent with the overall vision and goals the city has for restoration of the Salt River. We are prepared to move forward with the Army Corps to the next level of design and construction. This includes the sponsor's commitment to secure our financial share for preconstruction engineering and design costs once the project receives Congressional authorization.

We thank the Army Corps for their commitment and involvement in constructing the upstream Rio Salado environment restoration project. The successful grand opening of Rio Salado for our residents and all of its visitors on November 5, 2005 was a great beginning in making the riverbed an asset for our community and a natural resource. We look forward to working with the Army Corps to extend the improvements downstream by making Rio Salado Oeste a reality.

Sincerely,

Karen Williams

Karen Williams
Rio Salado Project Director
City Manager's Office

200 West Washington Street, 12th Floor • Phoenix, Arizona 85003 • 602.262.4041 • FAX 602.262.3027
www.phoenix.gov

May 16, 2006

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Avenue, Suite 900
Phoenix, AZ 85012-1939

Regarding Draft Feasibility Report and Environmental Impact Statement:

Dear Mr. Estergard,

I am the former Member of the Rio Salado Advisory Committee, the citizens committee that was part of the oversight of the first phase of the Rio Salado Project. We were formed to give the City of Phoenix citizen input and direction. Needless to say I have a great interest in the expansion of the recently opened and almost completed Rio Salado Project and would like to see the Rio Salado Oeste ecosystem restoration project move forward from 19th Avenue to 83rd Avenue.

I am asking for the U.S. Army Corps of Engineers to continue to work with the City of Phoenix, its partners and the communities to complete the Rio Salado Oeste Project. I would also at this time like to thank you and the Corps for your interest and work in the past on the Rio Salado Project of what we believe to be another "Point of Pride" in the City of Phoenix. As you know this could have not been possible without the Corps support and willingness to work with our partners.

Sincerely,

Dominick Commisso

Name
Address
8043 N 5 Ave
Phoenix Arizona 85021

ED PASTOR
[illegible]

COMMITTEE ON APPROPRIATIONS

[illegible]

[illegible]

[illegible]

Congress of the United States
House of Representatives

[illegible]

May 18, 2006

The Honorable Phil Gordon
City of Phoenix
200 W. Washington St.
Phoenix, AZ 85003

Dear Mayor Gordon:

I am away in Washington this week and unable to appear in person at the U.S. Army Corps of Engineers Public Hearing for the Rio Salado Oeste Project. Therefore, I would like to have this letter read into the record.

We have seen the success of the Rio Salado project and today I would like to reinforce my support for continuing the project downstream with the Rio Salado Oeste project. This next phase is a continuation of environmental restoration that would address renewal of riparian habitat in conjunction with water quality, flood control and recreational purposes in an eight-mile stretch from 19th to 83rd Avenues. The 1,500-acre project would include recreational features such as trails, wetland ponds, native plants and trees.

The project focuses on an area which, since 1978, has been subjected to five floods in excess of 100,000 cfs (cubic feet per second). The most recent flood occurred in January 1993, causing damages in excess of $6 million.

As with the Rio Salado project, Rio Salado Oeste would no doubt continue to renew the natural habitat and environment of the Salt, and spur additional community development and economic growth in the areas surrounding the project. Recognizing the national environmental and local economic benefits of this project, the House of Representatives Appropriations Committee has included $250,000 in the Fiscal Year 2007 Energy & Water Appropriations Bill for the Feasibility Study. I expect this bill to go to the House floor next week and I am confident my colleagues will recognize the importance of this project and approve the funding.

I thank the Corps and the city of Phoenix for its dedicated attention and hard work on this project. I look forward to seeing this project become a reality.

Sincerely,

Ed Pastor

Ed Pastor
Member of Congress

EP/mcs

PHOENIX COMMUNITY ALLIANCE

502 East Monroe
Suite 100
Phoenix, Arizona 85004-2337
602 254 7477
Fax 602 253 9192
phxcommall@aol.com
www.phoenixcommunityalliance.com

Celebrating 20 years of service to Phoenix's Central City

June 16, 2006

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Ave., Ste. 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard,

This letter is in support of the Rio Salado Oeste environment restoration project proposed by the City of Phoenix and the U.S. Army Corps of Engineers.

The Phoenix Community Alliance (PCA) is dedicated *solely* to Phoenix's Central City, its continuing renewal, quality development, economic vigor and growth as a premier urban center. PCA is proud of a 22 year old track record for achieving positive community outcomes and solving challenging community development problems. PCA is renowned for mobilizing collaborations and partnerships and for energizing a wealth of community resources. PCA is privately funded by the business community and has a 501(c) 3, non-profit IRS designation.

We see the improvements in the Salt River enhancing the quality of life for our community and fully support the Rio Salado Oeste environment restoration project downstream of the existing Rio Salado.

Sincerely,

Donald P. Keuth, Jr.
President
Phoenix Community Alliance

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Donald Bliss
Pinnacle West Chairman (1990-1993)
Dave Gardner
Pinnacle West Chairman (1992-2002)
Robert Mattheows
Pinnacle West Chairman (1982-1994)
Richard Snell
Pinnacle West Chairman (1994-1998)
Ronald S. Bookbinder

City of Phoenix
OFFICE OF THE CITY COUNCIL

Claude Mattox
Councilman, District 5

Pat Severance
Council Assistant
pat.severance@phoenix.gov

District 5
(602) 262-7446
Fax (602) 495-0626
Cell (602) 514-5533
District5@phoenix.gov

May 16, 2006

Mr. Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Ave., Ste. 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard:

This letter is in support of the Phoenix Rio Salado Oeste Habitat Restoration Project in the Salt River from 19th to 83rd Avenues.

The city has already reaped benefits from the Rio Salado Project upstream that opened to the public in November 2005. The recreational features, along with the ecosystem restoration, in the once blighted river corridor have created a wonderful amenity for our residents and visitors. Additionally, the improved infrastructure and development beyond the banks of the River is bringing positive improvements to our community surrounding the project.

As chairman of the City Council Land Use, Environment and Natural Resources Subcommittee, I have fully supported the Rio Salado environment restoration project and now support the Rio Salado Oeste Project.

I thank the Army Corps of Engineers for its dedicated attention on this project. I look forward to a favorable report to Congress for consideration in the Water Resources Development Act and to seeing this project become a reality.

Sincerely,

Claude Mattox
Councilman
District 5

200 West Washington Street, 11th Floor, Phoenix, Arizona 85003-1611
www.phoenix.gov
Recycled Paper

City of Phoenix

May 16, 2006

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 North Central Avenue, Suite 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard:

This letter is written on behalf of the City of Phoenix Parks and Recreation Board in support of the Rio Salado Oeste project. This project is beneficial on many levels including the continued clean up and restoration of the Salt River and the added recreational amenities, which are greatly needed for the increasing population growth. We know the amenities Rio Salado currently provides for the quality of life the citizens of Phoenix want.

With the opening of Rio Salado on November 5, 2005 visitors enjoy bike riding, walking, jogging, bird watching and exploring a re-created river environment within an urban setting. This unique resource also provides a learning opportunity for visitors of all ages in which they can discover a wetland, learn the benefits of native plants and identify insects, wildlife and migratory birds.

The continued clean up and improvements of the Salt River will be of benefit to the environment and current and future generations to enjoy and learn from.

Sincerely,

Diana Brooks, Chairperson
Phoenix Parks and Recreation Board

Recycled Paper

City of Phoenix

June 14, 2006

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Ave., Ste. 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard:

On June 14, 2006, the Phoenix Planning Commission adopted a resolution to support the U.S. Army Corps of Engineers plan for habitat restoration of the Rio Salado Oeste.

The Phoenix Planning Commission is a nine member body appointed by the Phoenix Mayor and City Council to serve as the body with primary responsibility to make recommendations to the Council on planning issues. The Commission recognizes the existing improvements in the riverbed upstream of the Rio Salado Oeste Project and sees the positive impact on the surrounding community.

The Planning Commission fully supports the improvements to the Salt riverbed from 19th to 83rd Avenues, which will also benefit the surrounding properties near the riverbed.

We look forward to Rio Salado Oeste becoming a reality.

Sincerely,

Chairperson
Phoenix Planning Commission

City of Phoenix

Doug Lingner

May 25, 2006

Craig Echeveste

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Ave., Ste. 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard:

It is my pleasure to support the Phoenix Rio Salado Oeste Project. The Rio Salado Oeste Project is truly visionary and will be a gem in the desert for all to enjoy. We have already seen great results with the Rio Salado ecosystem restoration upstream of Rio Salado Oeste. Besides the habitat improvements within the riverbed, we have our residents benefiting from the increase in recreational opportunities as well as many children and adults participating in environmental education opportunities. Additionally, the area beyond the banks of the Rio Salado has seen $350 million of new infrastructure and development improvements in the past four years.

I believe the Rio Salado Oeste Project will leave a positive and lasting legacy for the city and the constituents I represent in City Council District 7. I'm so pleased to have this wonderful project proposed for residents and visitors to the Valley of the Sun and look forward to the completed Chief's Report, then the successful authorization of the project in the Water Resources Development Act.

I would like to thank the Army Corps of Engineers for their dedicated work on Rio Salado Oeste Feasibility Report and Environmental Impact Statement that sets the foundation for bringing this project to reality.

Sincerely,

Doug Lingner
Vice Mayor

George A. Young

May 16, 2006

Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Avenue, Suite 900
Phoenix, AZ 85012-1939

Regarding Draft Feasibility Report and Environmental Impact Statement:

Dear Mr. Estergard,

I am the former Chairman of the Rio Salado Advisory Committee, the citizens committee that was part of the oversight of the first phase of the Rio Salado Project. We were formed to give the City of Phoenix citizen input and direction. Needless to say I have a great interest in the expansion of the recently opened and almost completed Rio Salado Project and would like to see the Rio Salado Oeste ecosystem restoration project move forward from 19th Avenue to 83rd Avenue.

I am asking for the U.S. Army Corps of Engineers to continue to work with the City of Phoenix, its partners and the communities to complete the Rio Salado Oeste Project. I would also at this time like to thank you and the Corps for your interest and work in the past on the Rio Salado Project of what we believe to be another "Point of Pride" in the City of Phoenix. As you know this could have not been possible without the Corps support and willingness to work the our partners.

Sincerely,

George A. Young
Chairman, South Mountain Village Planning Committee
514 West Sunland Avenue
Phoenix, AZ 85041
602-243-3162
gayoung@cox.net

VALLEY FORWARD

June 13, 2006

Valley Forward Association
3808 North Central Avenue, Suite 220
Phoenix, Arizona 85012
p: 602 240 2408
f: 602 240 2487
www.valleyforward.org

EXECUTIVE COMMITTEE

BOARD OF DIRECTORS

Mr. Scott Estergard
Planning Study Manager
U.S. Army Corps of Engineers
3636 N. Central Avenue, Suite 900
Phoenix, AZ 85012-1939

Dear Mr. Estergard:

As an historic advocate for the Phoenix Rio Salado project, Valley Forward is excited about the prospects of extending this milestone Salt River restoration effort downstream from 19th Avenue to 83rd Avenue through Rio Salado Oeste.

Valley Forward is a 37-year-old environmental public interest organization encompassing 250-plus members representing large corporations, small businesses, as well as local jurisdictions of government within our region, including most Valley cities and towns. Together, we advocate for a balance between economic growth and environmental quality.

We celebrated the opening of the Nature Park in Rio Salado six months ago and are pleased that people are now enjoying the trails and open space, urban wildlife and numerous attributes provided by this unique desert landmark. It is heartening that this project can be extended an additional eight-miles through plans for Rio Salado Oeste. The recreational trails, wetland ponds, native trees and plants envisioned in the continuation of environmental restoration are critical elements in building a more livable and sustainable community.

Valley Forward urges Federal support to implement this project along the Salt River from 19th to 83rd Avenues. The City of Phoenix and U.S. Army Corps of Engineers have demonstrated success with the Rio Salado Project. Rio Salado Oeste is a nateral extension

For more than three decades, our organization and many others passionately supported Rio Salado. We now stand ready to lend our resources to continuing this dream downstream with the addition of Rio Salado Oeste.

Sincerely,

Diane Brossart
President

Joan Eisenhauer
2006 Chair of the Board

Response:

Thank you for your comment and for your support of this project. If you are not all ready on our list and would like to receive a link, CD-ROM, or hard copy of the Final Report once it is complete, please contact our office. Once again, thank you for your continued support of the Rio Salado Oeste Ecosystem Restoration Study.

ARIZONA RIPARIAN COUNCIL

Global Institute of Sustainability
Arizona State University

PO Box 873211
Tempe, AZ 85287-3211

June 26, 2006

Michael J Fink, Environmental Coordinator
U.S. Army Corps of Engineers
Los Angeles District
Arizona-Nevada Area Office, Planning Section C
3636 N. Central Ave., Suite 900
Phoenix, AZ. 85012-1939
Michael.J.Fink@usace.army.mil

Dear Mr. Fink,

The Arizona Riparian Council (ARC) submits these comments concerning the Draft Feasibility Report and Environmental Impact Statement for the Rio Salado Oeste project. Now in our 20th year, the ARC is the state's major non governmental organization dedicated to the protection of riparian areas. Naturally, we are most interested in the issues as they relate to riparian habitat.

The ARC supports the Corps' mission for "ecosystem restoration" (5.3.1; page V-6) as it applies in the Draft Feasibility Report and Draft EIS. Furthermore, we support the three planning objectives (5.3.2, page V-7):

- Restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish, and wildlife species.
- Reduce flood damages to infrastructure and structures.
- Improve passive recreation and environmental-education opportunities.

In many places the two documents list the causes of riparian degradation and loss in the Salt River. This loss is attributable to many factors: dams and water storage reservoirs built first on the Salt River watershed, and then on the Verde River watershed; complete diversion of the base flow in the Salt River that reaches the Granite Reef Dam; pumping of groundwater that formerly contributed to base flow; improper condition of the upland watershed that now produces large spikes in flows, but less base flow; and the dams' capture of suspended solids, silt, and nutrients that formerly sustained the channel bed and riparian habitat through the Phoenix metropolitan area. Sand and gravel mining and the placement of landfills in the river channel have further degraded the river and riparian habitat. Agricultural and residential developments on the riverbanks have encroached into the floodplain. Water management laws of the state have been crafted to allow the removal of the entire natural base flow through the Phoenix area, further contributing to the loss of riparian habitats.

President, Tom Hildebrandt (480) 345-6194 · Vice President, Roger Joos
Secretary, Cindy D. Zisner (480) 965-2490 · Treasurer, Cory Helton

While we wish to offer support to a project outcome that prospectively will return native riparian habitat to this reach of the Salt River, our enthusiasm for the Oeste project is somewhat tempered by the highly artificial nature of the habitat replacement. That is to say, the Oeste's proposed constructed riparian areas would be quite unconnected from the hydrologic and geologic functions of the Salt River and would be entirely dependent on ongoing inputs of water and management for its very sustainability. As proposed, the constructed habitat areas would be designed to function independently from the Salt River. We find this intentional separation troublesome because it further disconnects what ought to be linked in a true ecosystem restoration. The project as proposed promotes riparian habitat only through use of the leftovers -- namely, the effluent from the 23rd Avenue wastewater treatment plant, urban stormwater runoff, and spillover from agriculture. The recommended alternative does little to promote naturally emergent riparian vegetation in the Salt River channel; instead, in the name of flood control, the alternative would apparently continue to remove the woody vegetation that emerges in the channel (although the document is not clear on this point).

The determination by the Army Corps of Engineers that discrete efforts to affect flood control by means of levees are uneconomical was a refreshingly forthright decision and one which we applaud. The fact that some of the habitat enhancement features will inadvertently assist flood amelioration is a welcome outcome. We believe that creation/designation of greenbelt zones along major southwest rivers that allow room for natural river processes to occur, including flooding, are the best type of flood control in any sufficiently long-term analysis.

The project will lead to the expenditure of some $150,000,000 in construction costs that the Arizona Riparian Council does not think is the best way such a sum could be used in the arena of riparian management. We understand that these funds have eligibility criteria associated with their sources that limit their application, and that the requirement for a local partner to partially fund projects will always mean that such funds are expended in areas where local communities can implement them for local benefit. Still, such sums expended in the protection of watersheds, rehabilitation of headwaters, the purchase of sensitive lands or on projects that inherently reconnect the entire suite of natural processes that lead to healthy riparian systems would undoubtedly be better use of the funds from a riparian management perspective.

In conclusion, we are in qualified support of the project in that it will provide a semblance of riparian habitat replacement in this reach of the Salt River and will offer an opportunity for the people of the Phoenix metro area to learn about riparian systems and enjoy them. Since the funds are not qualified to be used for projects that might more effectively restore riparian systems in a fundamental sense, this project should go forward with adaptive management and a commitment to making it the best project possible.

Thank you for considering our comments. Please add us to your correspondence lists for communications related to this project. We will be happy to participate further as the project develops.

Sincerely,

T. R. Hildebrandt

Tom Hildebrandt, President
Arizona Riparian Council

Thank you for your comments and qualified support for the project. You are correct that the funds utilized for the feasibility study and anything that would be approved for expenditure on the recommended alternative are not qualified to be utilized elsewhere. We are following our existing Authority and Congressional Direction, as well as local sponsor interest in conducting this study on the Salt River. Authority and a willing non federal sponsor are required to conduct a study elsewhere.

From the first paragraph on page 2 of your letter clarification is necessary pertaining to the proposed restoration and riparian features.

Since the Salt River is highly altered its hydrologic and geologic functions are already largely disconnected. The proposed habitat is not designed to function independently from the Salt River; in fact the channel restoration feature is intended to restore some degree of connectivity to the river. That restored channel will connect the upstream and downstream reaches of the river through these 8 miles and allow low flows to pass. It was a decision of the study team to largely avoid placing vegetation or constructed features within the 10 year area of inundation to minimize operation and maintenance costs.

The low flow channel in the Rio Salado Project has exhibited a large degree of natural generation of not only emergent vegetation but also cottonwoods and willows. As you will notice in the feasibility report it is assumed that the restored channel in the Rio Salado Oeste project will allow continuation of that emergent vegetation down steam. It is assumed that at least 34 acres of emergent vegetation will establish within the channel.

Since this is an urban river it will be necessary to maintain flood conveyance and avoid any threat to life and property. This does not mean that all woody vegetation will be removed from the channel. There is a monitoring and adaptive management plan proposed for this project for 5 years following construction. Specific needs for maintenance of woody vegetation will be revisited during that period.

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
2221 WEST GREENWAY ROAD
PHOENIX, AZ 85023-4399
(602) 942-3000 • AZGFD.GOV

GOVERNOR
COMMISSIONERS
DIRECTOR
DEPUTY DIRECTOR

June 14, 2006

U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
Attn: Mr. Michael Fink
3636 North Central Avenue, Suite 900
Phoenix, Arizona 85012-1936

Re: Draft Rio Salado Oeste EIS

Dear Mr. Fink:

The Arizona Game and Fish Department (Department) has reviewed the Rio Salado Oeste Draft Environmental Impact Statement (EIS) for the Rio Salado Oeste Feasibility Study Report.

This reach of the Salt River has been severely impacted over the last century by water diversion, channelization, gravel mining, pollution, vegetation clearing, wetland drainage and numerous other activities that have almost totally degraded what was once a rich riparian ecosystem. The Department strongly supports this effort to restore the value of the Salt River for wildlife. Additionally, the Department believes this project will elevate the value of the Salt River in the minds of Arizonans and contribute to a better appreciation and understanding of river ecosystems as valuable resources worthy of protection.

The Department supports the preferred alternative. It will provide much needed wetland/riparian habitat that will benefit a greater diversity and abundance of wildlife in the currently highly disturbed Salt River bed. In addition to the many benefits that this proposed project is expected to provide (i.e. improved flood control and water management, riparian habitat restoration, and pollution treatment) it will also provide a great recreational and educational arena for local communities and schools—wildlife watching and environmental education. We believe the plan is well-researched and realistic in implementation and expected benefits.

The following are specific comments regarding use of seed and plant material sources that are endemic to the site. Two mesquites species are common in this stretch of the Salt; velvet mesquite (*Prosopis velutin;* sometimes treated as a subspecies: *Prosopis glandulosa velutina*), and screwbean mesquite (*Prosopis pubescens*). The plan calls for planting scattered honey mesquite. However, "honey mesquite" is not native to this site. There are two taxa of mesquite commonly called "honey mesquite". Texas honey mesquite (*Prosopis glandulosa*

AN EQUAL OPPORTUNITY REASONABLE ACCOMMODATIONS AGENCY

glandulosa) is found in southeastern Arizona, New Mexico and Texas, but not along the Salt River. Torrey mesquite (*Prosopis glandulosa torreyana*) occurs on the lower Gila River and Colorado River. Botanists believe that at one time these two subspecies were originally one taxa, but were split into two populations when velvet mesquite evolved in the Salt and Verde River vicinity and separated the honey mesquite taxa into Texas honey mesquite to the east, and Torrey mesquite to the west. Torrey mesquite intergrades with velvet mesquite as you move upstream from Yuma along the Gila River, but in the Phoenix area velvet mesquite is the dominant native mesquite, along with screwbean mesquite. Previous revegetation plans have made the same error recommending planting of "honey mesquite" which resulted in planting and introduction of non-native species (or subspecies) of mesquite. Velvet mesquite and the two separated isolated subspecies of "honey mesquite" are closely related and will hybridize. To avoid errors in plant species selection, identification, materials selection or planting, the Department recommends that plant materials for dominant plants at least (mesquite, cottonwoods, elderberries, willows etc.) be grown from seed or cuttings collected from relict riparian sites in the local area.

The Rio Salado Oeste will be one in a chain of major river restoration projects being planned or implemented along the Salt and Gila Rivers including the Phoenix Rio Salado Project, the Va Shly 'Akimel project, Tempe Town Lake, the Tres Rios Project, and the El Rio Project. Together, these projects will result in an almost continuous riparian corridor that hopefully will connect riparian and wetland habitats downstream with similar areas upstream. The resulting connectivity in habitats will create a synergistn in habitat value and wildlife populations where each project will add to the value of the others. These projects are a beneficial use of recycled water taken from rivers upstream, used by our communities, then treated and returned back to the river, where it can support wildlife again. The Department strongly supports this concept in use of recycled or conserved water, and the Rio Salado Oeste project particularly in the bigger context of these other projects and the habitat connectivity that will result.

Thank you for the opportunity to comment on this project. We look forward to further involvement in the planning and implementation process.

Sincerely,

Bob Broscheid
Habitat Branch Chief

BB:rh:dw

cc: Rod Lucas, Region VI Supervisor
Dave Weedman, Habitat Branch
Russ Haughey, Habitat Program Manager, Region VI
Alicia Jontz, Wildlife Manager
Rebecca Davidson, Habitat Branch PEP

Response:

Thank you for your comment and for your support of this project. We have changed all references from honey mesquite (*Prosopis glandulosa*) to screwbean mesquite (*Prosopis pubescens*). We look forward to your future involvement in the planning and implementation process. We will be sending you a Final Feasibility Report and Environmental Impact Statement for further review once it is complete.

City of Phoenix

June 26, 2006

Scott K. Estergard
U.S. Army Corps of Engineers, Los Angeles District
Arizona-Nevada Area Office, Planning Section C
3636 N. Central Avenue, Suite 900
Phoenix, AZ 85012-1939
Washington, DC 20460

RE: Rio Salado Oeste Draft Feasibility Report and Environmental Impact Statement
EIS No. 20060170
Comments

Dear Scott:

Thank you for the opportunity to comment on the Rio Salado Oeste Draft Feasibility Report and Environmental Impact Statement dated March 2006.

The City of Phoenix (City) is the cooperating agency for the Rio Salado Oeste Project and commends the U.S. Army Corps of Engineers on a well-constructed and thorough set of documents. The Rio Salado Oeste Project will be extremely beneficial for wildlife and the City of Phoenix and we look forward to its authorization. I would, however, like to take this opportunity to correct a couple of oversights in the aforementioned documents.

The proposed wetlands at the stormwater outfalls will perform an important water quality improvement function that is not explicitly recognized in the Draft Feasibility Report and it is too early in the design process to know the best way to handle recreation in the terrace areas. To rectify this, I request the following changes:

Draft Feasibility Report, Chapter V, Section 5.3.3 Planning Constraints, second paragraph, last sentence (page V-7): delete "Incidental".

Draft Feasibility Report, Chapter V, Section 5.7.2 Ecosystem Restoration, Stormwater Outfalls paragraph, 3rd sentence (page V-20): revise as follows: "The weir would direct flows to a stormwater wetland constructed for the purpose of harvesting and improving the water quality of storm water and supporting adjacent habitat."

Draft Feasibility Report, Chapter VI, Section 6.2.2 Stormwater Wetlands, last sentence of first paragraph (page VI-2): add at the end: "and that they will improve the water quality."

Draft Feasibility Report Technical Appendixes, Appendix L Recreation and Environmental Education, Future Opportunities, The Terrace (page 5): delete "more limited and controlled"; The Terrace Experience, first paragraph (page 7): delete "Areas within The Terrace will be designated as sanctuary or conservation areas, with restricted public use, allowing for the protection of biologically sensitive animals and plant life."; Trails (page 7): delete "staff-guided."

Once again, the City applauds the many hours of hard work that obviously went into the documents and these comments are in no way meant to detract from their high quality.

If you have any questions or need additional information, you can contact me at 602-262-4717 or karen.williams@phoenix.gov.

Thank you in advance for your consideration.

Sincerely,

Karen L. Williams
Rio Salado Project Director

Response:

Thank you for your comments. Changes recommended to the feasibility report that refer to water quality improvement functions from wetlands have been made in the report as recommended. Changes were made to the language within the Recreation Plan to clarify that future recreation will be consistent with Corps Policy pertaining to recreation development at an ecosystem restoration project and that recreation will be managed to ensure the sustainability of restored habitat.

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 26, 2006

ER# 06/505

Scott Estergard, Public Affairs Specialist
U.S. Army Corps of Engineers
3636 North Central Avenue, Suite 900
Phoenix, Arizona 85012

Subject: Review of the Draft Environmental Impact Statement (DEIS) for the Rio Salado Oeste Feasibility Study Report, Salt River, City of Phoenix, Phoenix AZ

Dear Mr. Estergard:

The Department of the Interior (DOI) has reviewed the draft Environmental Impact Statement for the Rio Salado Oeste Feasibility Study Report, Salt River, City of Phoenix, Arizona, and has the following comments:

Recreational Resources
Several Land and Water Conservation Fund (L&WCF)-assisted projects were provided to sites along the Salt River. As a result, these sites are encumbered by Section 6(f)(3) of the L&WCF Act of 1965, as amended (Public Law 88-578), which states: "No property acquired or developed with assistance under this section shall, without the approval of the Secretary (of the Interior) be converted to other than public outdoor recreation uses."

Restoration of the 8-mile reach of the Salt River from 19th Avenue to approximately 93rd Avenue will have far-reaching benefits for the ecosystem as well as the residents located near the project area. We suggest that the Corps of Engineers consult with the official who administers the L&WCF program in Arizona to determine whether or nor any L&WCF projects will be directly impacted. The individual to contact is:

Mr. Jay Ziemann
Assistant Director
Arizona State Parks
1300 West Washington Street
Phoenix, Arizona 85007

Fish and Wildlife Resources

The Ecological Services Phoenix Field Office of the U.S. Fish and Wildlife Service has participated in the plan formulation process for this project through transfer fund agreements and has provided a Planning Aid Letter and 2(B) Report pursuant to the Fish and Wildlife Coordination Act. The Service has no additional comments on the draft Environmental Impact Statement for the Rio Salado Oeste Feasibility Study Report at this time but may comment on issues concerning the conservation, protection, and enhancement of fish and wildlife and their habitats in the final Feasibility Study Report if they are not adequately addressed through the above cited participation.

Thank you for the opportunity to review and comment on this DEIS.

Sincerely,

Patricia Sanderson Port
Regional Environmental Officer

cc: OEPC, HQ
FWS, Albuquerque, NM
NPS, Denver, CO
USGS, Seattle, WA

Response:

Thank you for your comment. In order to determine if any Land and Water Conservation Fund (L&WCF)-assisted projects were provided to lands along the Salt River within the Rio Salado Oeste Study Area, we contacted the Arizona State Parks Assitant Coordinator, Jay Zicmann, as suggested in your letter. He put us in touch with the Arizona State Parks Grant Coordinator, Pat Dutrack. She coordinated with Maricopa County and Phoenix Parks' Departments. Collectively, they determined there are no L&WCF-assisted projects within the Rio Salado Oeste Study Area and therefore none that will be affected by this project. We will be sending you a Final Feasibility Report and Environmental Impact Statement for further review once it is complete.

RECEIVED JUN 15 2006

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

June 8, 2006

Michael Fink
U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
3636 North Central Avenue, Suite 900
Phoenix, Arizona 85012-1936

Subject: Draft Environmental Impact Statement (DEIS) for the Rio Salado Oeste Feasibility Study Report (CEQ# 60170)

Dear Mr. Fink:

The U.S. Environmental Protection Agency (EPA) has reviewed the DEIS referenced above. Our review is 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.

The primary purpose of this restoration project is to improve the ecological condition of an eight-mile segment of the Salt River. The project will restore 1,466 acres of riparian habitat along the River and is one of four ecosystem restoration projects in various stages along the Salt River. Maricopa County has undergone tremendous growth in the last few decades which has degraded the river system directly and indirectly through groundwater contamination, overdraft, and sedimentation. Therefore, we are supportive of these restoration projects and we have rated the DEIS as Lack of Objections (LO) (see enclosed "Summary of Rating Definitions").

The proposed alternative will restore 375 acres of cottonwood/willow, 417 acres of mesquite, 326 acres of wetlands, 296 acres of riparian scrub, and 52 acres of scrub-shrub habitat (p. ES-3). The Corps has proposed mitigation for the impacts to vegetation, air emissions, and water quality associated with the proposed alternative. In addition, the Final Environmental Impact Statement (FEIS) should discuss adaptive management plans to meet mitigation requirements associated with the Clean Water Act Section 401 and 404 permits as well as the Endangered Species Act Section 7 consultation, as these processes have yet to be completed.

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We appreciate the opportunity to review this DEIS. When the FEIS is released for public review, please send (2) copies to the address above (mailcode: CED-2). If you have any questions, please contact me at 415-972-3988 or Summer Allen, the lead reviewer for this project at 415-972-3847 or allen.summer@epa.gov.

Sincerely,

Duane James, Manager
Environmental Review Office

Main ID # 4827
Enclosure: Summary of EPA's Rating Definitions

Response to EPA Letter dated June 8, 2006

The FEIS will recommend that the Corps' seek an exemption for this project pursuant to Section 404(r) of the Clean Water Act (FEIS Section 3.3.3.2.1; Section 7.3). Section 404(r) of the Clean Water Act waives the requirement to obtain the 401 State water quality certification and the 404 permit, provided that the discharge is part of a federal construction project authorized by Congress, and if the following conditions are met: (1) information on the effects of such discharge of dredged or fill material into waters of the United States, including the application of the Section 404(b)(1) Guidelines, are included in the Environmental Impact Statement (EIS) on the proposed project, and; 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. The Corps has determined that this project as proposed is consistent with the Section 404(b)(1) guidelines (Appendix A to the EIS), and is in compliance with the Clean Water Act. Use of the 404(r) exemption would mean that there would be no requirement to obtain the 404 permit or 401 water quality certification, or to meet mitigation requirements associated with these authorizations. The sponsor would be required to obtain a 404 permit and 401 water quality certification for O&M activities occurring after the 5-year adaptive management period.

Since the purpose of ecosystem restoration is to provide environmental benefits, the preferred alternative (Alternative 5A) has been formulated to eliminate the need to mitigate for impacts to waters of the U.S. The project also is designed to avoid any requirement for compensatory fish and wildlife mitigation, with the possible exception of Mitigation Measure BR-5: Trap and Relocate Native Fish (Table ES-2; Section 4.4.2.4.3; Section 8.3). This mitigation measure is intended to minimize impacts to any native fish species that may be present). All mitigation measures are discussed in Chapter 8 of the FEIS.

Adaptive management is discussed in *Appendix N: Monitoring and Adaptive Management* to the report titled *Rio Salado Oeste Interim Feasibility Report, Salt River – Phoenix, Arizona.* The feasibility report and its appendices are distributed with the EIS, and are incorporated by reference. The Monitoring and Adaptive Management Plan covers Corps-related monitoring and adaptive management actions during the first five years after initial project construction is complete. 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. 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.

Section 7.4 of the DEIS states that the results of the Section 7 will be included in the FEIS. A Biological Assessment (BA) was prepared and coordinated with the U.S. Fish and Wildlife Service (USFWS) by letter dated April 24, 2006. The Biological Assessment anticipates impacts of "No effect" or "May affect, not likely to adversely affect" for each of the 14 federally listed species on the USFWS list for Maricopa County. USFWS concurrence on the conclusions of this BA was provided by letter dated August 7, 2006, thus concluding the Section 7 consultation. The Biological Assessment and associated correspondence will be included in Appendix B to the FEIS.

WATER ENGINEERING & TRANSMISSION
Mail Station PAB103
P.O. Box 52025
Phoenix, Arizona 85072-2025
E-mail: pacherr@srpnet.com
(602) 236-2760
Fax (602) 307-9798

PAUL A. CHERRINGTON
MANAGER

June 14, 2006

U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area office
Attn: Mr. Michael Fink
3636 North Central Avenue, Suite 900
Phoenix, AZ 85012-1936

Re: Comments on the Draft Environmental Impact Statement for the Rio Salado Oeste Feasibility Study Report, Salt River, Phoenix, Arizona

Dear Mr. Fink:

Attached are SRP's comments on the subject report. We only reviewed and commented on SRP water-related subjects of surface water and groundwater found in sections 3.2 and a portion of 3.3.

Please contact Bob Gooch (602-236-5227, rsgooch@srpnet.com) if you have any questions regarding the attached comments.

Sincerely,

Paul Cherrington

PAC/RSG/wh

SRP Response to Section 3.2.1 REGIONAL HYDROLOGY AND SURFACE WATER RESOURCES

Responses to this DEIS are addressed in three ways. There are general comments, suggested writing, and analytical discussions. General comments are provided to point out areas where more clarification may be needed. The suggested writing is intended to better describe the SRP system and operation where necessary. Finally, some analytical discussion is attached to offer a more balanced approach to the changing flow regime through the Valley. In each section, the original documentation will be followed with SRP's response highlighted in blue.

3.2.1.1 Background

The Salt River drains 14,500 square miles of mountainous desert terrain in central and eastern Arizona and is the largest tributary to 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 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 its junction with 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 eight inches (Table 3.7-1). Precipitation (rain and melted snow) 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 typically develop from the flow of subtropical air masses from the Gulf of Mexico and the tropical eastern North Pacific. Regional storms from the Pacific Ocean generate gentle, widespread showers during the late fall and winter. Summers are hot, with daily temperatures exceeding 100° F from mid-June through August. During the summer, mean daily temperatures 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.

- Suggest replacing "junction" with "confluence." It is not entirely clear what aerial extent is being considered to determine that the precipitation at the highest elevations of the watershed ranges up to 14 inches. The Salt and Verde Watersheds average approximately 20 inches a year with the highest elevation areas averaging over 30 inches. The precipitation is derived of summer thunderstorms and regional winter storms.

- What location is being referenced for high temperatures exceeding 100 F? It is unclear what the description of mean daily temperatures ranging from 65° F to

104° F is referring to. Is this truly a mean daily or just the range of high temperatures from high elevation to low elevation?

- Suggest this be broken into two paragraphs: one on geography and one on climatology. In the new paragraphs, be clearer about what areas are being referenced.

3.2.1.2 Dam System (Reservoir System)

During the 20th century, the Phoenix area 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 river use 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 3.2-1). The Salt River Project (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 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. 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 Salt River), which provide an additional 310,000 ac-ft of storage. New Waddell Dam is located on Agua Fria River northwest of Phoenix and downstream of the study area.

- Suggest the following rewrite of the above paragraph:

During the 20th century, the Phoenix area changed from a mainly agricultural region to a mainly urban region, resulting in 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 irrigation, drainage, erosion protection and flood damage reduction. Numerous upstream dams on the Salt and Gila rivers have altered the natural flow regime of the rivers. See table 3.2-1 for a listing of the dams on the Salt, Verde, Agua Fria and Gila rivers.

The Salt River Project (SRP) operates six storage dams on the Salt and Verde rivers and a diversion dam just east of the City of Mesa. Granite Reef Diversion Dam (Granite Reef) does not have any storage capacity. The purpose of this facility is to divert water released from the reservoirs into the Arizona Canal (for the area north of Salt River), and the South Canal (for the area south of Salt River). The canals supply the Phoenix metropolitan area with water for agricultural and municipal and industrial (M&I) use. Stored water is allocated based on water rights associated with the land in the SRP service area.

All Salt River dams have hydrogeneration capacity. Safety of Dams modifications (completed in 1996) to Theodore Roosevelt Dam include a zone for flood control. The total space for water-supply storage behind the Salt River dams is 2,025,798 acre-feet (ac-ft) including the cities' new conservation storage, with an additional 556,196 ac-ft for flood damage reduction at Roosevelt Dam. The Roosevelt Reservoir is the largest reservoir of the SRP reservoir system. It stores runoff from about 5,800 square miles of the Salt River watershed.

Downstream of the Stewart Mountain Dam, the Verde River discharges into the Salt River. The drainage area of the Verde River is about 6,700 square miles. Two dams are located on the Verde River, Horseshoe Dam and Bartlett Dam with a total conservation capacity of 287,403 ac-ft.

Table 3.2-1. Major Dams and Reservoirs in the Gila River Basin

Dam	River	Reservoir	Date of Origin	Storage (acre-feet)
Waddell	Agua Fria	Lake Pleasant	1927	165,000a
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	1,600,000b
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

- Updated SRP and CAP Volumes (COE should get updated numbers for the other reservoirs. In addition, SRP prefers to list the dams from upstream to downstream: Roosevelt, Horse Mesa, Mormon Flat, Stewart Mountain on the Salt River and Horseshoe and Bartlett on the Verde River).
- Are Waddell and Painted Rock dams pertinent to this table and the project?

Table 3.2-1. Major Dams and Reservoirs in the Gila River Basin

Dam	River	Reservoir	Completed	Conservation Storage (acre-feet)
Waddell	Agua Fria	Lake Pleasant	1927, mods. 1994	812,100
Bartlett	Verde	Bartlett Lake	1939	178,186
Horseshoe	Verde	Horseshoe Lake	1946, mods. 1951 & 1995	109,217
Stewart Mountain	Salt	Saguaro Lake	1930	69,765
Mormon Flat	Salt	Canyon Lake	1925	57,852
Horse Mesa	Salt	Apache Lake	1927, mods. 1992	248,138
Roosevelt	Salt	Roosevelt Lake	1911, mods. 1996	1,653,043
Coolidge	Gila	San Carlos Lake	1928, mods 1992?	1,222,000
Painted Rock	Gila	Painted Rock Lake	1959, mods 1992?	2,500,000

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 releases water only for flood damage reduction purposes to lower reservoir levels, either prior to winter rains or when the reservoirs are unexpectedly full. 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 the Granite Reef Diversion Dam. The Granite Reef Diversion Dam is located about three 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 Salt River), and the South Canal (for the area south of Salt River). The canals crisscross the Phoenix metropolitan area for water delivery to agricultural, municipal and industrial users. There are no releases during climatically drier years, as occurred between 1942 and 1964. Except for stormwater runoff, groundwater emergence and effluent, the Salt River is dry during those times.

- During normal times, SRP releases water from the reservoirs to meet water needs in the Valley. When the reservoirs approach full capacity, a point which SRP is always fully aware, releases above the water order may be initiated. Water released in excess of the water order typically flows over or around Granite Reef Dam and flows into the normally dry Salt River channel. The actual amount is dependent upon numerous variables including: available storage space, forecasts, downstream impacts and constraints, and desired future storage levels.
- The canal system does not crisscross the area. The canals generally follow the topographic contour of the project area in order to provide gravity flow delivery of water to project lands.

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 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 the Granite Reef Diversion Dam, the flow is typically sustained for several days or more and of a significant magnitude. Since 1965, there have been about two releases per year. These releases 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 five-day average flow rate of 15,000 cfs, and a ten-day average flow rate of 10,000 cfs (U.S. Army Corps of Engineers, 2000).

- A description of the channel and location would be useful for this discussion.
- The use of averages in this paragraph is misleading. The majority of years experience no flow while a few of the years contain the vast majority of flow events and volume.

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 the Salt River streamflow infiltrated and recharged groundwater upstream from Indian Bend Wash near Scottsdale. Groundwater discharged to the channel provided 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. 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. The system of dams upstream of the study area effectively delays the flows by one month. This delay becomes insignificant, however, in light of the length of periods without flow in a river that was perennial under natural conditions.

- Prior to 1900, virtually all of Arizona's riparian areas, cottonwood and willow gallery forests, and mesquite bosques were still intact.
- Clarify the location of flows. The discussion applies to the Salt River below Granite Reef Dam but not necessarily above Granite Reef Dam.

3.2.1.3 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 3.2-1 shows the limits of the 100year 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 one mile, depending on the location. Significant problems related to flooding within the study area include large flood flows 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.

- During periods of high spill water releases from the dams, flood damage may occur in the Phoenix metropolitan area. This happened in the 1970s and early 1980s. Spill water releases exceeded 100,000 cfs in the Salt River below Granite Reef in 1978, 1980, and 1993.
- SRP does not release significant quantities of water based solely on the potential for large inflows of water.

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 (Table 3.2-2). 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 one fourth of the years. 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 16 years. Table 3.2-2, shows estimated flow values for variable frequency and duration flows within the Salt River channel near immediately upstream of the study area (U.S. Army Corps of Engineers, 1997). The peak 100-year flood flow is 166,000 cfs.

- The first three sentences seem to contradict themselves. Are peak flows higher or lower? One cannot compare peak discharges to mean peak discharges and get a meaningful comparison. The use of averages here is questionable.
- The dams have not exacerbated the high flow conditions. The cycles of the climatic regime have resulted in the greater occurrence of extreme high flows in the latter period.
- There have only been two occurrences of flows in excess of 100,000 cfs in the last 16 years.

- In the arid Southwest, the selection of the period of record for analysis of hydrologic statistics is critical because long-term cycles of precipitation result in highly variable runoff between decades (Shepard et al. 1999; Jarrett 1991; Meko and Graybill 1995). A well-known example of the peril of using a brief period of record for drawing conclusions is the Colorado River Compact, which allocated one-half of the apparent runoff at Lees Ferry to the Lower Basin States. The compact is based on the period of record of 1896 through 1930, when the average annual discharge of the river was 17 million acre-feet (MAF) (Jarrett 1991). However, during the following 35 years, the average annual discharge of the river was only about 13 MAF, slightly less than the estimated long-term average flow of 13.5 MAF (Id.).

  As in the Colorado River basin, the early decades of the 1900s were relatively wet in the Verde River watershed. The 1904-1938 "pre-dam" period of record used by Graf for several of his conclusions and by Beauchamp and Stromberg for all of their conclusions has average annual flows that are 30% larger than the 1939-1999 "post-dam" period (Figure 1). Thus, some of the hydrologic changes attributed to the construction of dams in their paper are actually differences in the period of record. Comparison of flows above and below the dams for the same period of record eliminates this problem of significant differences in the period of record. However, the period of record must be carefully selected to be representative of long-term hydrological conditions to avoid skewed results from unusually wet or dry decades.

References

Jarrett, R.D. 1991. Paleohydrology and its value in analyzing floods and droughts. Available at: http://geochange.er.usgs.gov/sw/impacts/hydrology/paleohydro. May 15, 2002.
Meko, D. and D.A. Graybill. 1995. Tree-ring reconstruction of upper Gila River discharge. Water Resources Bulletin, Vol. 31, No. 4. August
Sheppard, P.R., A.C. Comrie, G.D. Packin, K. Angersbach, and M.K. Hughes. In Press. The climate of the Southwest. Available at http://tree.ltrr.arizona.edu/~sheppard/swclimate/swclim.htm. May 15, 2002.

Table 3.2-2. Inundation-Duration Frequency 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	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)

(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 cfs is exceeded for 53 days during this event. Results are based upon simulation of Balanced Hydrographs.
Source: U.S. Army Corps of Engineers, 1997

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 salt cedar, an invasive nuisance species. Salt cedar 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 out-compete salt cedar. An example of this occurred following the 1993 flood when additional vegetation established itself in the river downstream of Phoenix. The Flood Control District of Maricopa County (FCDMC) applied for a Clean Water Act Section 404 permit to resume channel clearing. The permit was denied because of habitat removal concerns expressed by the Arizona Game & Fish Department (AGFD).

- It is unclear what point is being made regarding the FCDMC permit application.

3.2.1.4 Local Hydrologic Characteristics

The study area is located downstream of several other planned restoration projects, including the first phases of the Rio Salado Project located between upstream and downstream of the Tempe Town Lakes Project. The approximately 2-mile upstream section of the study area is surrounded by highly urbanized land-use areas. The lower five miles of the study area flow through a mix of residential and agricultural land-use areas with occasional commercial/industrial developments.

- A much more clear description of the project location and other ongoing projects is needed here.

Numerous urban drainage channels are located in the study area. They discharge local stormwater runoff to the Salt River channel. 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. 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. Flows would completely infiltrate into the channel substratum just downstream (U.S. Army Corps of Engineers, 1997).

- The conclusions in this paragraph are no longer valid. The existence of the Tempe Town Lake and standing water conditions both above and below the Town Lake has invalidated the 1997 study results.

SRP Response to Section 3.2.2, GROUNDWATER

"... 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 eight to 20 feet in the Mesa-Tempe area. The water table declined steadily from the 1930's into the 1960's 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 ten to 30 feet greater than in the early 1900's."

During the 1980's, pumping of groundwater declined in the Salt River Valley. Data collected from 1987 to 1992 from seven wells along the Salt River indicate that recent groundwater levels have not exhibited a distinct upward or downward trend, although they have fluctuated considerably."

- SRP records show that the water table rebounded on the order of 200 feet since the late 1970's in many portions of the SRP water service area. This section appears to be "comparing apples to oranges" by referring to the Salt River Valley as a whole when discussing the decline, to shallow bedrock areas when discussing the rebound, and to the seven wells along the river when discussing current conditions. This section needs to be rewritten for clarity and probably should be limited to the study area.

SRP Response to Section 3.3. WATER QUALITY

3.3.1 CONTAMINANTS

- There should be mention that the CAP can be a significant source of water in SRP canals in addition to the Salt and Verde.
- It should be mentioned that many cities send wastewater to the 91st Ave plant, not just Phoenix.
- VOC's -Clarify that VOCs are associated with groundwater, not surface water. VOCs often exceed drinking water standards in groundwater, but not standards for irrigation or wildlife uses.
- Mercury: mercury is not detected in the Salt and Verde rivers, but in effluent.

3.3.3.1.3 Salt River Project (SRP)

"... SRP operates seven major dams upstream of the metropolitan area on the Salt and Verde Rivers, and therefore must be included in any plans for managing river flows and floods through the urban area."

- Just to make it somewhat clearer, say that SRP operates six major dams and the Granite Reef Diversion Dam. SRP also operates C.C. Cragin Dam (formerly Blue Ridge Dam) on the Little Colorado River. Water will be pumped from there to provide water to communities on the Salt River watershed.

Response:

Thank you for your comments in response to your review of SRP water-related subjects. We have incorporated many of your recommended changes to sections 3.2.1.1 thru 3.3.3.1.3 at our discretion. We will be sending you a Final Feasibility Report and Environmental Impact Statement for further review once it is complete. Thank you again for your comments.

YAVAPAI
PRESCOTT • INDIAN • TRIBE

June 26, 2006

U.S. Army Corps of Engineers
Los Angeles District
Arizona/Nevada Area Office
Attn: Mr. Michael Fink
3636 North Central Avenue, Suite 900
Phoenix, Arizona 85012-1936

RE: Rio Salado Oeste Feasibility Study Report and Draft Environmental Impact Statement

Dear Mr. Fink:

The Yavapai-Prescott Indian Tribe received the Rio Salado Oeste Draft Feasibility Report and Environmental Impact Statement sent by the Los Angeles District Corps of Engineers, and we strongly support the proposed improvement of the overall ecological health of the Salt River. As we saw the adverse effects of reduced wetlands and the associated loss of the natural ecosystem functions and processes with the hurricanes last year, we believe the proposal to restore the natural ecosystem functions and processes of this eight-mile segment of the Salt River will have many positive outcomes as the EIS presents.

We noted that no cultural resources were identified in the survey by the Corp's Archaeologist. The documents and correspondences between the Corps and the Arizona SHPO that the Draft Feasibility Report said were to be found in Appendix N of the EIS (see page IV-43 of the Draft Feasibility Report, 3rd Paragraph, last sentence) were not included in the copy sent to our Tribe, but these documents were provided to us upon request by Staff Archaeologist Ms. Pamela Maxwell of the Corps. After reviewing these documents we are fully satisfied with both the Corp's efforts to identify historic properties and with the results of the literature search and archaeology survey.

One note, on page IV-41 of the Draft Feasibility Report, under 4.2.8.3, first paragraph, the reference should read "Downum and Bostwick", and not "Downun and Bostwick".

We wish you great success with the project and appreciate the Corps initiative. We would be interested in visiting the project once it gets started. Thank you for consulting with us.

Sincerely,
Gregory T. Glassco
Greg Glassco
Director, Cultural Resource Dept.
Yavapai-Prescott Indian Tribe

YAV-CR-2006-049

530 E. MERRITT PRESCOTT, AZ 86301-2038 Phone 928-445-8790 FAX 928-778-9445

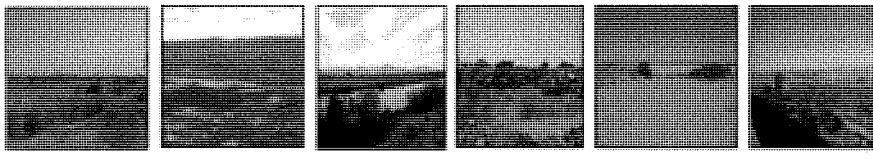
Response:

Thank you for your comment and for your support. We have added the documents and correspondence with the Arizona SHPO to Appendix C Cultural Appendix. We have also corrected the misspelling. We will be sending you a Final Feasibility Report and Environmental Impact Statement for further review once it is complete. Thank you, again.

Volume 2 of 2

Final Feasibility Report Technical Appendixes

Rio Salado Oeste



Salt River-Phoenix, Arizona

Prepared by:

US Army Corps of Engineers

Los Angeles District

South Pacific Division

City of Phoenix

September 2006

APPENDIXES

Appendix A: Hydrology and Hydraulics

Appendix B: Water Budget Report and Interior Drainage Report

Appendix C: Groundwater Modeling

Appendix D: Groundwater Quality and Hydrogeology Report

Appendix E: Geotechnical Evaluation

Appendix F: Modified Phase I Environmental Site Assessment

Appendix G: Economic Evaluation

Appendix H: Real Estate

Appendix I: Functional Assessment Methodology

Appendix J: Design

Appendix K: Cost Estimate

Appendix L: Recreation

Appendix M: Wetland Restoration

Appendix N: Monitoring and Adaptive Management

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX A
HYDROLOGY AND HYDRAULICS

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

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INTRODUCTION

Purpose

The purpose of this appendix is to document the hydrologic and hydraulic analyses completed in support of the Rio Salado Oeste 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 alternative.

Description of Study Area

The Rio Salado Oeste 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 19th Ave on the east side of the study area and extends downstream to the west for a distance of approximately 9 miles as show on Figure 1.

The study area is within the jurisdiction of the City of Phoenix, Maricopa County, Arizona.

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

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 flood flows vary in duration, quantity and magnitude depending on the nature of the flood

DISCHARGE-FREQUENCY ANALYSIS

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.

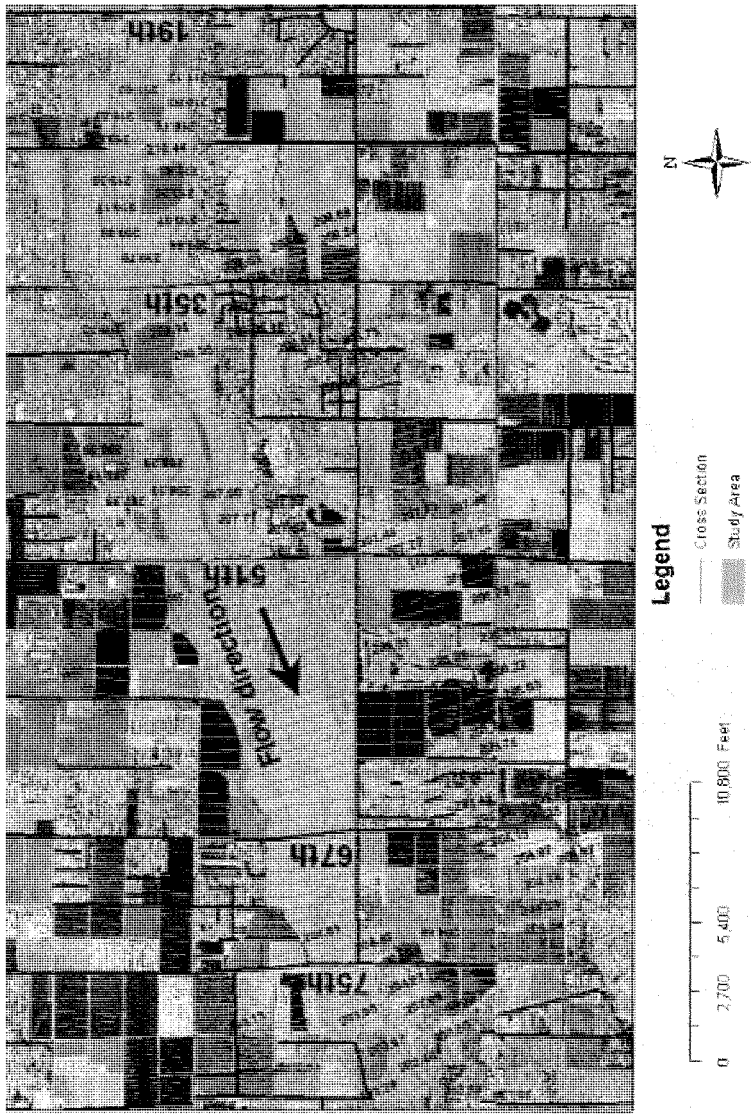

Figure 1: Study Area

Table 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

A flow frequency distribution information set was developed for the Salt River Rio Salado Oeste study reach based on the dammed Modified Theodore Roosevelt operating condition. The following Table 2 summarizes the discharges that were analyzed for this study's hydraulic models. Note, changes in flow between the two river stations are due to storage effects within the effected floodplain.

Table 2: Flow Frequency for Salt River.

Return Period	Upstream limit at River Station 211.52 (cfs)	River Station 205.52 (cfs)
5 –Year	20200	20000
10 - Year	53000	87000
20 - Year	87000	84000
50 - Year	135000	132000
100 - Year	166000	164000
200 - Year	202000	200000
500 - Year	240000	237000

The average rainfall for the Phoenix area is summarized in the following Table. 3. The information for this rainfall data was extracted from rainfall recorded at the Phoenix Sky Harbor Airport located seven miles east of the downstream section of the study area. However, its important to note that summer thunderstorms can produce local precipitation that exceeds the monthly average which can result 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. Therefore, 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 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

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.

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.

Interior drainage is an assessment of the storm water runoff that accumulated on the up gradient side of levees. But, since the Rio Salado Oeste study reach does not have any significant levees or flood control structures, there are no interior drainage conditions to address. However, there are side drains that outfall into the Salt River within the study area. These drains were evaluated in terms of location and estimated discharge quantity and a more detailed discussion of this topic is presented in the Water Balance Section of these Appendixes.

Table 4 below illustrates an example of typical hydraulic flow conditions at selected locations within the study reach. This pertinent hydraulic information was extracted from the Baseline Without Project 100-Year flood frequency event condition.

Table 4: Selected Cross Section Pertinent Hydraulic Information Data for Baseline Without Project 100-Year Frequency Event Condition

Location Description	River Station In Miles	Min.Channel Elevation (ft)	Water Surface Elevation (ft)	Critical Water Surface (ft)	Slope (ft/ft)	Velocity Channel (ft/s)
19th Ave	211.51	1021.8	1043.8	1037.9	0.002129	15.6
27th Ave	210.44	1017.6	1040.7	1028.8	0.000521	7.4
35th Ave	209.54	1019.6	1036.6	1035.9	0.003416	13.9
43rd Ave	208.48	1007.6	1021.3	1017.8	0.001756	8.4
51st Ave	207.53	999.2	1012.6	1008.1	0.001041	7.5
59th Ave	206.51	990.2	1002.1	999.9	0.002356	10.4
67th Ave	205.52	975.9	994.0	987.0	0.000516	5.7
75th Ave	204.42	971.4	985.5	982.8	0.002884	9.6
83rd Ave	203.48	962.1	975.8	972.0	0.001186	6.5

STUDY METHODOLOGY

Analysis Tool

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 3.1, 5, 10, 20, 50, 100, 200 and 500 –Year Flood Frequency Events.

Determination of Manning's Roughness Coefficient

All "n" values were based on similar vegetation and channel conditions that were used in Tres Rio (down stream), Rio Salado (upstream), and Va Shly'ay (upstream) studies since they have similarities hydraulic "n" value characteristics.

Environmental Features

The Rio Salado Oeste study area has locations where there is existing vegetation supported by precipitation, seepage, periodic flood flows, stormwater runoff. The USACE project design developed three alternatives in support of the Feasibility Study F4 Milestone. The goals of these three alternatives were to: 1) increase the native riparian vegetation: 2) increase the vegetation connectivity; and 3) stabilize bank sections where needed. A mixture of four environmental features was incorporated into these With Project alternatives. These four principle environmental features are classified and denoted as Cottonwood/Willow, Mesquite, Wetlands, and River Bottom.

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.

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 water from the SBIN will support the vegetation. In the model, MS was assigned an "n" value of 0.073.

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.

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 0.03

Structural Features

There are several structural features within the study area that have been identified as bridges, sand and gravel mining operation sites, and a grade control structure.

The principle bridges in the study area are identified at the River Mile stations shown in Table 5 below. Also, there is a single buried grade control structure in the Salt River immediately located downstream of the 19th Avenue Road Bridge.

Table 5: Bridges with the Rio Salado Oeste Study Reach

Bridges Name	River Station
19th Avenue Bridge	211.52
Conveyor Bridge at 27th Avenue	210.43
35th Avenue Bridge	209.53
51st Avenue Bridge	207.48

Finally, there are a number of active sand and gravel mining operations within the Salt River floodplain of the subject study reach. The locations of these operations are largely between 51st and 35th Avenues and are shown in Figure 2 below.

HYDRAULIC ANALYSIS & RESULTS

A hydraulic analysis of the existing and future without project conditions were developed using the HEC-RAS River Analysis System modeling process. The initial hydraulic analyses were based on a digital terrain model generated from aerial survey's completed in December of 2001. But, since active mining has continued to change the basic terrain along the Salt River floodplain after the December 2001 date, the initial Baseline Without Project model did not reflect this revised condition. However, to account for this ongoing projected mining condition, the Baseline Without Project model was modified by adjusting the current and potential sand and gravel impacted areas by assuming a final mined out "footprint" condition. Once the Baseline model had been revised to reflect the future mined condition, then With Project alternatives were subsequently developed. There were three environmental

alternative concepts that were developed by the study team and carried forward in the evaluation process. These three alternatives were assessed in terms of their respective level of habitat value and identified as Alternative "High", Alternative "Medium", and Alternative "Low".

Without Project Modeling

Initially, West consultants completed a hydraulic analysis of the existing without project conditions using HEC-RAS (West, 2002). A 1-dimensional model of the reach was created using HEC-RAS and the HEC-GeoRAS extension in ArcView 3.2a (Environmental Systems Research Institute, Inc). The cross section geometry for this model was obtained from the TIN using the same cut lines utilized in the FEMA Flood Insurance Study (FIS) model prepared originally by Michael Baker Jr., Inc. However, The WEST hydraulic analysis was based on a digital terrain model generated from updated aerial surveys completed in December of 2001. Finally, the results generated from the West existing model are referred too as the Existing Condition Baseline Model (again prior to WEST 2002 work).

Within the study reach, the Baseline Existing Condition HEC-RAS 100-year water surface elevation results are generally lower than the corresponding elevations in the FEMA Flood Insurance Study (FIS) model prepared by Michael Baker Jr., Inc. The difference in the water surface elevation can be attributed to different geometric cross section information. The FIS model geometry was reported to be based upon aerial surveys flown in 1992 and 1993. In WEST's Baseline Existing Condition model, the cross section floodplain geometry was updated between River Mile Stations 211.51 to 216.53 with one-foot contour interval mapping developed from aerial information flown in1998. In general, the comparative channel inverts for the updated cross sections were on the order of three to four feet lower than those contained in the Baker model.

A normal depth stage discharge boundary analysis was preformed at cross section I, which is approximate 1.6 miles downstream of RM 203.29. Consequently, all water surfaces are noralized and stable at the beginning of the study reach (RM 203.29).

New 35th Avenue Bridge

The City of Phoenix has designed and is planning improvements to the 35th Avenue Bridge crossing the Salt River within the study area. The purpose is to improve the safety and operation of traffic along 35th Avenue between Broadway Road and Lower Buckeye Road and to provide an all-weather crossing over the Salt River. The existing 35th Avenue Bridge across the Salt River was built in 1983 as an emergency repair project to replace a bridge that was washed out by flooding. It was built as a half-bridge and designed to accommodate the 35-year flow event, and planned to be widened and lengthened in the future.
The proposed work includes construction of a new 5-lane, 8-pier, 9-span precast concrete I-girder bridge with cast-in-place concrete deck slab to replace the existing

two-lane bridge. The bridge will be constructed upstream of the current bridge, which will be demolished after traffic is rerouted onto the new bridge. Old fill material on the north and south sides of the river will be excavated and replaced by the new bridge abutments. Rock protection will be placed at the bridge abutments to protect the new bridge. Additional fill will be removed from the river bed to allow the new bridge to convey the 100-year discharge.
Modifications to this bridge have been considered as part of the future without and future with project conditions in planning for the Rio Salado Oeste project. The new structure will be in place prior to construction of any proposal resulting from this feasibility study.

With Project Modeling

Determination of Manning's Roughness Coefficient

The maximum Manning's roughness coefficient (*n* value) that can be used in the environmental restoration area without affecting the channel capacity was determined and was correlated to plant density (or % obstruction across the cross-section). This was accomplished by using normal depth calculations for typical cross-sections along the study reach. Then the *n* value was varied horizontally across each cross-section; i.e., the *n* value was set equal to 0.032 for the low flow channel segment while it was varied for the vegetated area.

Discharge frequency values for with project condition

The 100-year discharge of 166,000 cfs was used to design the With Project Salt River floodway through the study reach. Incorporated in this design phase was the need for a low flow channel feature for 5-year peak events with capable of conveying 20,200 cfs. Details on this latter feature will be discussed under the "Low Flow Channel" section of this appendix.

Structural Features

For the With Project Condition analyses, a number of structural features were incorporated into each of the alternative evaluations. These structural features included to some degree a low flow channel, new 35th Avenue Bridge, a grade control structure, wetland creation, and some type of 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).

Low Flow Channel

Maintenance or restoration of physical aquatic habitat in streams during critical periods can often be accommodated with the development of low flow channels,

designed to concentrate flows and increase channel velocity and depth during low flow periods.

A low flow channel was included in the design along two segments of the Rio Salado Oeste study reach. Specifically, a low flow channel was designed between River Mile Station 203.39 to 207.43 and another segment between River Mile Station 209.53 to 211.52. Essentially, these two low flow segments extend downstream and upstream to the study limits from 51st and 35th Avenues respectively. Both subreaches are shown in Figure 4.

The primary purpose of the low flow channels are to increase overall conveyance within the Salt River floodway to offset the increased roughness caused by new vegetation being 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 20,200 cfs (approximately a 5-year peak event). Initial channel dimensions were based on the following general constraints: 1) an average bottom width varying between 300 to 800 feet; 2) an average flow depth of 5 to 10 feet; 3) a design slope of 0.14%; 4) constructed side slope of 1 vertical for 3 horizontal; and 5) a channel n value of 0.032. The low flow channel was configured to follow the existing river thalwag, which performed reasonably well in terms of maintaining its current alignment and general invert elevation after experiencing on approximate 40,000 cfs discharge during a February 2005 storm event. Finally, the channel design does not incorporate any lining or low flow guide or containment structures. However, based on the performance of the study reach to date, there is no evidence of any significant lateral channel migration concerns that would carry over into the with project condition.

With Future Mining

The City of Phoenix purchased approximately 250 acres of riverbed between 35th and 51st Avenues. The City has been working on a plan to lease the property for removal of aggregate in a manner that will leave the river cross section suitable for restoration. Future with project conditions assume that modifications to this reach of the river will occur prior to the project.

This area is approximately between River Station 207.62 to 209.24 (about 500 feet downstream from the 35th Avenue Bridge) and is shown in Figure 2 below.

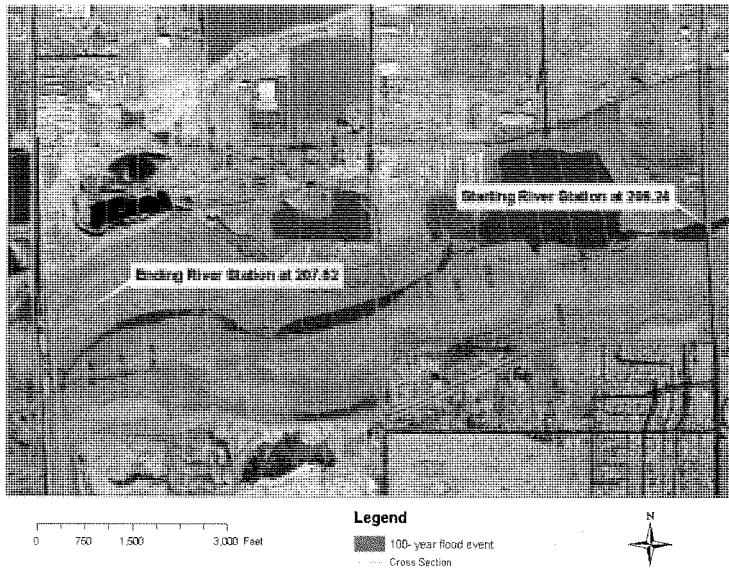

Figure 2: Location of New Mining Operation

The updated revised Existing Condition Baseline model for the Salt River between 51st and 35th Avenues reflects this future mining activity as of target year 2011. These significant channel thalweg depressions can be seen in Figure 3 below.

The associated impact on the channel and overbank in terms of modeled Manning's roughness coefficients ("n" value) were established at 0.035 and 0.043 respectively.

The peak discharges presented in the Discharge Frequency Analysis section of this appendix were used in both the Baseline Conditions and Without Project Condition model simulations.

For the 100-year frequency discharge event, the Future With Project Condition water surface elevations were compared to the original Baseline Without Project model results. The comparative resultant water surface profiles are shown in Figure 3 below.

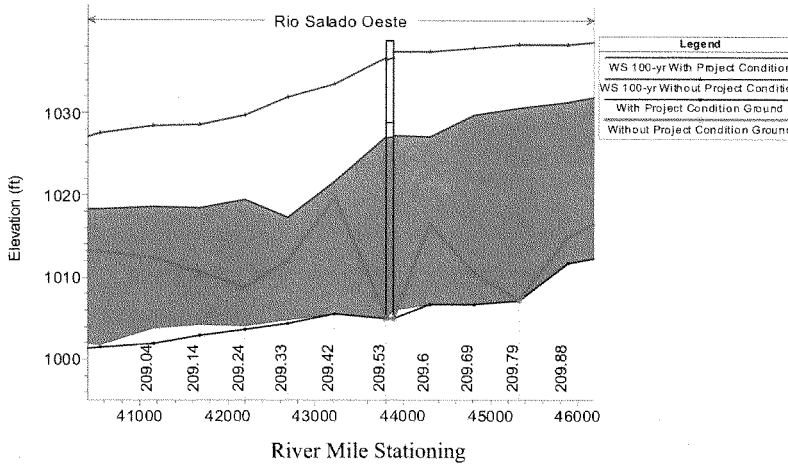

Figure 3: WS 100-yr for Without Project Condition and With Project (Future Mining Operations) Condition between River Mile Stations 209.04 to 209.88.

It was assumed that the channel Manning's roughness coefficient and the ineffective flow areas did not change from the Existing Without Project Baseline Condition or Future With Project Baseline Condition throughout most of the study area.

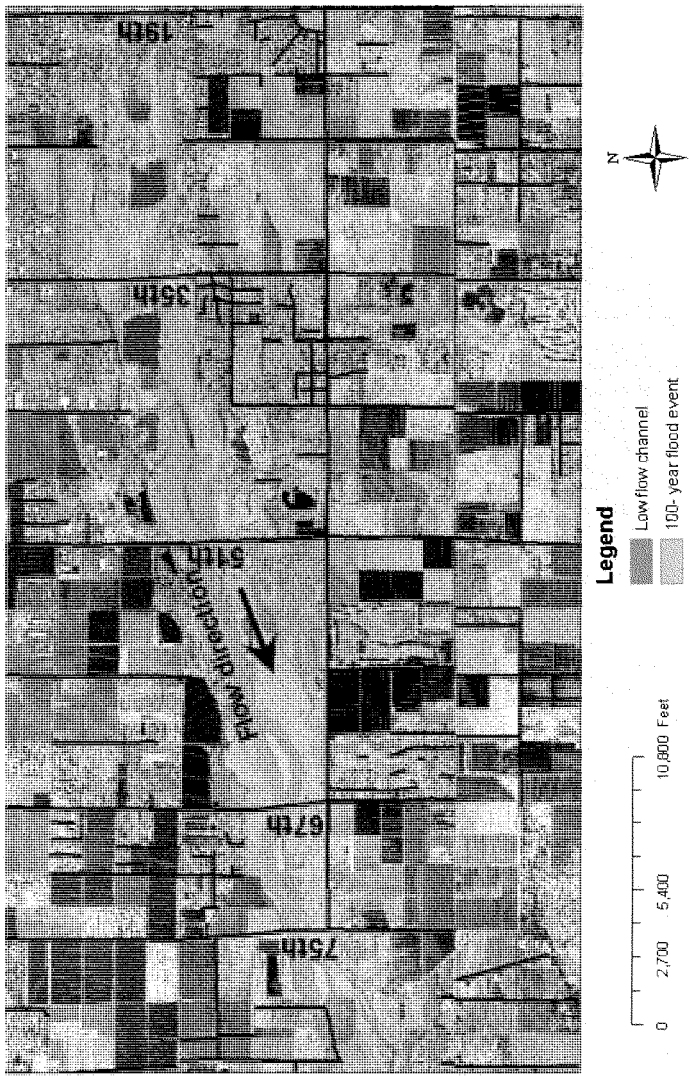

Figure 4: Low Flow Channel

Grade Control Structure

Current and projected mining along the Salt River within the study area has several large depressions. Evidence of a typical depression is identified in Figure 5 below. As expected, these areas have significant flow conveyance and sediment transport impacts within the floodplain. As a minimum, these large depressions alter the hydraulic conditions that translate into riverbed scouring and/or deposition upstream and downstream of their locations and can also potentially induce bank instability concerns as well.

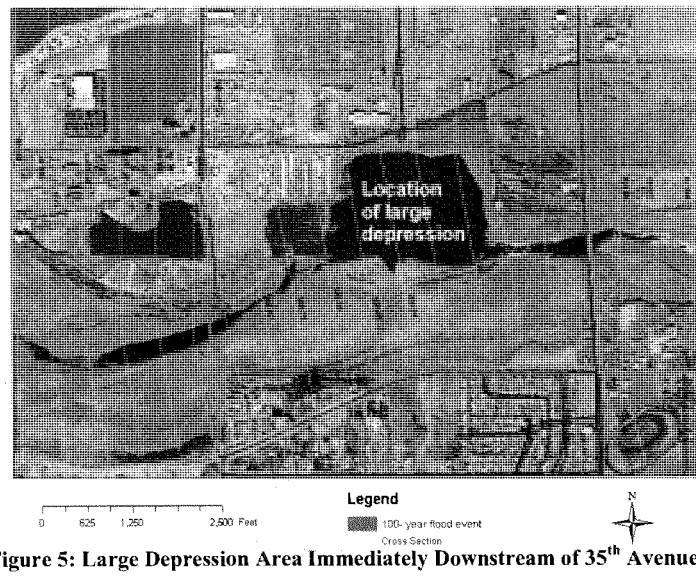

Figure 5: Large Depression Area Immediately Downstream of 35th Avenue

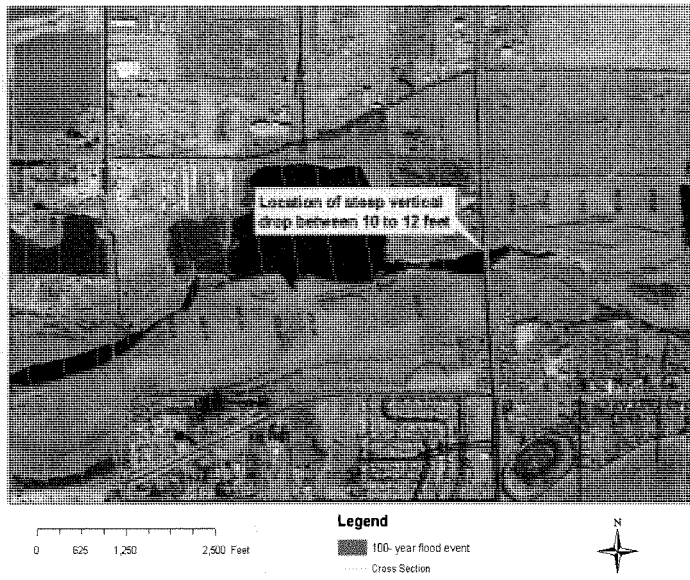

Figure 6: Steep Vertical Drop at 35th Avenue

As a direct result of the large depression and future mining (proposed modification) operation between 35th Avenue and 51th Avenue of downstream of 35th Avenue, there is a 10 to 12 feet thalweg grade break differential. The vicinity of this grade break (future gravel pit mining induced) location is shown in Figure 6 above. And also Figure 3 shows HEC-RAS water surface profile drop, between river stations 209.88 to 209.04, from 10 to 12 feet. In the likelihood that a head will propagate upstream and undermine the 35th Avenue Bridge area, a grade control structure is being recommended to prevent this particular scenario from occurring.

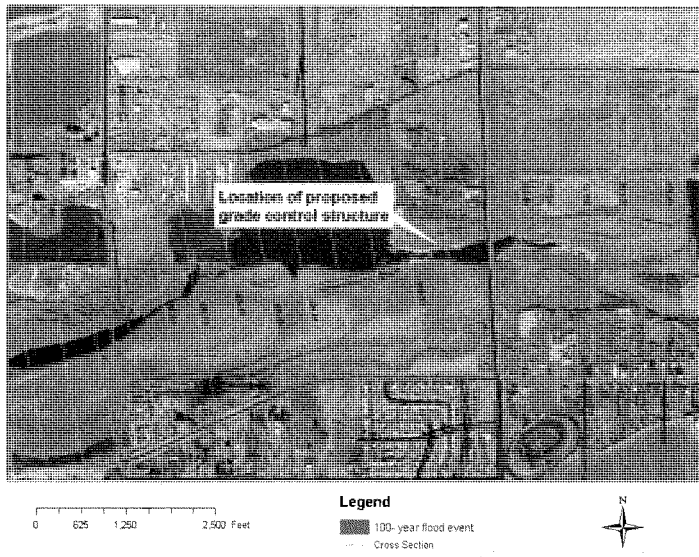

Figure 7: Proposed Location of Grade Control Structure

The proposed grade control structure would be located at approximate River Mile Station 209.42, as shown in Figure 7 above. The proposed grade control structure would extend across the full width of the floodway channel. Preliminary analyses indicate that there would be a requirement for toe protection to extend approximately 27 feet below low flow channel invert.

The grade control structure was designed based on a similar structure used in the upstream Rio Salado Phoenix Project.

Toe-Down Depths
The Veronese equation, as presented by Pemberton and Lara (1984), was used.

$$Ds = 1.32\ \Delta H^{0.225}\ q^{0.54} - y_2$$

Where Ds = depth of scour (ft)
q= unit discharge (cfs/ft)
y_2 = downstream(tailwater) depth(ft)
ΔH=difference in head from upstream reservoir to tailwater(ft)

$$Ds = 1.32 \times 10^{0.225} \times (166000/1250)^{0.54} - 10 = 21.05 \text{ ft}$$

Toe-down Depths = factor of safety x Ds = 1.3 x 21.05 = 27.36 ft

While the low flow channel is designed to convey 20,200 cfs (approximately a 5-year peak event). The grade control structure would be designed to withstand the 100-year frequency flood peak event. Tentatively, the grade control structure would be constructed out of roller compacted concrete (RCC) and would be similar in design that the two structures that are currently incorporated in the Rio Salado Phoenix project immediately upstream.

Project Features

Initially, the principle environmental project feature alternatives were developed by the study manager in close coordination with the local sponsor. These project features evolved into three distinct alternatives that were closely tied to the density level and site specific location of vegetation patterns throughout the study reach. These three unique vegetation alternatives were identified and classified as "High", "Medium", and "Low". As a further refinement and development of a final recommended alternative, the study team elected to proceed exclusively with the "High" Alternative option with its associated project features.

As discussed earlier, a HEC-RAS model was developed to assess the "with project" impacts on the Baseline Future Condition Without Project condition. The vegetation layout plan associated with this "High Alternative" is displayed in Figure 8 below. The vegetation types incorporated in this alternative included Cottonwood/Willow (CW), Emergent Wetlands (WT), and Mesquite (MS).

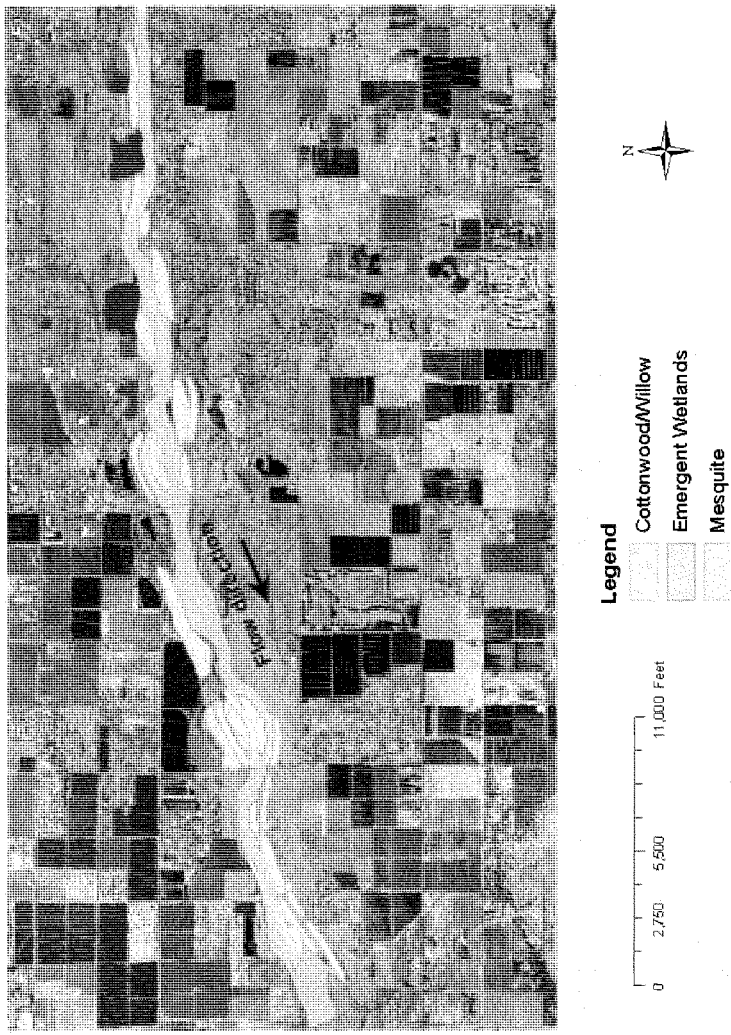

Figure 8: "High Alternative" Environmental Project Features

To properly simulate the with project conditions, several changes had to be made to the Existing Future Without Project Baseline condition model. Essentially, these changes involved modifications to the original model's ineffective flow areas and adjusting the n values where necessary. With respect to this latter item, n value in the channel and overbank on the floodplain terrace were increased to 0.037 and 0.043 respectively. The increases were required to offset the additional roughness associated with greater surface irregularities, channel cross section variation, and more increased vegetation channel obstruction.

With Project Results

Multiple Discharge Analysis

Since the With Project water surface profiles associated with the 3.1-, 5-, 10-, 20-, 50, 100-, 200-, and 500-year frequency flood events are similar to that of the 100-year frequency flood event (with the exception of magnitude), only the 100-year With Project model results were displayed in this document. Figure 9 below captures the With- and Without Future Condition water surface profile for subject study reach.

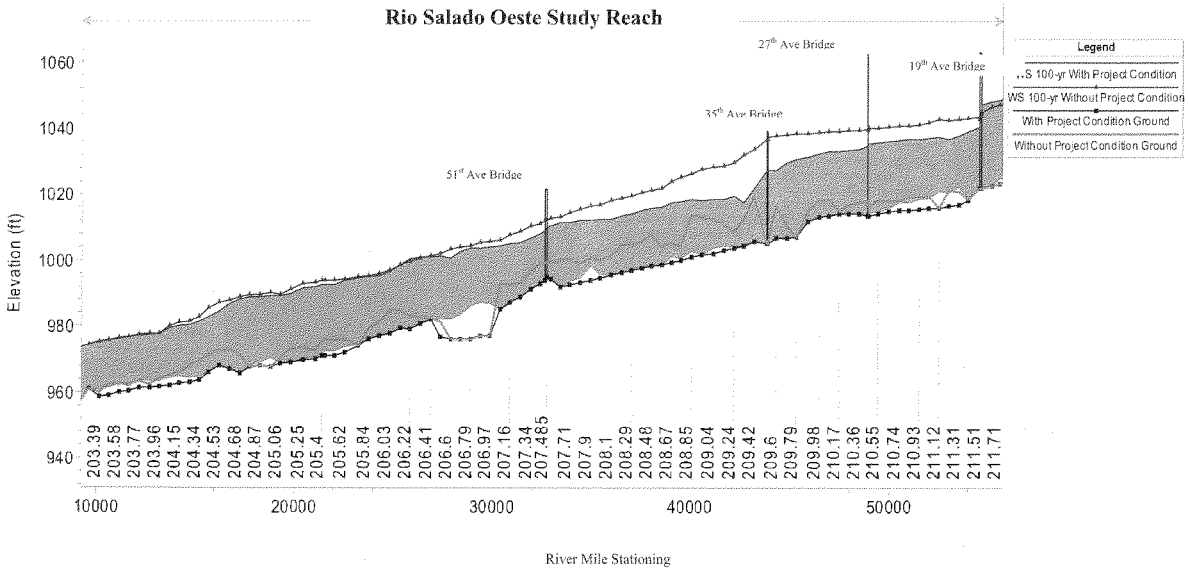

Figure 9: 100-Year Event Water Surface Profile

100-Year Event Discharge Analysis

Corresponding Table 6 below shows pertinent hydraulic 100-year flood frequency event peak discharge information for both With- and Without Project conditions.

Table 6: 100-Year Flood Frequency Event Peak Discharge Analysis for With- and Without Project Conditions

River Station	Q (cfs)	Water Surface Elevation (ft)		Minimum Channel Elevation (ft)		Water Depth (ft)		Average Velocity (ft/s)	
		W/O	W/	W/O	W/	W/O	W/	W/O	W/
211.51	166000	1043.35	1040.29	1021.80	1021.90	21.55	18.39	15.98	22.46
211.41	166000	1043.08	1039.00	1018.30	1018.80	24.78	20.20	13.64	19.08
211.31	166000	1042.54	1037.64	1020.80	1022.20	21.74	15.44	12.61	16.87
211.21	166000	1042.33	1036.74	1021.10	1020.40	21.23	16.34	10.31	13.73
211.12	166000	1042.59	1037.41	1015.67	1020.90	26.92	16.51	7.25	7.58
211.02	166000	1041.67	1036.93	1019.35	1018.90	22.32	18.03	9.46	7.33
210.93	166000	1041.02	1036.78	1018.71	1018.50	22.31	18.28	10.04	6.10
210.83	166000	1040.64	1036.52	1019.14	1017.30	21.50	19.22	9.53	6.14
210.74	166000	1040.56	1036.18	1018.18	1017.40	22.38	18.78	8.11	5.93
210.64	166000	1040.35	1035.84	1017.72	1015.90	22.63	19.94	7.69	6.19
210.55	166000	1040.15	1035.55	1018.02	1014.60	22.13	20.95	7.35	5.43
210.46	166000	1040.03	1035.27	1016.27	1014.30	23.76	20.97	6.80	5.75
210.44	166000	1039.70	1034.82	1017.63	1013.53	22.07	21.29	7.84	7.96
210.43	166000	1039.50	1034.54	1017.52	1013.51	21.98	21.03	7.96	8.00
210.36	166000	1039.29	1033.49	1017.39	1013.92	21.90	19.57	7.19	9.60
210.26	166000	1039.19	1033.28	1016.87	1014.21	22.32	19.07	5.92	7.86
210.17	166000	1039.07	1032.88	1014.74	1013.98	24.33	18.90	5.23	7.54
210.07	166000	1039.05	1032.91	1018.47	1013.50	20.58	19.41	3.98	5.22
209.98	166000	1038.75	1032.31	1018.07	1013.00	20.68	19.31	5.02	6.81
209.88	166000	1038.41	1031.34	1014.72	1011.65	23.69	19.69	5.72	7.71
209.79	166000	1038.28	1030.57	1020.00	1007.14	18.28	23.43	5.27	6.94
209.69	166000	1037.97	1029.71	1019.00	1006.78	18.97	22.93	5.89	7.79
209.6	166000	1037.51	1027.05	1016.38	1006.68	21.13	20.37	7.36	12.71
209.54	166000	1037.47	1027.26	1005.00	1006.00	32.47	21.26	5.27	8.56
209.53	166000	1036.69	1027.05	1005.00	1005.00	31.69	22.05	5.42	8.39
209.42	166000	1033.54	1021.71	1019.56	1005.50	13.98	16.21	13.47	17.49
209.33	166000	1031.92	1017.29	1019.07	1004.80	12.85	12.49	12.55	19.38
209.24	166000	1029.65	1019.51	1017.41	1004.10	12.24	15.41	14.08	6.18
209.14	166000	1028.58	1018.60	1014.45	1004.20	14.13	14.40	11.42	8.61
209.04	166000	1028.34	1018.52	1012.24	1003.80	16.10	14.72	8.72	6.00
208.95	166000	1027.44	1018.35	1013.05	1001.70	14.39	16.65	9.57	5.18
208.85	166000	1026.09	1018.31	1013.35	1002.50	12.74	15.81	9.79	4.25
208.75	166000	1025.17	1017.93	1011.00	1000.70	14.17	17.23	8.92	5.70
208.67	166000	1023.79	1017.37	1010.00	1000.80	13.79	16.57	10.06	7.38
208.57	166000	1021.83	1015.95	1010.00	998.70	11.83	17.25	11.58	10.76
208.48	166000	1021.28	1015.72	1007.62	998.10	13.66	17.62	8.44	9.01

River Station	Q (cfs)	Water Surface Elevation (ft)		Minimum Channel Elevation (ft)		Water Depth (ft)		Average Velocity (ft/s)	
		W/O	W/	W/O	W/	W/O	W/	W/O	W/
208.39	166000	1020.35	1015.17	1005.57	997.50	14.78	17.67	8.58	8.09
208.29	166000	1019.47	1013.97	1004.70	996.79	14.77	17.18	8.13	9.45
208.19	166000	1018.78	1013.55	1004.66	996.10	14.12	17.45	7.40	8.23
208.1	166000	1017.96	1012.33	1001.33	995.80	16.63	16.53	7.23	9.38
207.99	166000	1016.85	1012.39	999.85	995.70	17.00	16.69	7.85	5.55
207.9	166000	1016.26	1012.15	1000.76	998.10	15.50	14.05	6.73	5.04
207.8	166000	1015.28	1011.96	999.08	994.60	16.20	17.36	7.69	4.62
207.71	166000	1014.31	1011.55	1000.34	993.70	13.97	17.85	8.15	5.12
207.62	166000	1012.94	1011.28	1000.23	992.00	12.71	19.28	9.61	5.40
207.53	166000	1012.59	1010.23	999.27	994.37	13.32	15.86	7.48	8.88
207.49	166000	1012.38	1009.97	999.41	994.96	12.97	15.01	7.48	8.70
207.48	166000	1012.05	1009.08	999.23	994.04	12.82	15.04	7.72	9.05
207.43	166000	1011.14	1008.14	999.03	992.99	12.11	15.15	9.33	10.50
207.34	166000	1010.29	1006.54	996.54	991.22	13.75	15.32	9.80	11.75
207.27	166000	1008.74	1005.31	993.27	988.96	15.47	16.35	11.10	11.64
207.16	166000	1007.70	1004.84	992.67	987.06	15.03	17.78	9.58	9.23
207.07	166000	1006.06	1004.22	992.78	985.20	13.28	19.02	11.78	9.07
206.97	166000	1005.79	1003.89	992.70	986.80	13.09	17.09	8.32	7.75
206.88	166000	1005.42	1003.76	992.60	987.00	12.82	16.76	7.69	6.26
206.79	166000	1004.38	1003.53	993.00	986.30	11.38	17.23	9.34	5.89
206.7	166000	1004.10	1002.72	991.20	983.50	12.90	19.22	7.20	7.64
206.6	166000	1003.43	1000.44	990.50	982.10	12.93	18.34	7.88	11.95
206.51	166000	1002.10	1001.39	990.20	982.00	11.90	19.39	10.43	5.04
206.41	166000	1001.20	1001.05	988.80	982.20	12.40	18.85	9.49	6.00
206.32	166000	1000.48	1000.83	987.40	981.00	13.08	19.83	8.09	6.25
206.22	166000	999.54	1000.35	986.00	979.16	13.54	21.19	8.06	6.82
206.13	166000	998.57	998.72	984.62	979.43	13.95	19.29	7.99	9.61
206.03	166000	996.94	996.48	984.67	977.85	12.27	18.63	9.84	11.73
205.94	166000	995.95	995.37	981.52	977.00	14.43	18.37	8.08	7.50
205.84	166000	995.38	995.14	979.54	975.96	15.84	19.18	6.80	4.47
205.75	166000	994.73	994.44	973.88	974.50	20.85	19.94	7.06	6.34
205.62	166000	994.28	993.94	975.97	973.60	18.31	20.34	6.18	4.43
205.52	164000	994.03	992.62	975.91	972.20	18.12	20.42	5.68	7.76
205.43	164000	993.74	992.52	976.08	972.20	17.66	20.32	5.99	6.25
205.4	164000	993.73	992.47	975.49	971.80	18.24	20.67	5.29	5.39
205.34	164000	993.37	992.02	972.70	970.70	20.67	21.32	6.53	6.96
205.25	164000	992.88	991.63	973.42	969.90	19.46	21.73	6.93	6.84
205.15	164000	991.15	989.89	973.07	969.00	18.08	20.89	10.75	10.58
205.06	164000	989.65	989.02	970.41	968.50	19.24	20.52	10.77	10.39
204.97	164000	990.01	989.22	967.59	970.30	22.42	18.92	5.62	6.59
204.87	164000	989.45	988.96	968.08	968.90	21.37	20.06	6.94	6.04
204.78	164000	989.39	988.75	967.60	967.90	21.79	20.85	5.08	4.16
204.68	164000	988.71	988.16	971.32	965.54	17.39	22.62	7.22	5.96
204.61	164000	987.92	986.83	972.56	966.95	15.36	19.88	8.55	7.71
204.53	164000	987.03	984.42	972.73	968.00	14.30	16.42	8.73	10.40
204.42	164000	985.49	982.89	971.40	965.98	14.09	16.91	9.64	10.54

River Station	Q (cfs)	Water Surface Elevation (ft)		Minimum Channel Elevation (ft)		Water Depth (ft)		Average Velocity (ft/s)	
		W/O	W/	W/O	W/	W/O	W/	W/O	W/
204.34	164000	982.74	981.44	969.27	964.50	13.47	16.94	12.19	10.94
204.25	164000	981.35	980.52	967.99	964.10	13.36	16.42	10.54	9.76
204.15	164000	981.23	980.14	965.87	964.70	15.36	15.44	7.14	7.41
204.05	164000	980.23	979.29	964.99	964.10	15.24	15.19	8.49	7.90
203.96	164000	977.57	977.80	964.14	963.20	13.43	14.60	11.99	9.69
203.86	164000	977.66	977.41	962.22	963.40	15.44	14.01	6.92	7.21
203.77	164000	977.24	976.94	963.26	963.70	13.98	13.24	6.50	6.60
203.67	164000	976.81	976.66	962.27	961.40	14.54	15.26	6.47	5.85
203.58	164000	976.33	976.08	962.07	962.10	14.26	13.98	6.54	7.06
203.48	164000	975.83	975.76	962.18	961.30	13.65	14.46	6.48	5.99
203.39	164000	975.18	975.24	959.89	960.60	15.29	14.64	6.57	6.04

W/ -With Project condition
W/O -Without Project condition

Minor Water Surface Anomalies

The only significant changes that occurred when introducing the With Project features on the Without Project Baseline conditions were observed between River Mile Stations 206.13 to 206.32. The water surface profile through this area is displayed in Figure 10 below while the corresponding water surface elevation differentials are shown in Table 7.

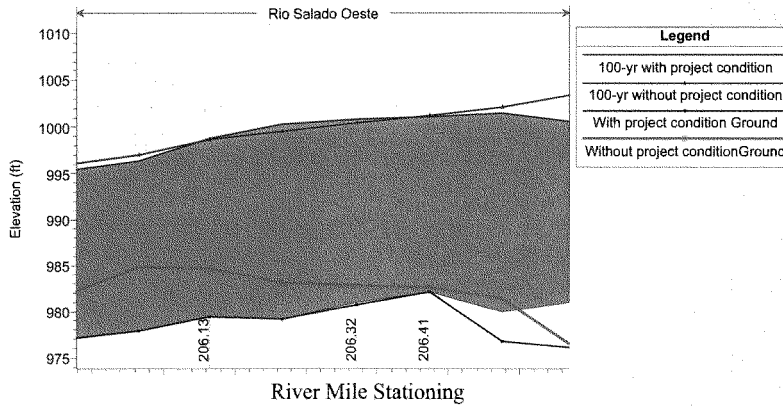

Figure 10: 100-Year Flood Frequency Event Water Surface Profile for River Station between 206.13 and 206.32

Table 7: 100-Year Flood Frequency Event Comparative Water Surface Elevation Differentials Between River Mile Station 206.32 to 206.13

River Station	100- year event discharge (cfs)	Project Condition	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Difference in Water Surface between W/ and W/O (ft)
206.32	166000	W/O	987.40	1000.48	
206.32	166000	W/	981.00	1000.83	0.35
206.22	166000	W/O	986.00	999.54	
206.22	166000	W/	979.16	1000.35	0.81
206.13	166000	W/O	984.62	998.57	
206.13	166000	W/	979.43	998.72	0.15

W/ - With Project condition
W/O – Without Project condition

A detailed assessment of the areas in which the With Project water surface elevations are higher than the Without Project Baseline conditions is noted in the accompanying effected River Mile cross sections. Upon a closer examination of Figures 11,12, and 13 below indicate that there would be minimal flood damages since the overbanks are essentially higher in both the With- and Without Project condition.

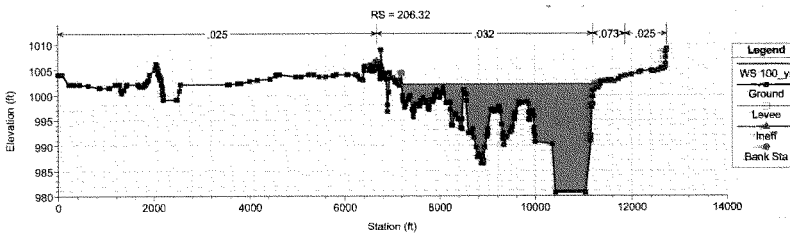

Figure 11: Cross Section at River Mile Station 206.32

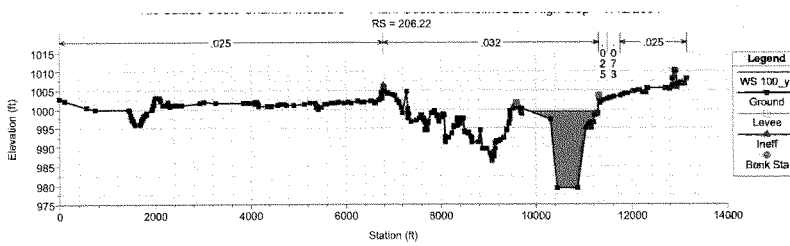

Figure 12: Cross Section at River Mile Station 206.22

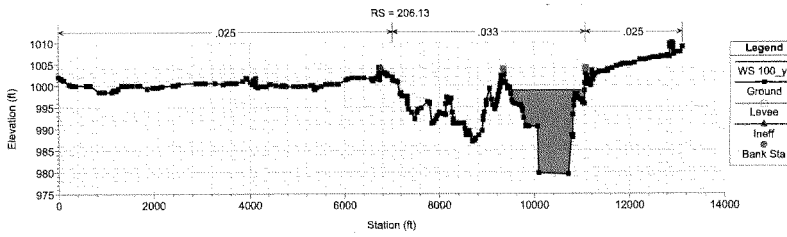

Figure 13: Cross Section at River Mile Station 206.13

However, if flood damages are in fact significantly increased, then further hydraulic modifications will be made during the later feasibility phases to accommodate a more acceptable pre-project condition.

Overall With Project water surface elevations were decreased from River Mile Stations 203.39 to 207.48 and also from River Mile Stations 209.53 to 211.51 as a direct result of the incorporation of a low flow channel feature. Finally, the water surface elevations were also decreased between River Mile Station 207.62 to 209.42 as a direct consequence of channel mining activity.

EDIMENTATION ANALYSIS

'ithout Project

A detailed Without Project sediment transport analysis was performed for this study and the results are contained in the F3 Without Project Final Hydraulic Analysis Report. Specifically, the report titled Rio Salado Oeste Study Without Project Final Hydraulic Analysis Report (June 2002) was prepared under contract by WEST Consultants, Inc.

eneral

The objective of the sediment transport analysis is to identify baseline sediment conditions, which will be used with later alternative conditions studies to identify the preferred project alternatives. A base conditions sediment transport model was created using the geometry from the existing conditions hydraulic model.
The computer program HEC-6T "Sedimentation in Stream Networks", version 5.13.15 of May 24, 2001, was used to conduct the numerical sediment transport modeling in this study. HEC-6T was developed by Mr. William A. Thomas of Mobile Boundary Hydraulics, Clinton, Mississippi.

EC-RAS Model Conversion

odel Geometry

The geometry of the hydraulic model was converted into a text file with the format required by the HEC-6T program. Roughness coefficients in several cross sections of the hydraulic model vary horizontally with distance in the cross section. HEC-6T does not allow as much horizontal variation of Manning's n, so an alternative method of expressing the roughness coefficient was required. After running the 5-, 10-, 20-, 50-, 100- and 500-year flood events in HEC-RAS, the profile output tables were used to request conveyance weighted Manning's n values for the channel, left and right overbanks for the different discharges. These data were then entered into the HEC-6T input file using NV records. A default value of 0.04 was used to fill blanks when the conveyance in an overbank area was zero. The result was a configuration of roughness coefficients changing in the vertical by discharge rather than in the horizontal by distance.

Conveyance limits defined in HEC-RAS using ineffective flow boundaries were coded using XL records in HEC-6T. The advantage of using XL records is that they allow deposition to occur in the ineffective flow areas. The effect of bridges crossing the river in the study area was accounted for using a single cross section with the pier geometry superimposed as recommended in the HEC-6T manual. Of the two bounding cross sections used to define each bridge in HEC-RAS, only the upstream one was retained in HEC-6T. The two bounding cross sections are very close to each other and keeping both in HEC-6T could cause numerical instabilities.

ixed Bed Simulation

An elevation-discharge rating curve was developed at the downstream boundary (cross section 1) for starting water surface elevations. Water surface elevations were computed at this location assuming normal depth and a slope of 0.0019 ft/ft, for discharge values ranging from 7,500 cfs to 285,000 cfs, at 7,500 cfs increments (Figure 14).

HEC-6T was then run with a fixed bed using the 5-, 10- and 100-year flood events, and the resulting water surface elevations were compared to the HEC-RAS existing conditions model. In order to guarantee the quality of the sediment model, the water surface elevations computed by HEC-6T for each of the three events were examined at each cross section to ensure that they did not differ from the HEC-RAS results by either 10% of the maximum depth or 1 foot, whichever was less.

ediment Parameters

The Corps computer program SAMAID was used to select the most appropriate sediment transport relationship. SAMAID results indicated that Madden's 1985 modification of Laursen's equation and Yang's equation were respectively best and second best sediment transport relations for the characteristics of the study reach. Schoklitsch's equation came out in third place. WEST has used Yang's equation in the past on the Salt River upstream and downstream of the project site. In general, this equation performs well for mid sized rivers transporting large amounts of sand,

which is typical of many streams in Arizona. Therefore, the sediment transport equation selected for this study was Yang's unit stream power.

Bed Sediment Characteristics

Nineteen locations were identified for sediment sampling and development of gradation curves. Sampling sites were located approximately 0.5 miles apart, from 19th Avenue to 91st Avenue. Samples were collected from 0 to 2 feet, and laboratory grain-size analyses were performed on the samples. In addition, an in-situ particle count consisting of 100 particles spaced at 1 foot intervals was performed. Bed gradation data were entered into the HEC-6T input file using PF records.

Inflowing Sediment Rating Curve

Recorded information about sediment loads in the Salt River upstream of the study reach is not available. There are however previous studies reporting sediment transport simulations. One of these studies is the Low Flow Channel Design Analysis for Rio Salado (2000) performed by WEST for the Corps. This study presented a sediment transport model of the Salt River from approximately the I-10 Bridge to the 27th Avenue alignment, based on the Toffaleti, Meyer-Peter and Muller combination transport method. The model used an estimated sediment inflow at the upstream end of the reach based on an equilibrium bed material load analysis performed on a 0.5 mile reach upstream of I-10.

The simulated loads from this previous study were not considered appropriate inflow loads to our model because they were not developed using any of the sediment transport equations identified as suitable for the current study (Yang's equation or Madden's 1985 modification of Laursen's equation). If a sediment inflow based on a different equation was used in the current model, depending on the amount of the sediment loads, there is a possibility that it could lead to either unrealistic erosion or deposition in the upstream end of our study reach.

Since we were confronted with a lack of adequate data on inflowing sediment loads into our study reach, an equilibrium bed material load was assumed. The inflowing load at the upstream end of the model was determined on a reach approximately 3 miles long at the upstream end of the study reach (from RM 211.21 to RM 214.14) with the gradation information from the two most upstream sediment sample locations. Equilibrium sediment loads for this reach were determined for a range of discharges from 20 to 200,000 cfs. To determine the equilibrium load, HEC-6T was run using clear water inflow as the initial condition and the recirculation option on ($RE record). The recirculation option instructs the program to use the sediment discharge at the downstream end of the reach as the sediment inflow at the upstream end for the following time step. When equilibrium is attained, sediment load entering the reach is about equal to the load leaving the reach. For discharges between 20 and 50000 cfs, the simulations were run typically for 10 to 100 days with time steps in the

order of 0.01 to 0.1 days. For larger discharges (100,000 to 200,000 cfs), typical durations were between 5 and 10 days with time steps of 0.001 to 0.01 days.

The inflowing sediment loads defined with Yang and Laursen-Madden relationships are shown in Figures 15 and 16. The gradation of the inflowing load from the equilibrium analysis is shown in Figures 17 and 18. This information was entered into the HEC-6T input files using LQ, LT and LF records.

Movable Bed Limits

In general, sediment dynamics tend to be more significant within the active channel, where the bed can either degrade or aggrade in response to erosion or deposition. The overbank areas tend to be more stable and normally are free of erosion, but can experience deposition. HD records were used to specify a bed sediment depth of 20 feet for all cross sections but one. At river mile 211.54 the sediment depth was set to zero to account for the grade control structure located immediately downstream of the 19th Avenue Bridge. Movable bed limits were not identified in the HD records, implying that deposition could occur anywhere in the wetted perimeter. In addition,

HE records were used to limit erosion within the channel bank stations.
In order to develop a sound hydraulic model, the mining pits, in particular those located in the channel, were blocked to ensure a solution with a subcritical water profile along the reach. However, when flooded, the mining pits will likely act as sediment traps. For that reason, the sediment deposited on top of the blocked areas within or next to the channel was removed from the system using the dredging options in HEC-6T. HI records were used to identify the areas where sediment should be removed in the case that deposition took place, and the $DREDGE record was used to instantaneously take away the deposited sediment after each time step. In addition, when mining pits were located in the channel, the HE limits were relocated to exclude the pit from the area of potential erosion.

Hydrology

A continuous 50-year hydrograph consisting of historical flows between 1889 and 1938 was provided by the Corps. This flow series corresponds to the "worst case" continuous 50-year period, in terms of both peak flows and storm volumes, within the 105 years of record, from 1889 to 1993. Discharges less than 20 cfs were removed from the hydrology since no sediment was transported for flows of 20 cfs or less. Simulations were performed with the 50-year hydrograph, with simulation results requested by decade. Figure 19 shows the complete 50-year hydrologic input and identifies the end of each decade.

Results

The sediment transport analysis results are presented in terms of average bed elevation by decade (Figure 20). The average bed elevation corresponding to a 10,000

cfs discharge of very short duration (0.00001 days) was computed in HEC-6T at 10-year intervals. This discharge was selected to generate average bed elevations because, in general, it provided coverage of the channel bottom (HEC-6T computes average bed elevations only from "wetted" points of the cross sections). The 10,000 cfs discharge is used only to generate output, and the short duration minimizes sediment movement.

The results show two distinct areas with respect to sediment dynamics. Downstream of 35th Avenue the reach mainly experiences degradation, with deposition limited to just a few cross sections. One of the depositional areas is defined by cross sections 203.58 to 203.86, and corresponds to an abandoned mining operation. The end result is a channel with a more homogenous bed slope. There are two areas downstream of 35th Avenue where the model predicts severe erosion:

- The first one is defined by cross sections 206.7 to 206.97. This is an area with active mining pits in the channel and a small berm to prevent low flows into the pit. The small flows (the majority in the hydrologic input) are then confined to a channel just about 200 feet wide resulting in severe degradation. Due to the limitations of the model (1-D steady state) it is not possible to simulate the complex interaction that may occur between the mining pit and the channel. The flows could very well breach the berm and enter the pit, limiting degradation in the channel but creating a headcut that would progress upstream.
- The second area corresponds to cross sections 209.24 to 209.54. This is another mined reach with pits on the right overbank and channel in cross sections 209.24 and 209.33. Cross section 209.54 represents the small bridge opening at 35th Avenue. Erosion in this case is associated with the cross sectional area reduction and velocity increase caused by the bridge.

Upstream of the 35th Avenue Bridge the bed slope is milder. That, along with the backwater effect of the bridge, creates the conditions for sediment deposition in most of the cross sections.
In general, average bed elevation changes are more significant in regions of the reach that are currently affected by mining operations in the channel. Where mining is not an issue, average bed changes reach a maximum of 5.8 ft after 50 years of sediment transport, with an average change of 1.9 ft.

During the simulations most of the bed changes took place in the first decade, with minor adjustments occurring in the remaining time. The first decade contained the flow events with the two largest peaks. In addition, it can be seen that the trend observed after the first decade is sometimes reversed after subsequent decades. This is a consequence of both changes in the cross section geometry with time, and changes in sediment dynamics associated with flows of very different magnitudes. Appendix H shows plots comparing the cross sections before and after the sediment transport analysis.

Sensitivity Analysis

The purpose of the analysis was to explore the sensitivity of the sediment transport model to variations in the parameters, in an attempt to determine the appropriateness of the selected values. Sensitivity runs were performed on the base conditions HEC-6T input file to determine the relative effect of changes to Manning's n, inflowing sediment load, and transport equation to the average bed elevation profiles. Results in tabular and graphic format are provided in Appendix I.

Hydraulic Roughness

The sensitivity of the sediment transport model to the hydraulic roughness coefficients was examined. The base conditions sediment transport model results have been compared to simulation outputs resulting from increasing and reducing all Manning's n coefficients in the input file by 25%.

After 50 years of simulating sediment dynamics, the high roughness profile is generally higher than the base condition profile. This is the result of deposition or reduced scour due to reduced flow velocities caused by the higher roughness coefficients. On the other hand, the low roughness profile is generally lower than the base conditions profile because of higher flow velocities. The average bed profile change was 0.7 ft for high roughness and 1.2 ft for low roughness, implying that small errors in the roughness coefficients selected for the base conditions model probably will not have a significant effect on the results.
The largest differences occur in mined reaches, where a 25% increase in Manning's n can reduce erosion by as much as 3.7 ft, and a 25% decrease in Manning's n can augment erosion by as much as 5.9 ft.

Inflowing Sediment Load

The effect of the inflowing sediment load has been assessed by comparing the base conditions sediment transport model with simulation results after increasing and reducing the sediment discharge to twice and half the equilibrium load determined with Yang's equation.

The most important differences can be observed upstream of the 35th Avenue Bridge. In the reach between cross sections 210.07 and 211.34 the double-inflow profile elevation increases an average of 0.6 ft with respect to the base condition, while for the half inflow profile it decreases an average of 0.5 ft. Downstream of 35th Avenue the differences are reduced as the sediment load reaches equilibrium.

Sediment Transport Equation

Simulation results generated with Yang's unit stream power equation have been compared to the simulation results produced with Madden's 1985 modification of Laursen's sediment transport equation.

The two equations yield bed profiles with the same trends in terms of degradational and agradational areas, with slight differences in the depth of eroded or deposited material. The main differences appear at the upstream end of the study reach. The upstream end of the reach is a transition between a narrow segment with levees in both banks and a wider segment severely disturbed by mining operations. It is not surprising that the model results show some instability in this area, until a new equilibrium is reached a little distance downstream. Laursen's equation, as modified by Madden, seems more susceptible to this effect than Yang's equation.

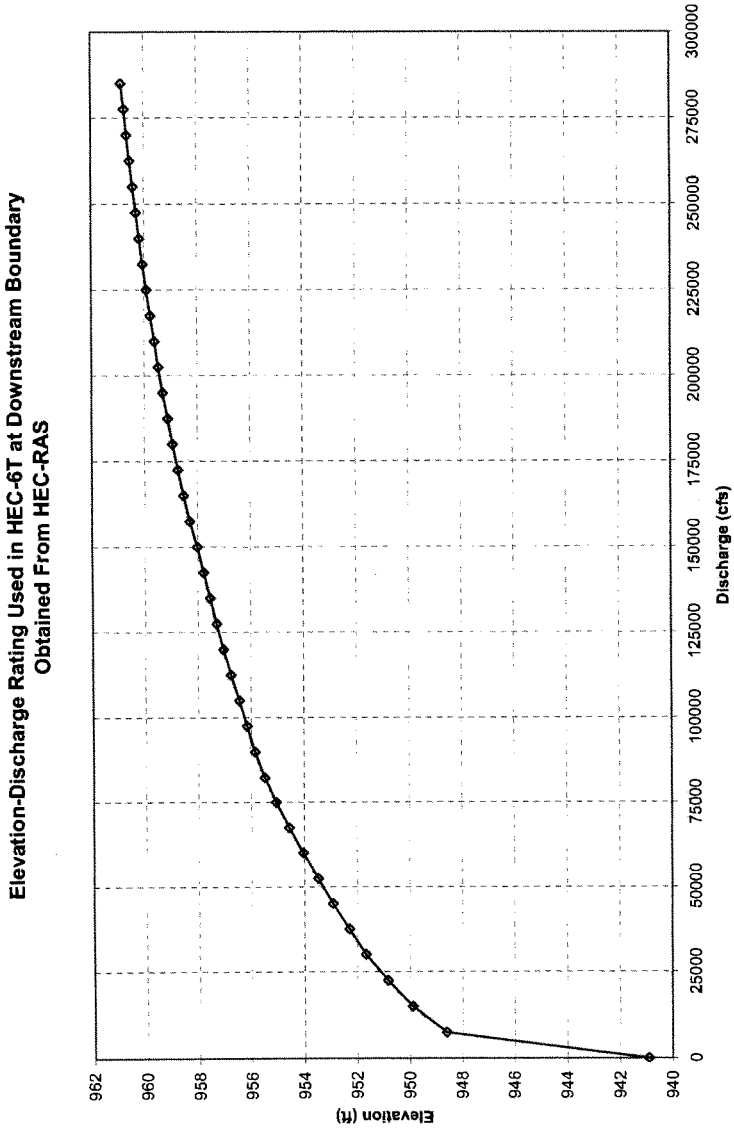

Figure 14: Rating curve at downstream end of sediment transport model.

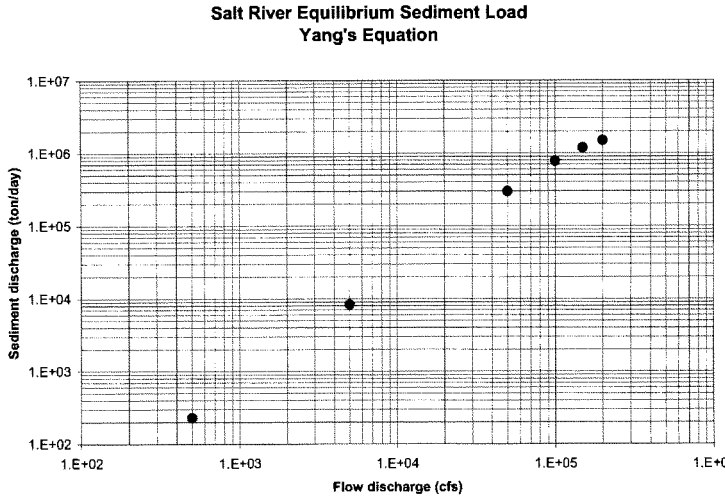

Figure 15: Equilibrium sediment load with Yang's equation.

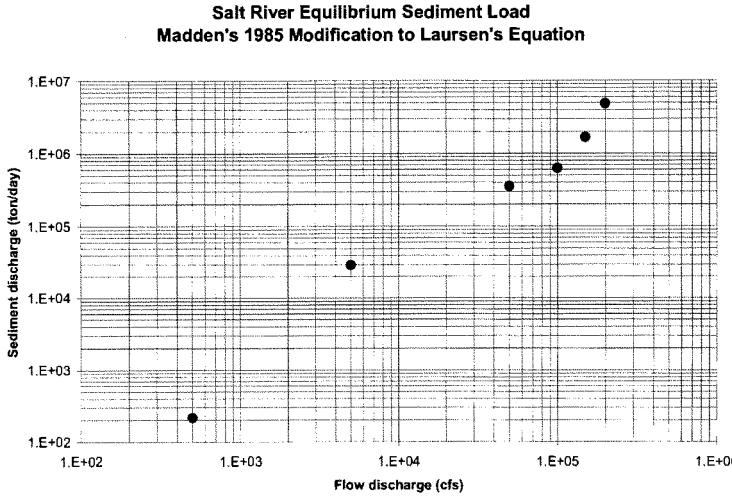

Figure 16: Equilibrium sediment load with Laursen-Madden's relation.

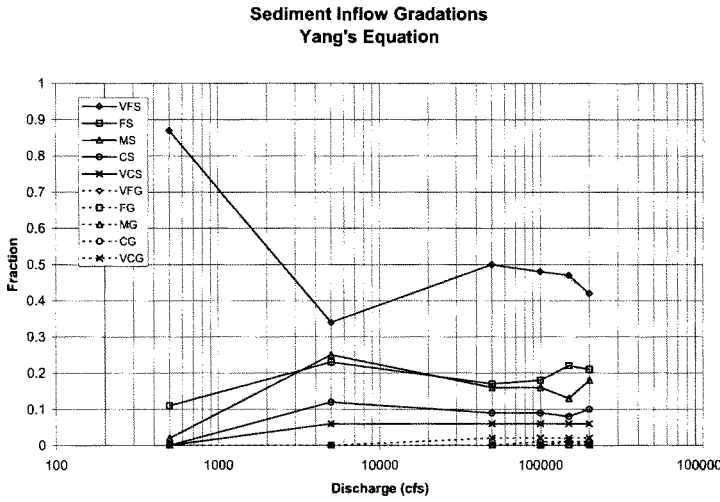

Figure 17: Sediment inflow gradations with Yang's equation.

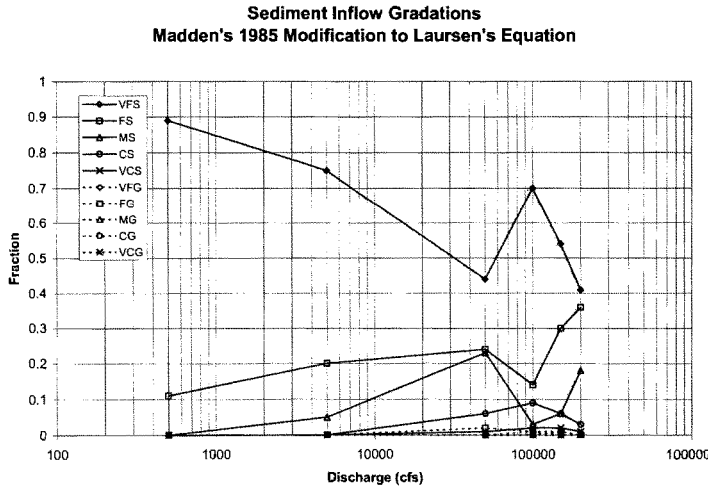

Figure 18: Sediment inflow gradations with Laursen-Madden's relation.

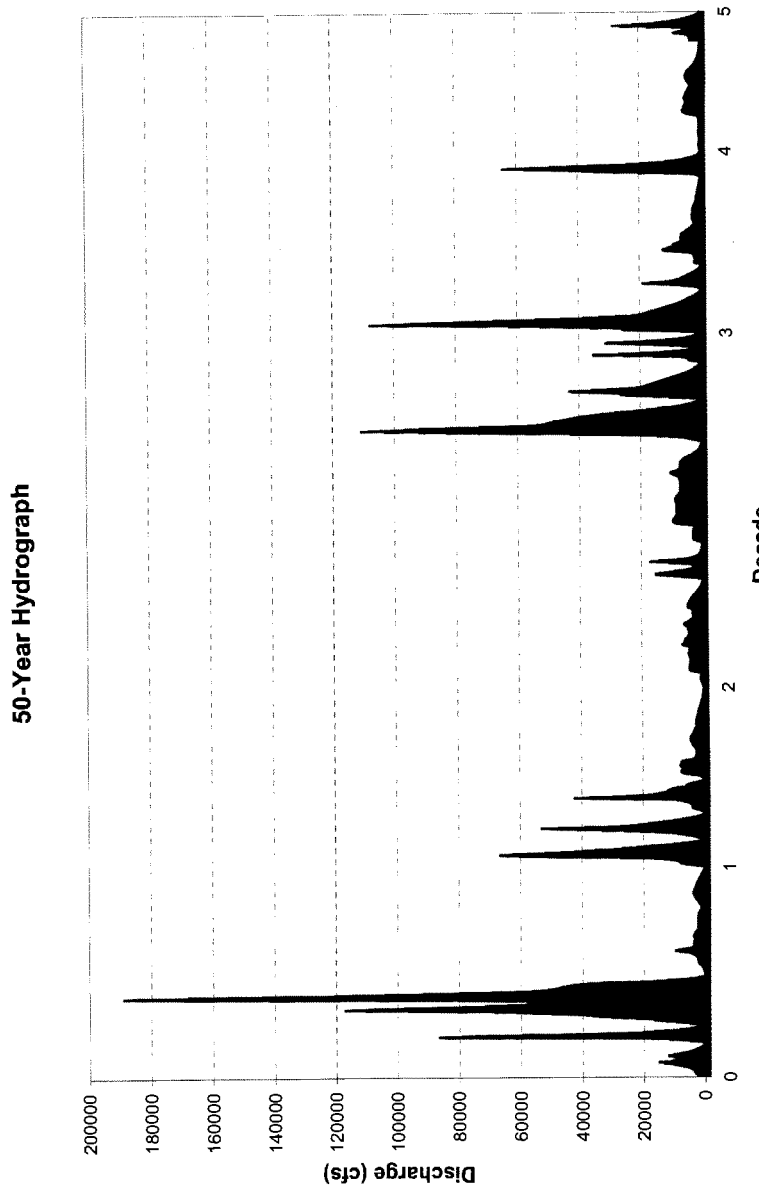

Figure 19: 50-year hydrograph used to run the sediment transport model.

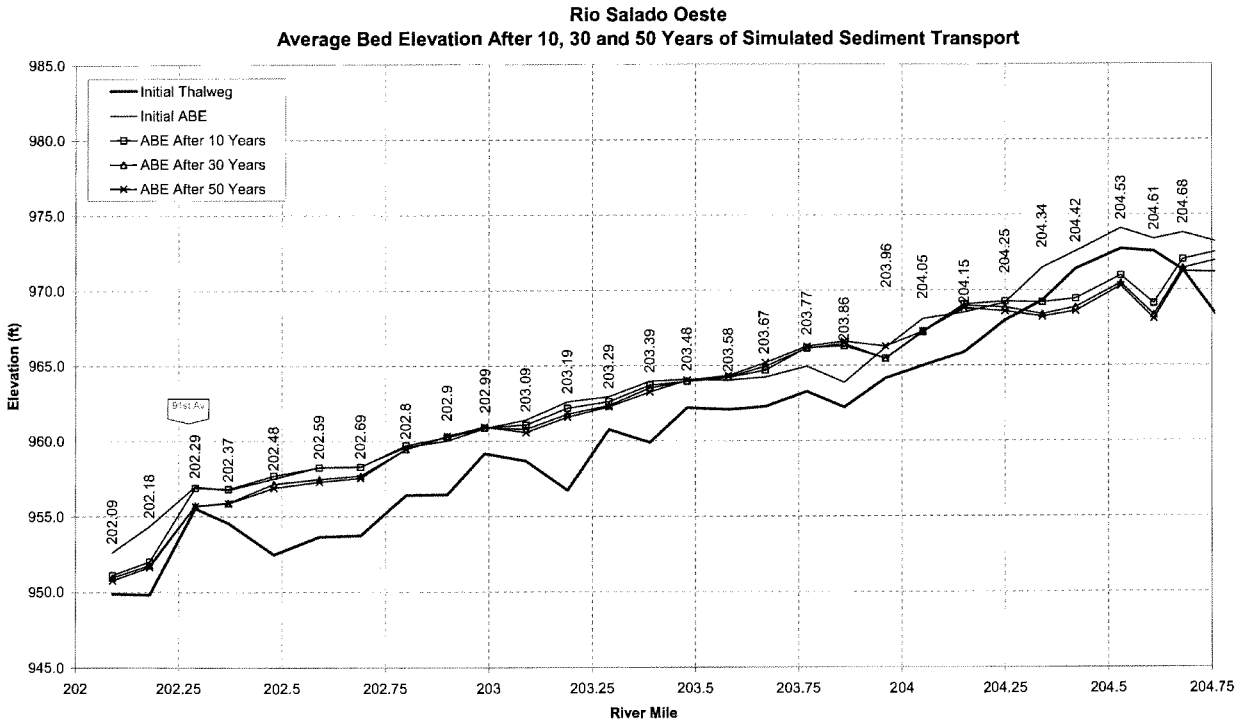

Figure 20: Simulated average bed elevation for selected decades.

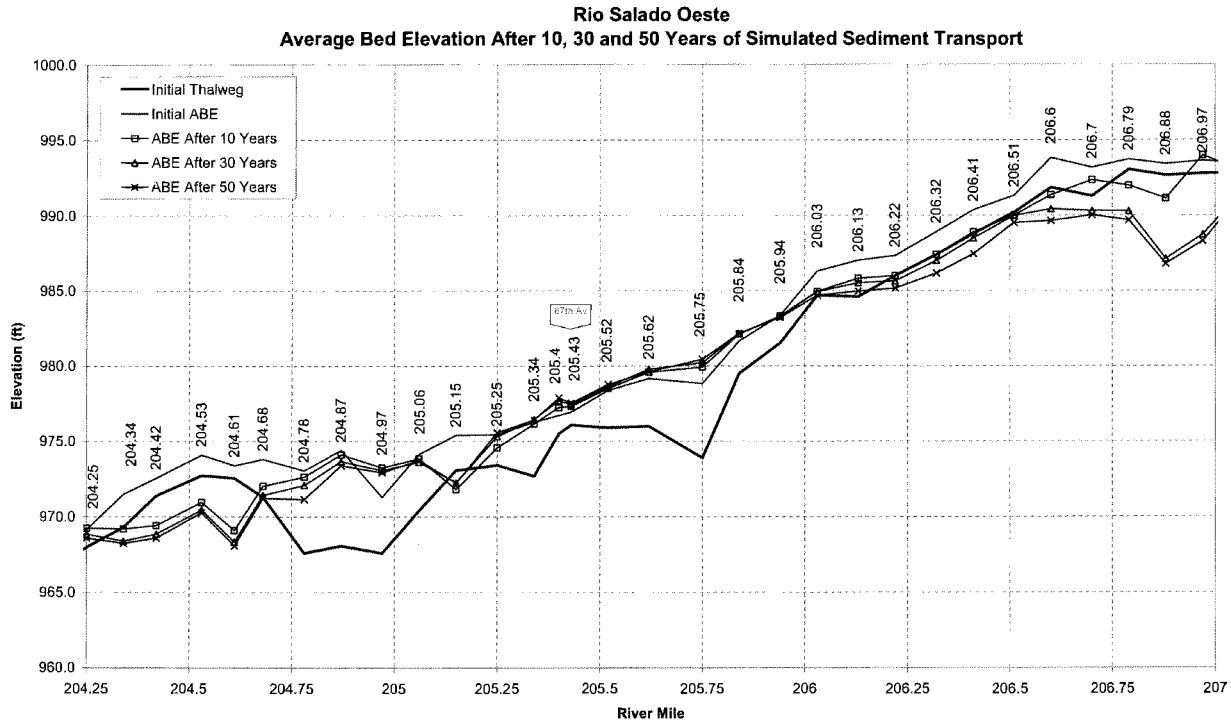

Figure 20: ***Continued.***

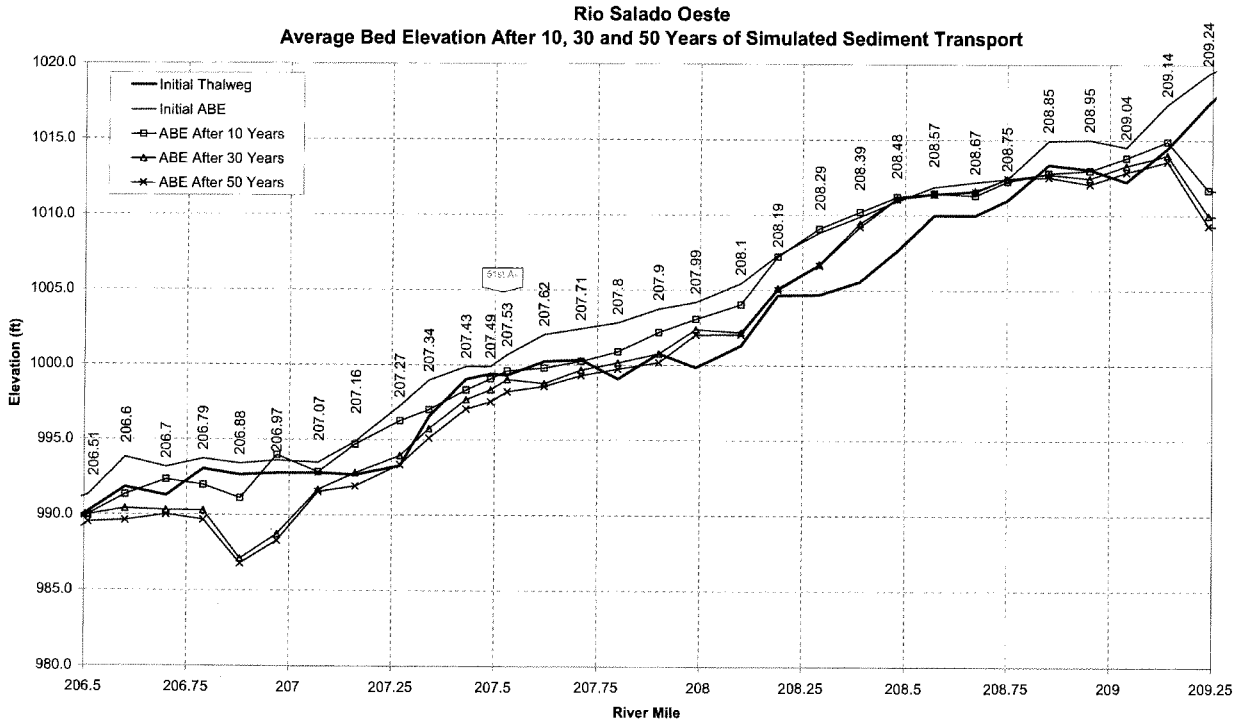

Figure 20: *Continued.*

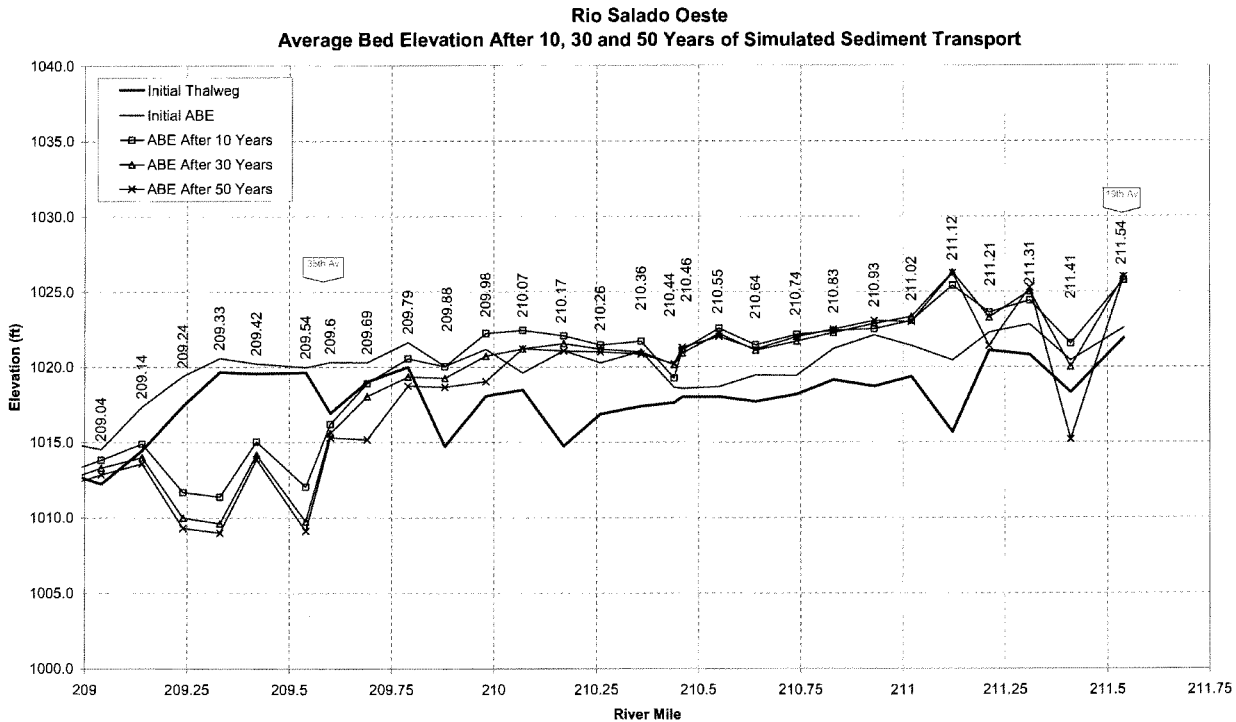

Figure 20: *Continued.*

Without Project (w/ Proposed 35th Avenue Bridge)

Since the 35th Avenue Bridge will be replaced in the near future by the City of Phoenix Street Transportation Department, the without project sediment transport analysis was modified by replacing the existing 35th Avenue Bridge. The bridge replacement will consist of removing the existing bridge and abutments, widening and deepening the existing channel in the immediate vicinity, and constructing a wider bridge. The existing bridge is approximately 500-ft wide with three groups of 5- to 6-ft wide cylindrical piers. The proposed bridge would be approximately 1100-ft wide with eight groups of 6-ft wide cylindrical piers. It would be expected that this new bridge and widened channel combination would decrease the backwater upstream and consequently affect the sediment routing.

Model Geometry

The without project sediment transport analysis numerical models were modified to reflect the proposed 35th Avenue Bridge by changing cross-section 209.54 in the model. The numerical models were then calibrated with the fixed bed (HEC-RAS) numerical models. Finally, the numerical models were rerun to simulate 50 years of sediment transport.

Results

The sediment transport analysis results are presented in terms of thalweg bed elevation by decade show on Figure 21 and Tables 8 to 10). The existing conditions (with existing 35th Avenue Bridge) results are also presented in Figure 22 and Tables 11 to 13 for comparison. In general, the results of the without project (with the proposed 35th Avenue Bridge) simulation are similar to the without project (with the existing 35th Avenue Bridge) simulation. The main differences are the following.

- A scour hole would develop downstream of the 35th Avenue Bridge. The most probable cause of this scour hole is the initial hole from the proposed bridge construction. During the simulation, this latter hole would fill in, and the resulting clearer water would scour out the channel bed immediately downstream.

- Upstream of the 35th Avenue Bridge, the deposition would be less than if the existing bridge is still in place. This is a result of the wider bridge causing less backwater, and therefore, less deposition upstream.

- Finally, more sediment would leave the study area. After 50 years of simulated sediment transport, approximately 615,000 additional tons of sediment (4 ac-ft/year) would leave the study area with the proposed bridge in place. This indicates that the study area, with the proposed bridge in place, would be more efficient in transporting sediment.

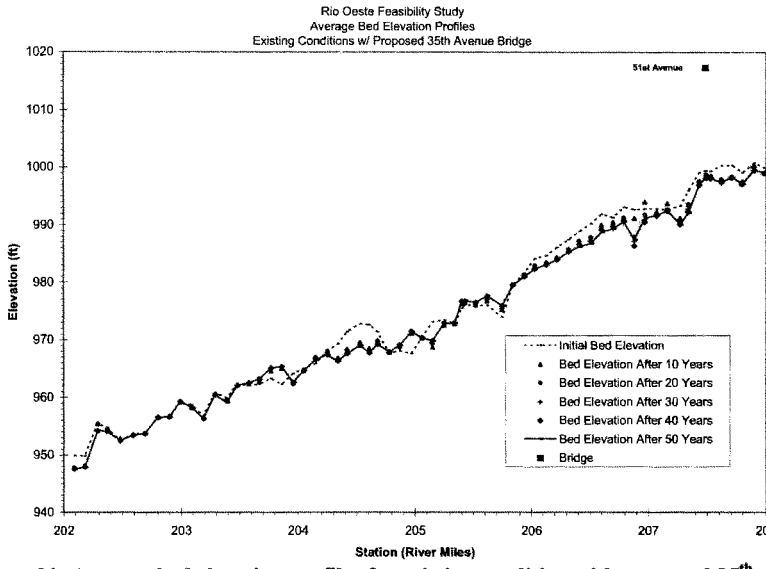

Figure 21: Average bed elevation profiles for existing condition with proposed 35th Avenue Bridge.

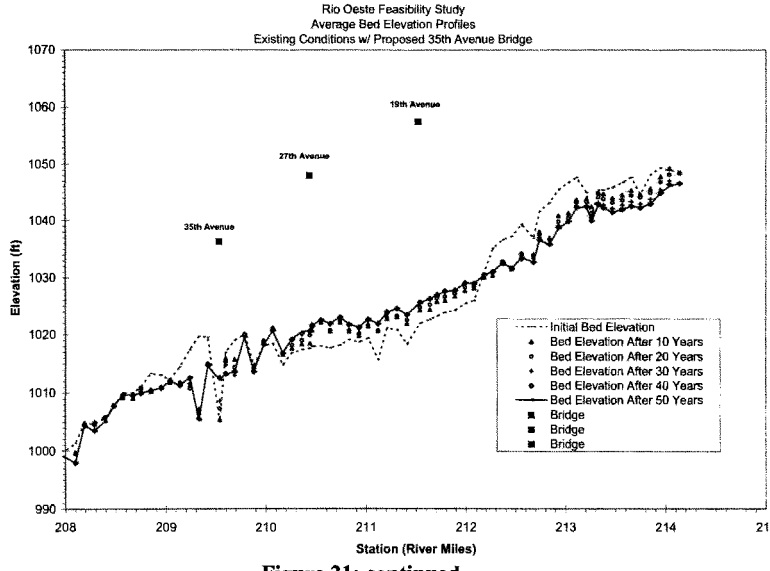

Figure 21: continued

Table 8: Average bed elevation profiles for existing condition with proposed 35th Avenue Bridge.

River Station (miles)	Initial Avg. Bed Elev. (ft)	Avg. Bed Elev. After 10 Years (ft)	Avg. Bed Elev. After 20 Years (ft)	Avg. Bed Elev. After 30 Years (ft)	Avg. Bed Elev. After 40 Years (ft)	Avg. Bed Elev. After 50 Years (ft)
202.1	949.9	947.8	947.8	947.7	947.6	947.5
202.2	949.8	948.1	948.0	947.9	947.9	947.8
202.3	955.5	955.4	955.3	954.2	954.2	954.2
202.4	954.6	954.6	954.5	954.2	954.1	954.1
202.5	952.5	952.8	952.5	952.5	952.5	952.5
202.6	953.7	953.6	953.5	953.5	953.5	953.5
202.7	953.7	953.8	953.7	953.7	953.7	953.7
202.8	956.4	956.5	956.6	956.5	956.5	956.5
202.9	956.5	956.6	956.7	956.7	956.6	956.6
203.0	959.2	959.2	959.3	959.2	959.2	959.2
203.1	958.7	958.2	958.2	958.2	958.2	958.2
203.2	956.7	956.4	956.4	956.3	956.3	956.3
203.3	960.8	960.5	960.5	960.4	960.4	960.5
203.4	959.9	959.6	959.6	959.4	959.4	959.1
203.5	962.2	962.0	962.0	962.0	962.0	962.0
203.6	962.1	962.3	962.4	962.4	962.5	962.5
203.7	962.3	962.7	962.9	963.1	963.1	963.2
203.8	963.3	964.5	965.0	965.0	965.1	965.1
203.9	962.2	965.0	965.2	965.2	965.3	965.3
204.0	964.1	962.4	962.3	962.5	962.6	962.6
204.1	965.0	964.6	964.6	964.6	964.7	964.7
204.1	965.9	967.0	966.9	966.7	966.6	966.5
204.3	968.0	968.0	968.0	967.6	967.4	967.4
204.3	969.3	966.8	966.3	966.5	966.3	966.3
204.4	971.4	968.3	968.1	967.8	967.6	967.6
204.5	972.7	969.5	969.4	969.2	969.0	969.0
204.6	972.6	968.5	968.2	967.9	967.7	967.7
204.7	971.3	969.9	969.8	969.5	969.2	969.2
204.8	967.6	967.8	967.7	967.8	967.9	967.9
204.9	968.1	968.9	968.7	969.0	969.1	969.0
205.0	967.6	971.2	971.2	971.4	971.4	971.4
205.1	970.4	970.3	970.3	970.3	970.4	970.3
205.1	973.1	968.7	969.4	969.4	969.8	969.8
205.3	973.4	972.5	972.8	973.0	972.9	972.9
205.3	972.7	972.7	972.9	973.0	972.9	972.9
205.4	975.5	976.2	976.6	976.6	976.7	976.7
205.4	976.1	976.5	976.6	976.6	976.7	976.7
205.5	975.9	976.0	976.0	976.2	976.5	976.5
205.6	976.0	976.7	976.9	977.2	977.5	977.6
205.8	973.9	975.2	975.4	975.6	975.9	975.9

205.8	979.5	979.6	979.5	979.5	979.5	979.4
205.9	981.5	981.2	981.3	981.0	981.0	980.9
206.0	984.0	982.8	982.9	982.7	982.3	982.3
206.1	984.6	983.4	983.3	983.2	983.0	983.0
206.2	986.0	984.3	984.1	983.9	983.9	983.9
206.3	987.4	985.8	985.7	985.5	985.3	985.2
206.4	988.8	987.2	987.1	986.8	986.5	986.2
206.5	990.2	987.4	987.8	987.9	987.1	986.7
206.6	991.8	990.0	989.4	989.3	989.2	988.7
206.7	991.3	990.5	989.8	989.3	989.7	989.3
206.8	993.0	991.3	991.2	991.0	990.7	990.6
206.9	992.7	991.1	987.9	987.1	986.3	987.4
207.0	992.8	994.0	991.8	990.9	990.5	991.2
207.1	992.8	992.3	991.8	991.5	991.6	991.6
207.2	992.7	993.7	992.7	992.5	992.4	992.5
207.3	993.3	991.1	990.9	990.2	990.0	990.0
207.3	995.9	993.6	993.6	992.8	992.2	992.1
207.4	999.0	997.5	997.5	997.3	996.9	996.9
207.5	999.4	998.7	998.7	998.4	998.2	998.2
207.5	999.3	998.4	998.4	998.2	998.0	998.0
207.6	1000.2	997.9	997.9	997.5	997.3	997.4
207.7	1000.3	998.3	998.3	998.3	998.2	998.3
207.8	999.1	997.5	997.0	997.2	997.1	997.2
207.9	1000.8	1000.2	1000.0	999.5	999.4	999.4
208.0	999.8	998.9	998.9	999.1	999.0	999.1
208.1	1001.3	999.8	999.5	998.0	998.0	998.0
208.2	1004.7	1004.8	1004.7	1004.6	1004.4	1004.3
208.3	1004.7	1004.9	1004.8	1004.4	1003.5	1003.4
208.4	1005.6	1005.8	1005.8	1005.7	1005.7	1005.1
208.5	1007.6	1007.8	1007.9	1007.8	1007.8	1007.7
208.6	1010.0	1009.2	1009.4	1009.6	1009.7	1009.7
208.7	1010.0	1009.1	1009.4	1009.6	1009.7	1009.7
208.8	1011.0	1010.9	1010.9	1010.3	1010.0	1009.9
208.9	1013.3	1010.3	1010.3	1010.4	1010.5	1010.5
208.9	1013.0	1011.0	1010.9	1011.0	1010.8	1010.8
209.0	1012.2	1011.8	1011.8	1012.1	1012.1	1012.1
209.1	1014.5	1011.8	1011.7	1011.8	1011.3	1011.3
209.2	1017.4	1011.4	1010.8	1011.6	1012.6	1012.7
209.3	1019.7	1007.2	1006.6	1006.4	1005.6	1005.3
209.4	1019.6	1014.9	1015.0	1015.0	1014.8	1014.6
209.5	1005.0	1005.4	1007.3	1008.6	1012.6	1012.3
209.6	1016.9	1015.9	1015.3	1014.8	1013.3	1013.2
209.7	1019.0	1015.7	1014.4	1013.1	1013.7	1013.6
209.8	1020.0	1020.0	1020.0	1020.0	1020.0	1019.6
209.9	1014.7	1014.5	1014.2	1013.8	1013.7	1013.6
210.0	1018.1	1019.0	1018.9	1018.4	1018.3	1018.2
210.1	1018.5	1021.2	1021.0	1020.7	1020.7	1020.7
210.2	1014.7	1016.6	1016.7	1016.7	1016.7	1016.8

210.3	1016.9	1017.7	1018.2	1019.1	1019.2	1019.3
210.4	1017.4	1018.4	1019.0	1020.1	1020.2	1020.4
210.4	1017.6	1018.5	1019.9	1020.6	1020.5	1020.7
210.5	1018.0	1020.7	1021.3	1021.8	1021.4	1021.5
210.6	1018.0	1022.1	1022.4	1022.4	1022.5	1022.6
210.6	1017.7	1020.6	1020.7	1021.8	1021.8	1021.9
210.7	1018.2	1022.1	1022.3	1022.8	1023.0	1023.1
210.8	1019.1	1020.6	1020.7	1021.5	1021.7	1021.7
210.9	1018.7	1019.8	1020.1	1020.9	1021.2	1021.3
211.0	1019.3	1021.5	1021.6	1022.3	1022.6	1022.7
211.1	1015.7	1020.6	1020.7	1021.8	1021.9	1021.8
211.2	1021.1	1022.7	1022.9	1023.5	1023.9	1023.9
211.3	1020.8	1023.1	1023.3	1024.4	1024.5	1024.5
211.4	1018.3	1021.9	1022.5	1023.4	1023.4	1023.4
211.5	1021.9	1024.3	1024.7	1025.5	1025.6	1025.5
211.6	1022.6	1024.3	1025.2	1026.1	1026.2	1026.2
211.7	1023.2	1025.8	1026.4	1026.9	1027.0	1026.9
211.8	1023.8	1025.9	1026.6	1027.5	1027.6	1027.5
211.9	1024.2	1026.7	1027.2	1027.7	1027.8	1027.7
212.0	1025.4	1027.7	1028.3	1028.9	1029.1	1029.0
212.1	1025.9	1028.1	1028.5	1028.9	1028.9	1028.9
212.2	1030.8	1030.0	1030.3	1030.5	1030.5	1030.4
212.3	1035.1	1030.4	1030.9	1031.0	1031.0	1031.0
212.4	1036.6	1032.5	1032.8	1032.7	1032.6	1032.6
212.5	1037.2	1031.5	1031.7	1031.6	1031.5	1031.6
212.6	1039.3	1034.1	1034.2	1033.8	1033.3	1033.5
212.7	1036.9	1034.1	1033.8	1033.4	1032.7	1032.7
212.7	1041.6	1038.0	1037.5	1037.0	1036.6	1036.6
212.8	1043.1	1037.0	1036.7	1036.0	1035.8	1035.8
212.9	1045.4	1040.8	1039.8	1039.1	1038.8	1038.6
213.0	1046.7	1041.3	1040.5	1039.9	1039.9	1039.8
213.1	1047.6	1043.7	1043.2	1042.6	1042.3	1042.2
213.2	1044.9	1043.8	1043.3	1042.7	1042.5	1042.4
213.3	1040.4	1042.5	1041.3	1040.4	1040.0	1039.9
213.3	1045.4	1045.0	1044.2	1043.2	1042.9	1042.8
213.4	1045.4	1044.7	1043.8	1042.8	1042.2	1042.2
213.5	1045.8	1044.0	1043.2	1042.1	1041.5	1041.4
213.6	1046.7	1044.5	1043.6	1042.7	1042.0	1042.0
213.7	1047.6	1045.3	1044.4	1043.3	1042.5	1042.5
213.8	1044.6	1044.6	1044.1	1043.0	1042.2	1042.3
213.9	1048.1	1045.6	1044.9	1043.8	1042.9	1043.0
213.9	1049.3	1047.8	1046.8	1045.5	1044.9	1044.8
214.0	1048.8	1049.2	1048.1	1047.1	1046.4	1046.1
214.1	1048.7	1048.5	1048.4	1046.6	1046.6	1046.5

Table 9: Change in average bed elevation with proposed 35th Avenue Bridge.

River Station (miles)	Change in Avg. Bed Elev. After 10 Years (ft)	Change in Avg. Bed Elev. After 20 Years (ft)	Change in Avg. Bed Elev. After 30 Years (ft)	Change in Avg. Bed Elev. After 40 Years (ft)	Change in Avg. Bed Elev. After 50 Years (ft)
202.1	-2.0	-2.1	-2.2	-2.3	-2.3
202.2	-1.7	-1.8	-1.9	-1.9	-2.0
202.3	-0.1	-0.2	-1.3	-1.3	-1.3
202.4	0.0	0.0	-0.3	-0.4	-0.4
202.5	0.4	0.1	0.0	0.0	0.0
202.6	-0.1	-0.2	-0.2	-0.2	-0.2
202.7	0.1	0.0	0.0	0.0	0.0
202.8	0.1	0.2	0.1	0.1	0.1
202.9	0.2	0.3	0.2	0.2	0.2
203.0	0.0	0.1	0.1	0.1	0.1
203.1	-0.5	-0.5	-0.5	-0.5	-0.4
203.2	-0.3	-0.3	-0.5	-0.4	-0.3
203.3	-0.3	-0.3	-0.3	-0.3	-0.3
203.4	-0.3	-0.4	-0.5	-0.5	-0.8
203.5	-0.2	-0.2	-0.2	-0.2	-0.2
203.6	0.2	0.4	0.3	0.4	0.5
203.7	0.4	0.7	0.8	0.9	1.0
203.8	1.3	1.8	1.8	1.9	1.9
203.9	2.8	3.0	3.0	3.1	3.2
204.0	-1.6	-1.7	-1.6	-1.5	-1.4
204.1	-0.4	-0.4	-0.4	-0.4	-0.3
204.1	1.1	1.0	0.8	0.7	0.7
204.3	0.0	0.0	-0.5	-0.7	-0.7
204.3	-2.5	-2.9	-2.9	-2.9	-2.9
204.4	-3.1	-3.2	-3.7	-3.9	-3.9
204.5	-3.2	-3.4	-3.6	-3.7	-3.7
204.6	-4.0	-4.4	-4.8	-4.9	-4.9
204.7	-1.5	-1.6	-1.9	-2.1	-2.1
204.8	0.2	0.2	0.2	0.3	0.3
204.9	0.9	0.6	0.9	1.0	0.9
205.0	3.5	3.5	3.7	3.9	3.8
205.1	-0.1	-0.2	-0.1	0.0	-0.1
205.1	-4.4	-3.8	-3.8	-3.2	-3.3
205.3	-0.9	-0.7	-0.5	-0.6	-0.6
205.3	0.0	0.2	0.2	0.2	0.2
205.4	0.7	1.1	1.1	1.2	1.1
205.4	0.5	0.5	0.5	0.6	0.6
205.5	0.1	0.1	0.3	0.5	0.5
205.6	0.7	0.9	1.2	1.5	1.6

205.8	1.3	1.5	1.8	2.0	2.0
205.8	0.1	0.0	0.0	0.0	-0.1
205.9	-0.3	-0.3	-0.5	-0.5	-0.6
206.0	-1.2	-1.2	-1.5	-1.9	-1.9
206.1	-1.3	-1.4	-1.5	-1.7	-1.7
206.2	-1.5	-1.9	-2.0	-2.1	-2.2
206.3	-1.6	-1.7	-2.0	-2.1	-2.2
206.4	-1.6	-2.1	-2.3	-2.6	-3.0
206.5	-2.7	-2.3	-2.8	-3.3	-3.6
206.6	-2.1	-2.7	-2.9	-2.9	-3.3
206.7	-0.6	-1.5	-2.3	-1.8	-1.9
206.8	-1.8	-1.8	-2.4	-2.5	-2.7
206.9	-2.0	-4.9	-4.9	-5.0	-4.5
207.0	1.1	-1.8	-2.4	-1.6	-1.7
207.1	-0.6	-1.1	-1.5	-1.2	-1.2
207.2	0.5	-0.9	-0.7	-0.7	-0.6
207.3	-2.0	-2.1	-2.7	-2.9	-3.0
207.3	-2.7	-2.7	-3.8	-4.0	-4.2
207.4	-1.5	-1.5	-1.6	-2.1	-2.2
207.5	-0.9	-0.9	-1.6	-1.8	-1.9
207.5	-1.0	-0.9	-1.1	-1.4	-1.4
207.6	-2.6	-2.6	-3.2	-3.3	-3.3
207.7	-2.1	-2.0	-2.0	-2.1	-2.0
207.8	-1.6	-2.2	-2.1	-2.2	-2.2
207.9	-0.6	-0.9	-1.4	-1.4	-1.5
208.0	-1.0	-1.0	-1.0	-1.0	-1.0
208.1	-1.7	-2.1	-3.3	-3.3	-3.3
208.2	0.1	0.0	-0.7	-0.7	-0.7
208.3	0.2	0.1	-0.6	-1.4	-1.5
208.4	0.2	0.2	0.1	-0.6	-1.6
208.5	0.2	0.2	0.2	0.1	0.1
208.6	-0.9	-0.6	-0.5	-0.4	-0.5
208.7	-1.0	-0.7	-0.6	-0.4	-0.5
208.8	-0.2	-0.2	-0.9	-1.1	-1.2
208.9	-3.0	-3.0	-3.1	-3.1	-3.1
208.9	-1.9	-1.9	-1.9	-1.8	-1.9
209.0	-0.9	-0.8	-0.9	-0.9	-0.9
209.1	-2.1	-1.9	-2.0	-2.0	-2.0
209.2	-7.9	-8.1	-8.5	-8.5	-8.5
209.3	-8.3	-8.7	-9.0	-9.1	-9.1
209.4	-6.3	-6.6	-7.1	-7.1	-7.2
209.5	-5.8	-6.3	-6.4	-5.5	-5.5
209.6	-5.1	-5.1	-5.2	-5.2	-5.1
209.7	-2.2	-2.3	-3.0	-3.8	-4.0
209.8	0.0	0.0	-0.1	-0.2	-0.5
209.9	0.1	0.2	1.6	1.4	1.4
210.0	0.7	0.6	1.6	0.7	0.5
210.1	2.8	2.8	4.1	3.7	3.3

210.2	3.1	3.0	3.1	3.0	3.0
210.3	1.9	1.9	2.9	2.5	2.8
210.4	1.9	2.6	4.0	4.0	4.1
210.4	1.3	3.3	4.1	3.7	3.9
210.5	3.5	4.1	4.2	3.9	4.1
210.6	4.7	4.5	5.9	5.8	5.8
210.6	3.2	3.8	4.5	4.2	4.3
210.7	4.5	4.5	5.6	5.9	5.9
210.8	2.1	2.3	3.2	3.1	3.2
210.9	1.7	1.8	2.8	3.0	3.0
211.0	2.8	2.8	4.2	4.5	4.6
211.1	4.9	5.1	5.8	6.1	6.1
211.2	2.4	2.5	3.6	4.2	4.2
211.3	2.5	2.5	3.7	3.8	3.8
211.4	4.4	4.9	6.1	6.1	6.2
211.5	2.6	2.8	3.9	3.7	3.7
211.6	2.5	3.2	4.1	4.4	4.3
211.7	2.8	3.2	3.9	4.0	4.0
211.8	2.5	3.2	4.0	4.3	4.3
211.9	2.6	3.1	3.7	3.9	3.8
212.0	2.6	3.2	3.9	3.9	3.9
212.1	2.4	2.7	3.1	3.3	3.3
212.2	-0.6	-0.4	-0.1	-0.1	-0.1
212.3	-4.5	-4.1	-3.9	-3.8	-3.9
212.4	-4.0	-3.6	-3.7	-3.8	-3.8
212.5	-5.5	-5.3	-5.4	-5.5	-5.4
212.6	-5.1	-5.0	-5.4	-5.8	-5.6
212.7	-2.7	-3.0	-3.4	-4.0	-4.0
212.7	-3.5	-4.0	-4.5	-4.8	-4.8
212.8	-6.1	-6.4	-6.9	-7.1	-7.1
212.9	-4.6	-5.5	-6.1	-6.5	-6.6
213.0	-5.5	-6.2	-6.6	-6.6	-6.6
213.1	-3.7	-4.3	-4.9	-5.1	-5.3
213.2	-0.8	-1.5	-2.1	-2.2	-2.3
213.3	2.1	1.0	0.1	-0.4	-0.4
213.3	-0.5	-1.2	-2.0	-2.3	-2.4
213.4	-0.6	-1.5	-2.6	-3.1	-3.1
213.5	-1.8	-2.7	-3.6	-4.2	-4.2
213.6	-2.2	-3.0	-3.9	-4.6	-4.6
213.7	-2.3	-3.1	-4.2	-5.0	-5.0
213.8	0.0	-0.4	-1.5	-2.3	-2.2
213.9	-2.5	-3.2	-4.3	-5.1	-5.1
213.9	-1.5	-2.4	-3.8	-4.4	-4.4
214.0	0.4	-0.6	-1.7	-2.3	-2.6
214.1	-0.2	-0.3	-2.0	-2.1	-2.1

Table 10: Accumulated sand delivery for with proposed 35th Avenue Bridge

River Station (miles)	Accumulated Sand Delivery (tons)	Accumulated Sand Delivery (tons/year)	Accumulated Sand Delivery (cy/year)	Accumulated Sand Delivery (ac-ft/year)
202.1	15037569	300751	186020	115.3
202.2	14967304	299346	185151	114.8
202.3	14944806	298896	184873	114.6
202.4	14946462	298929	184893	114.6
202.5	14951205	299024	184952	114.6
202.6	14943625	298873	184858	114.6
202.7	14909069	298181	184431	114.3
202.8	14905746	298115	184390	114.3
202.9	14953643	299073	184982	114.7
203.0	15003490	300070	185599	115.0
203.1	15015896	300318	185752	115.1
203.2	14978741	299575	185293	114.9
203.3	14936465	298729	184770	114.5
203.4	14924907	298498	184627	114.4
203.5	14906192	298124	184395	114.3
203.6	14915493	298310	184510	114.4
203.7	14945329	298907	184879	114.6
203.8	15029182	300584	185917	115.2
203.9	15144626	302893	187345	116.1
204.0	15285842	305717	189092	117.2
204.1	15222140	304443	188304	116.7
204.1	15225308	304506	188343	116.7
204.3	15296343	305927	189221	117.3
204.3	15272909	305458	188932	117.1
204.4	15193313	303866	187947	116.5
204.5	15096844	301937	186754	115.8
204.6	15019508	300390	185797	115.2
204.7	14932123	298642	184716	114.5
204.8	14896353	297927	184273	114.2
204.9	14930478	298610	184696	114.5
205.0	14973850	299477	185232	114.8
205.1	15071792	301436	186444	115.6
205.1	15061388	301228	186315	115.5
205.3	15048621	300972	186157	115.4
205.3	15088853	301777	186655	115.7
205.4	15107140	302143	186881	115.8
205.4	15167595	303352	187629	116.3
205.5	15205258	304105	188095	116.6
205.6	15259522	305190	188766	117.0
205.8	15355878	307118	189958	117.7
205.8	15451985	309040	191147	118.5

205.9	15553847	311077	192407	119.3
206.0	15629758	312595	193346	119.8
206.1	15621629	312433	193245	119.8
206.2	15623828	312477	193273	119.8
206.3	15626949	312539	193311	119.8
206.4	15620117	312402	193227	119.8
206.5	15557389	311148	192451	119.3
206.6	15511074	310221	191878	118.9
206.7	15549149	310983	192349	119.2
206.8	15711058	314221	194352	120.5
206.9	15884286	317686	196495	121.8
207.0	16281333	325627	201406	124.8
207.1	16656015	333120	206041	127.7
207.2	16635213	332704	205784	127.6
207.3	16587300	331746	205191	127.2
207.3	16506229	330125	204188	126.6
207.4	16449965	328999	203492	126.1
207.5	16421358	328427	203138	125.9
207.5	16420542	328411	203128	125.9
207.6	16427266	328545	203211	126.0
207.7	16335306	326706	202074	125.3
207.8	16233476	324670	200814	124.5
207.9	16148249	322965	199760	123.8
208.0	16121743	322435	199432	123.6
208.1	16109035	322181	199275	123.5
208.2	16100372	322007	199168	123.5
208.3	16153297	323066	199822	123.9
208.4	16166333	323327	199984	124.0
208.5	16233848	324677	200819	124.5
208.6	16297963	325959	201612	125.0
208.7	16327028	326541	201971	125.2
208.8	16364057	327281	202429	125.5
208.9	16393665	327873	202796	125.7
208.9	16370831	327417	202513	125.5
209.0	16398309	327966	202853	125.7
209.1	16547624	330952	204700	126.9
209.2	16629587	332592	205714	127.5
209.3	16698455	333969	206566	128.0
209.4	16736727	334735	207040	128.3
209.54	16708192	334164	206687	128.1
209.6	16920108	338402	209308	129.7
209.69	16917886	338358	209281	129.7
209.79	16929810	338596	209428	129.8
209.88	17110826	342217	211667	131.2
209.98	17120436	342409	211786	131.3
210.07	17273856	345477	213684	132.4
210.17	17559752	351195	217221	134.6
210.26	17779852	355597	219943	136.3

210.36	17942596	358852	221957	137.6
210.44	18049232	360985	223276	138.4
210.46	18115474	362309	224095	138.9
210.55	18264508	365290	225939	140.0
210.64	18715186	374304	231514	143.5
210.74	19110600	382212	236405	146.5
210.83	19540114	390802	241718	149.8
210.93	19837184	396744	245393	152.1
211.02	20197370	403947	249849	154.9
211.12	20580582	411612	254589	157.8
211.21	20923114	418462	258827	160.4
211.31	20996336	419927	259732	161.0
211.41	21043660	420873	260318	161.4
211.54	21114384	422288	261193	161.9
211.64	21206044	424121	262327	162.6
211.71	21254220	425084	262923	163.0
211.79	21298988	425980	263476	163.3
211.89	21366950	427339	264317	163.8
211.99	21433396	428668	265139	164.3
212.08	21649204	432984	267809	166.0
212.18	21943948	438879	271455	168.3
212.27	22131948	442639	273780	169.7
212.37	22442508	448850	277622	172.1
212.46	22686196	453724	280637	173.9
212.56	22704850	454097	280867	174.1
212.68	22643656	452873	280110	173.6
212.74	22594456	451889	279502	173.2
212.84	22540922	450818	278840	172.8
212.93	22435342	448707	277533	172.0
213.03	22326774	446535	276190	171.2
213.11	22205016	444100	274684	170.3
213.21	22102780	442056	273420	169.5
213.26	22075462	441509	273082	169.3
213.33	22069956	441399	273014	169.2
213.38	22044334	440887	272697	169.0
213.47	22004646	440093	272206	168.7
213.57	21940752	438815	271415	168.2
213.66	21870748	437415	270549	167.7
213.75	21807436	436149	269766	167.2
213.85	21772134	435443	269329	166.9
213.95	21750404	435008	269061	166.8
214.04	21696148	433923	268389	166.4
214.14	21660388	433208	267947	166.1

Note: weight of sand = 120 pcf, 1 ton = 16.7 cubic feet
This is a table of the total weight of sand and larger transported past each cross section in the model plotted versus channel station.
Sediment inflow = 166 ac-ft/year

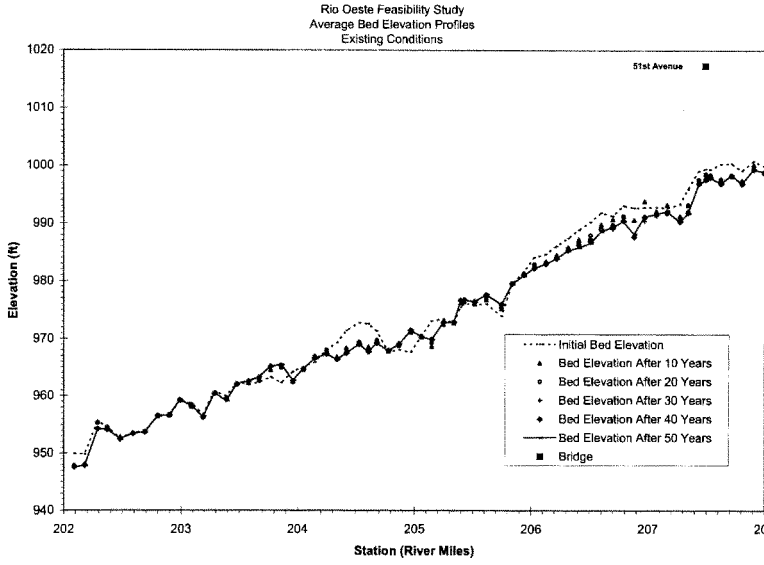

Figure 22: Average bed elevation profiles for with existing 35th Avenue Bridge.

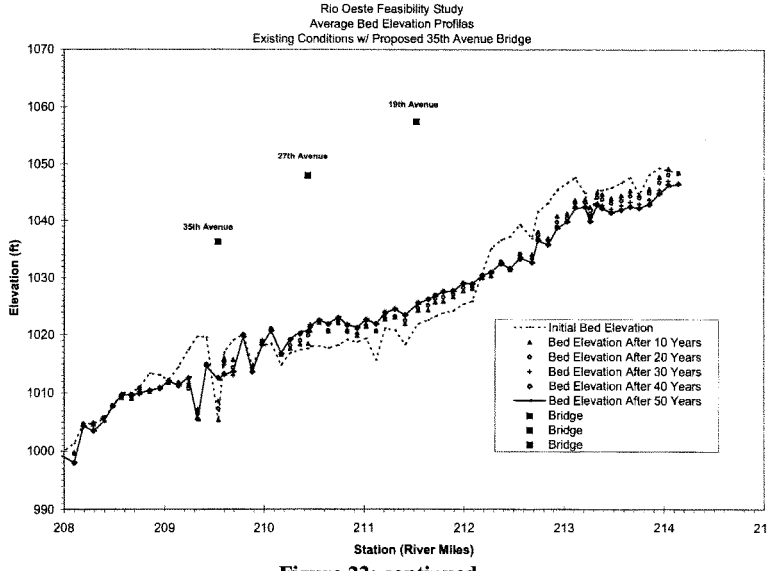

Figure 22: continued

Table 11: Average bed elevation profiles for with existing 35th Avenue Bridge.

River Station (miles)	Initial Avg. Bed Elev. (ft)	Avg. Bed Elev. After 10 Years (ft)	Avg. Bed Elev. After 20 Years (ft)	Avg. Bed Elev. After 30 Years (ft)	Avg. Bed Elev. After 40 Years (ft)	Avg. Bed Elev. After 50 Years (ft)
202.1	949.9	947.9	947.8	947.7	947.6	947.6
202.2	949.8	948.2	948.0	947.9	947.9	947.8
202.3	955.5	955.4	955.4	954.3	954.3	954.3
202.4	954.6	954.6	954.5	954.3	954.2	954.1
202.5	952.5	952.8	952.6	952.5	952.5	952.5
202.6	953.7	953.6	953.5	953.5	953.5	953.5
202.7	953.7	953.8	953.8	953.7	953.7	953.7
202.8	956.4	956.5	956.6	956.5	956.5	956.5
202.9	956.5	956.6	956.7	956.7	956.6	956.6
203.0	959.2	959.2	959.3	959.2	959.2	959.2
203.1	958.7	958.2	958.2	958.2	958.2	958.3
203.2	956.7	956.4	956.4	956.3	956.3	956.4
203.3	960.8	960.5	960.5	960.4	960.4	960.5
203.4	959.9	959.6	959.5	959.4	959.4	959.1
203.5	962.2	962.0	962.0	962.0	962.0	962.0
203.6	962.1	962.3	962.5	962.4	962.5	962.5
203.7	962.3	962.7	963.0	963.1	963.2	963.2
203.8	963.3	964.6	965.1	965.0	965.1	965.1
203.9	962.2	965.0	965.2	965.2	965.3	965.4
204.0	964.1	962.5	962.4	962.5	962.6	962.7
204.1	965.0	964.6	964.6	964.6	964.6	964.7
204.1	965.9	966.9	966.9	966.6	966.6	966.6
204.3	968.0	968.0	968.0	967.5	967.3	967.3
204.3	969.3	966.8	966.4	966.4	966.4	966.4
204.4	971.4	968.3	968.2	967.7	967.5	967.5
204.5	972.7	969.5	969.4	969.1	969.0	969.0
204.6	972.6	968.6	968.1	967.8	967.7	967.7
204.7	971.3	969.8	969.7	969.4	969.2	969.2
204.8	967.6	967.8	967.8	967.8	967.9	967.9
204.9	968.1	969.0	968.7	968.9	969.1	969.0
205.0	967.6	971.1	971.1	971.3	971.4	971.4
205.1	970.4	970.3	970.3	970.3	970.4	970.4
205.1	973.1	968.7	969.3	969.3	969.9	969.8
205.3	973.4	972.5	972.8	972.9	972.9	972.8
205.3	972.7	972.7	972.9	972.9	972.9	972.9
205.4	975.5	976.2	976.5	976.6	976.7	976.6
205.4	976.1	976.5	976.6	976.6	976.7	976.7
205.5	975.9	976.0	976.0	976.2	976.4	976.4
205.6	976.0	976.7	976.9	977.2	977.5	977.6

205.8	973.9	975.2	975.4	975.7	975.9	975.9
205.8	979.5	979.6	979.5	979.5	979.5	979.4
205.9	981.5	981.2	981.3	981.0	981.0	980.9
206.0	984.0	982.9	982.9	982.6	982.2	982.2
206.1	984.6	983.3	983.2	983.1	982.9	982.9
206.2	986.0	984.5	984.1	984.0	983.9	983.8
206.3	987.4	985.8	985.7	985.4	985.3	985.2
206.4	988.8	987.2	986.7	986.5	986.2	985.8
206.5	990.2	987.5	987.9	987.4	986.9	986.6
206.6	991.8	989.8	989.1	988.9	989.0	988.6
206.7	991.3	990.7	989.7	989.0	989.5	989.3
206.8	993.0	991.3	991.3	990.6	990.5	990.4
206.9	992.7	990.6	987.7	987.8	987.6	988.1
207.0	992.8	993.8	991.0	990.4	991.2	991.1
207.1	992.8	992.2	991.7	991.3	991.6	991.6
207.2	992.7	993.2	991.7	991.9	992.0	992.1
207.3	993.3	991.3	991.1	990.6	990.3	990.3
207.3	995.9	993.2	993.2	992.2	991.9	991.8
207.4	999.0	997.5	997.6	997.4	996.9	996.8
207.5	999.4	998.5	998.5	997.8	997.6	997.5
207.5	999.3	998.3	998.4	998.2	997.9	997.9
207.6	1000.2	997.7	997.6	997.0	996.9	996.9
207.7	1000.3	998.2	998.3	998.3	998.2	998.3
207.8	999.1	997.4	996.8	996.9	996.9	996.9
207.9	1000.8	1000.2	999.9	999.4	999.3	999.3
208.0	999.8	998.8	998.8	998.9	998.8	998.9
208.1	1001.3	999.6	999.2	998.0	998.0	998.0
208.2	1004.7	1004.8	1004.6	1004.0	1004.0	1004.0
208.3	1004.7	1004.9	1004.8	1004.1	1003.3	1003.2
208.4	1005.6	1005.8	1005.7	1005.6	1005.0	1004.0
208.5	1007.6	1007.8	1007.8	1007.8	1007.7	1007.7
208.6	1010.0	1009.1	1009.4	1009.5	1009.6	1009.5
208.7	1010.0	1009.0	1009.3	1009.4	1009.6	1009.5
208.8	1011.0	1010.8	1010.8	1010.1	1009.9	1009.8
208.9	1013.3	1010.3	1010.3	1010.3	1010.3	1010.3
208.9	1013.0	1011.1	1011.2	1011.2	1011.3	1011.2
209.0	1012.2	1011.4	1011.4	1011.4	1011.3	1011.3
209.1	1014.5	1012.4	1012.5	1012.4	1012.5	1012.4
209.2	1017.4	1009.5	1009.3	1008.9	1008.9	1008.9
209.3	1019.7	1011.4	1011.0	1010.7	1010.5	1010.6
209.4	1019.6	1013.3	1013.0	1012.4	1012.5	1012.4
209.5	1019.6	1013.8	1013.3	1013.2	1014.2	1014.1
209.6	1016.9	1011.8	1011.8	1011.8	1011.8	1011.8
209.7	1019.0	1016.8	1016.7	1016.0	1015.2	1015.0
209.8	1020.0	1020.0	1020.0	1019.9	1019.8	1019.5
209.9	1014.7	1014.8	1014.9	1016.3	1016.2	1016.1
210.0	1018.1	1018.7	1018.7	1019.6	1018.7	1018.6
210.1	1018.5	1021.3	1021.3	1022.6	1022.2	1021.8

210.2	1014.7	1017.8	1017.7	1017.8	1017.7	1017.8
210.3	1016.9	1018.7	1018.8	1019.7	1019.4	1019.7
210.4	1017.4	1019.3	1020.0	1021.4	1021.4	1021.5
210.4	1017.6	1018.9	1020.9	1021.7	1021.3	1021.6
210.5	1018.0	1021.5	1022.1	1022.2	1021.9	1022.1
210.6	1018.0	1022.7	1022.6	1023.9	1023.8	1023.8
210.6	1017.7	1020.9	1021.5	1022.2	1021.9	1022.0
210.7	1018.2	1022.7	1022.6	1023.8	1024.1	1024.1
210.8	1019.1	1021.2	1021.4	1022.3	1022.2	1022.3
210.9	1018.7	1020.4	1020.5	1021.5	1021.7	1021.7
211.0	1019.3	1022.1	1022.2	1023.5	1023.9	1023.9
211.1	1015.7	1020.6	1020.8	1021.5	1021.8	1021.8
211.2	1021.1	1023.5	1023.6	1024.7	1025.3	1025.3
211.3	1020.8	1023.3	1023.3	1024.5	1024.6	1024.6
211.4	1018.3	1022.7	1023.2	1024.4	1024.4	1024.5
211.5	1021.9	1024.5	1024.7	1025.8	1025.6	1025.6
211.6	1022.6	1025.1	1025.8	1026.7	1026.9	1026.9
211.7	1023.2	1026.0	1026.4	1027.1	1027.2	1027.2
211.8	1023.8	1026.3	1027.1	1027.8	1028.1	1028.1
211.9	1024.2	1026.8	1027.3	1027.9	1028.1	1028.0
212.0	1025.4	1028.0	1028.6	1029.3	1029.3	1029.3
212.1	1025.9	1028.3	1028.6	1029.0	1029.2	1029.2
212.2	1030.8	1030.2	1030.4	1030.7	1030.7	1030.7
212.3	1035.1	1030.6	1031.0	1031.2	1031.3	1031.2
212.4	1036.6	1032.6	1033.0	1032.9	1032.8	1032.8
212.5	1037.2	1031.7	1031.9	1031.8	1031.7	1031.8
212.6	1039.3	1034.2	1034.3	1033.9	1033.5	1033.7
212.7	1036.9	1034.2	1033.9	1033.5	1032.9	1032.9
212.7	1041.6	1038.1	1037.6	1037.1	1036.8	1036.8
212.8	1043.1	1037.0	1036.7	1036.2	1036.0	1036.0
212.9	1045.4	1040.8	1039.9	1039.3	1038.9	1038.8
213.0	1046.7	1041.2	1040.5	1040.1	1040.1	1040.1
213.1	1047.6	1043.9	1043.3	1042.7	1042.5	1042.3
213.2	1044.9	1044.1	1043.4	1042.8	1042.7	1042.6
213.3	1040.4	1042.5	1041.4	1040.5	1040.0	1040.0
213.3	1045.4	1044.9	1044.2	1043.4	1043.1	1043.0
213.4	1045.4	1044.8	1043.9	1042.8	1042.3	1042.3
213.5	1045.8	1044.0	1043.1	1042.2	1041.6	1041.6
213.6	1046.7	1044.5	1043.7	1042.8	1042.1	1042.1
213.7	1047.6	1045.3	1044.5	1043.4	1042.6	1042.6
213.8	1044.6	1044.6	1044.2	1043.1	1042.3	1042.4
213.9	1048.1	1045.6	1044.9	1043.8	1043.0	1043.0
213.9	1049.3	1047.8	1046.9	1045.5	1044.9	1044.9
214.0	1048.8	1049.2	1048.2	1047.1	1046.5	1046.2
214.1	1048.7	1048.5	1048.4	1046.7	1046.6	1046.6

Table 12: Change in average bed elevation for with existing 35th Avenue Bridge.

River Station (miles)	Change in Avg. Bed Elev. After 10 Years (ft)	Change in Avg. Bed Elev. After 20 Years (ft)	Change in Avg. Bed Elev. After 30 Years (ft)	Change in Avg. Bed Elev. After 40 Years (ft)	Change in Avg. Bed Elev. After 50 Years (ft)
202.1	-2.0	-2.1	-2.2	-2.3	-2.3
202.2	-1.7	-1.8	-1.9	-1.9	-2.0
202.3	-0.1	-0.2	-1.3	-1.3	-1.3
202.4	0.0	0.0	-0.3	-0.4	-0.4
202.5	0.4	0.1	0.0	0.0	0.0
202.6	-0.1	-0.2	-0.2	-0.2	-0.2
202.7	0.1	0.0	0.0	0.0	0.0
202.8	0.1	0.2	0.1	0.1	0.1
202.9	0.2	0.3	0.2	0.2	0.2
203.0	0.0	0.1	0.1	0.1	0.1
203.1	-0.5	-0.5	-0.5	-0.5	-0.4
203.2	-0.3	-0.3	-0.5	-0.4	-0.3
203.3	-0.3	-0.3	-0.3	-0.3	-0.3
203.4	-0.3	-0.4	-0.5	-0.5	-0.8
203.5	-0.2	-0.2	-0.2	-0.2	-0.2
203.6	0.2	0.4	0.3	0.4	0.5
203.7	0.4	0.7	0.8	0.9	1.0
203.8	1.3	1.8	1.8	1.9	1.9
203.9	2.8	3.0	3.0	3.1	3.2
204.0	-1.6	-1.7	-1.6	-1.5	-1.4
204.1	-0.4	-0.4	-0.4	-0.4	-0.3
204.1	1.1	1.0	0.8	0.7	0.7
204.3	0.0	0.0	-0.5	-0.7	-0.7
204.3	-2.5	-2.9	-2.9	-2.9	-2.9
204.4	-3.1	-3.2	-3.7	-3.9	-3.9
204.5	-3.2	-3.4	-3.6	-3.7	-3.7
204.6	-4.0	-4.4	-4.8	-4.9	-4.9
204.7	-1.5	-1.6	-1.9	-2.1	-2.1
204.8	0.2	0.2	0.2	0.3	0.3
204.9	0.9	0.6	0.9	1.0	0.9
205.0	3.5	3.5	3.7	3.9	3.8
205.1	-0.1	-0.2	-0.1	0.0	-0.1
205.1	-4.4	-3.8	-3.8	-3.2	-3.3
205.3	-0.9	-0.7	-0.5	-0.6	-0.6
205.3	0.0	0.2	0.2	0.2	0.2
205.4	0.7	1.1	1.1	1.2	1.1
205.4	0.5	0.5	0.5	0.6	0.6
205.5	0.1	0.1	0.3	0.5	0.5
205.6	0.7	0.9	1.2	1.5	1.6
205.8	1.3	1.5	1.8	2.0	2.0

205.8	0.1	0.0	0.0	0.0	-0.1
205.9	-0.3	-0.3	-0.5	-0.5	-0.6
206.0	-1.2	-1.2	-1.5	-1.9	-1.9
206.1	-1.3	-1.4	-1.5	-1.7	-1.7
206.2	-1.5	-1.9	-2.0	-2.1	-2.2
206.3	-1.6	-1.7	-2.0	-2.1	-2.2
206.4	-1.6	-2.1	-2.3	-2.6	-3.0
206.5	-2.7	-2.3	-2.8	-3.3	-3.6
206.6	-2.1	-2.7	-2.9	-2.9	-3.3
206.7	-0.6	-1.5	-2.3	-1.8	-1.9
206.8	-1.8	-1.8	-2.4	-2.5	-2.7
206.9	-2.0	-4.9	-4.9	-5.0	-4.5
207.0	1.1	-1.8	-2.4	-1.6	-1.7
207.1	-0.6	-1.1	-1.5	-1.2	-1.2
207.2	0.5	-0.9	-0.7	-0.7	-0.6
207.3	-2.0	-2.1	-2.7	-2.9	-3.0
207.3	-2.7	-2.7	-3.8	-4.0	-4.2
207.4	-1.5	-1.5	-1.6	-2.1	-2.2
207.5	-0.9	-0.9	-1.6	-1.8	-1.9
207.5	-1.0	-0.9	-1.1	-1.4	-1.4
207.6	-2.6	-2.6	-3.2	-3.3	-3.3
207.7	-2.1	-2.0	-2.0	-2.1	-2.0
207.8	-1.6	-2.2	-2.1	-2.2	-2.2
207.9	-0.6	-0.9	-1.4	-1.4	-1.5
208.0	-1.0	-1.0	-1.0	-1.0	-1.0
208.1	-1.7	-2.1	-3.3	-3.3	-3.3
208.2	0.1	0.0	-0.7	-0.7	-0.7
208.3	0.2	0.1	-0.6	-1.4	-1.5
208.4	0.2	0.2	0.1	-0.6	-1.6
208.5	0.2	0.2	0.2	0.1	0.1
208.6	-0.9	-0.6	-0.5	-0.4	-0.5
208.7	-1.0	-0.7	-0.6	-0.4	-0.5
208.8	-0.2	-0.2	-0.9	-1.1	-1.2
208.9	-3.0	-3.0	-3.1	-3.1	-3.1
208.9	-1.9	-1.9	-1.9	-1.8	-1.9
209.0	-0.9	-0.8	-0.9	-0.9	-0.9
209.1	-2.1	-1.9	-2.0	-2.0	-2.0
209.2	-7.9	-8.1	-8.5	-8.5	-8.5
209.3	-8.3	-8.7	-9.0	-9.1	-9.1
209.4	-6.3	-6.6	-7.1	-7.1	-7.2
209.5	-5.8	-6.3	-6.4	-5.5	-5.5
209.6	-5.1	-5.1	-5.2	-5.2	-5.1
209.7	-2.2	-2.3	-3.0	-3.8	-4.0
209.8	0.0	0.0	-0.1	-0.2	-0.5
209.9	0.1	0.2	1.6	1.4	1.4
210.0	0.7	0.6	1.6	0.7	0.5
210.1	2.8	2.8	4.1	3.7	3.3
210.2	3.1	3.0	3.1	3.0	3.0

210.3	1.9	1.9	2.9	2.5	2.8
210.4	1.9	2.6	4.0	4.0	4.1
210.4	1.3	3.3	4.1	3.7	3.9
210.5	3.5	4.1	4.2	3.9	4.1
210.6	4.7	4.5	5.9	5.8	5.8
210.6	3.2	3.8	4.5	4.2	4.3
210.7	4.5	4.5	5.6	5.9	5.9
210.8	2.1	2.3	3.2	3.1	3.2
210.9	1.7	1.8	2.8	3.0	3.0
211.0	2.8	2.8	4.2	4.5	4.6
211.1	4.9	5.1	5.8	6.1	6.1
211.2	2.4	2.5	3.6	4.2	4.2
211.3	2.5	2.5	3.7	3.8	3.8
211.4	4.4	4.9	6.1	6.1	6.2
211.5	2.6	2.8	3.9	3.7	3.7
211.6	2.5	3.2	4.1	4.4	4.3
211.7	2.8	3.2	3.9	4.0	4.0
211.8	2.5	3.2	4.0	4.3	4.3
211.9	2.6	3.1	3.7	3.9	3.8
212.0	2.6	3.2	3.9	3.9	3.9
212.1	2.4	2.7	3.1	3.3	3.3
212.2	-0.6	-0.4	-0.1	-0.1	-0.1
212.3	-4.5	-4.1	-3.9	-3.8	-3.9
212.4	-4.0	-3.6	-3.7	-3.8	-3.8
212.5	-5.5	-5.3	-5.4	-5.5	-5.4
212.6	-5.1	-5.0	-5.4	-5.8	-5.6
212.7	-2.7	-3.0	-3.4	-4.0	-4.0
212.7	-3.5	-4.0	-4.5	-4.8	-4.8
212.8	-6.1	-6.4	-6.9	-7.1	-7.1
212.9	-4.6	-5.5	-6.1	-6.5	-6.6
213.0	-5.5	-6.2	-6.6	-6.6	-6.6
213.1	-3.7	-4.3	-4.9	-5.1	-5.3
213.2	-0.8	-1.5	-2.1	-2.2	-2.3
213.3	2.1	1.0	0.1	-0.4	-0.4
213.3	-0.5	-1.2	-2.0	-2.3	-2.4
213.4	-0.6	-1.5	-2.6	-3.1	-3.1
213.5	-1.8	-2.7	-3.6	-4.2	-4.2
213.6	-2.2	-3.0	-3.9	-4.6	-4.6
213.7	-2.3	-3.1	-4.2	-5.0	-5.0
213.8	0.0	-0.4	-1.5	-2.3	-2.2
213.9	-2.5	-3.2	-4.3	-5.1	-5.1
213.9	-1.5	-2.4	-3.8	-4.4	-4.4
214.0	0.4	-0.6	-1.7	-2.3	-2.6
214.1	-0.2	-0.3	-2.0	-2.1	-2.1

Table 13: Accumulated sand delivery for with existing 35th Ave Bridge.

River Station (miles)	Accumulated Sand Delivery (tons)	Accumulated Sand Delivery (tons/year)	Accumulated Sand Delivery (cy/year)	Accumulated Sand Delivery (ac-ft/year)
202.1	14422208	288444	178408	110.6
202.2	14352047	287041	177540	110.0
202.3	14329823	286596	177265	109.9
202.4	14333327	286667	177309	109.9
202.5	14339765	286795	177388	110.0
202.6	14331662	286633	177288	109.9
202.7	14295841	285917	176845	109.6
202.8	14291759	285835	176794	109.6
202.9	14340572	286811	177398	110.0
203.0	14390974	287819	178022	110.3
203.1	14404236	288085	178186	110.4
203.2	14368498	287370	177744	110.2
203.3	14325232	286505	177208	109.8
203.4	14312941	286259	177056	109.7
203.5	14293714	285874	176819	109.6
203.6	14302732	286055	176930	109.7
203.7	14333628	286673	177312	109.9
203.8	14416945	288339	178343	110.5
203.9	14533425	290669	179784	111.4
204.0	14675276	293506	181539	112.5
204.1	14611829	292237	180754	112.0
204.1	14612501	292250	180762	112.0
204.3	14685253	293705	181662	112.6
204.3	14658035	293161	181325	112.4
204.4	14572993	291460	180273	111.7
204.5	14469595	289392	178994	110.9
204.6	14385128	287703	177949	110.3
204.7	14293674	285873	176818	109.6
204.8	14252748	285055	176312	109.3
204.9	14285831	285717	176721	109.5
205.0	14328664	286573	177251	109.9
205.1	14426900	288538	178466	110.6
205.1	14417327	288347	178348	110.5
205.3	14394932	287899	178071	110.4
205.3	14432187	288644	178531	110.7
205.4	14446262	288925	178706	110.8
205.4	14498503	289970	179352	111.2
205.5	14531543	290631	179761	111.4
205.6	14579293	291586	180351	111.8
205.8	14668813	293376	181459	112.5
205.8	14758751	295175	182571	113.2

205.9	14857138	297143	183788	113.9
206.0	14929605	298592	184685	114.5
206.1	14909628	298193	184438	114.3
206.2	14911000	298220	184455	114.3
206.3	14905861	298117	184391	114.3
206.4	14898132	297963	184295	114.2
206.5	14824492	296490	183384	113.7
206.6	14777841	295557	182807	113.3
206.7	14810993	296220	183217	113.6
206.8	14957615	299152	185031	114.7
206.9	15118055	302361	187016	115.9
207.0	15454313	309086	191176	118.5
207.1	15757776	315156	194930	120.8
207.2	15722182	314444	194489	120.6
207.3	15661582	313232	193740	120.1
207.3	15573266	311465	192647	119.4
207.4	15491502	309830	191636	118.8
207.5	15453835	309077	191170	118.5
207.5	15438854	308777	190984	118.4
207.6	15428208	308564	190853	118.3
207.7	15327505	306550	189607	117.5
207.8	15229600	304592	188396	116.8
207.9	15132987	302660	187201	116.0
208.0	15103263	302065	186833	115.8
208.1	15077987	301560	186520	115.6
208.2	15064528	301291	186354	115.5
208.3	15111648	302233	186937	115.9
208.4	15121992	302440	187065	115.9
208.5	15172666	303453	187691	116.3
208.6	15229482	304590	188394	116.8
208.7	15257794	305156	188745	117.0
208.8	15278637	305573	189002	117.2
208.9	15305602	306112	189336	117.4
208.9	15263395	305268	188814	117.0
209.0	15296104	305922	189218	117.3
209.1	15410151	308203	190629	118.2
209.2	15534060	310681	192162	119.1
209.3	15550754	311015	192369	119.2
209.4	15549481	310990	192353	119.2
209.54	15322105	306442	189540	117.5
209.6	15296562	305931	189224	117.3
209.69	15262057	305241	188797	117.0
209.79	15561085	311222	192496	119.3
209.88	15868319	317366	196297	121.7
209.98	16038306	320766	198400	123.0
210.07	16310772	326215	201770	125.1
210.17	16749400	334988	207196	128.4
210.26	17124292	342486	211834	131.3

210.36	17352282	347046	214654	133.1
210.44	17525652	350513	216799	134.4
210.46	17593666	351873	217640	134.9
210.55	17748626	354973	219557	136.1
210.64	18237946	364759	225610	139.8
210.74	18689042	373781	231190	143.3
210.83	19202294	384046	237539	147.2
210.93	19585068	391701	242275	150.2
211.02	19995070	399901	247346	153.3
211.12	20396388	407928	252311	156.4
211.21	20760274	415205	256812	159.2
211.31	20863642	417273	258091	160.0
211.41	20913878	418278	258712	160.4
211.54	20998620	419972	259761	161.0
211.64	21089320	421786	260883	161.7
211.71	21147284	422946	261600	162.1
211.79	21213886	424278	262424	162.7
211.89	21289324	425786	263357	163.2
211.99	21363218	427264	264271	163.8
212.08	21587200	431744	267042	165.5
212.18	21911450	438229	271053	168.0
212.27	22148280	442966	273982	169.8
212.37	22396204	447924	277049	171.7
212.46	22641114	452822	280079	173.6
212.56	22660454	453209	280318	173.8
212.68	22603146	452063	279609	173.3
212.74	22555978	451120	279026	172.9
212.84	22504458	450089	278388	172.6
212.93	22401770	448035	277118	171.8
213.03	22296008	445920	275810	171.0
213.11	22178918	443578	274361	170.1
213.21	22079558	441591	273132	169.3
213.26	22059252	441185	272881	169.1
213.33	22055918	441118	272840	169.1
213.38	22033092	440662	272558	168.9
213.47	21993772	439875	272071	168.6
213.57	21931304	438626	271298	168.2
213.66	21863528	437271	270460	167.6
213.75	21801168	436023	269689	167.2
213.85	21767034	435341	269266	166.9
213.95	21747616	434952	269026	166.8
214.04	21694544	433891	268370	166.3
214.14	21659744	433195	267939	166.1

Note: weight of sand = 120 pcf, 1 ton = 16.7 cubic feet
This is a table of the total weight of sand and larger transported past each cross section in the model plotted versus channel station.
Sediment inflow = 166 ac-ft/year

With Project

The without project sediment transport analysis numerical models were modified to reflect the with project conditions. The proposed project would consist of a trapezoidal low flow channel approximately 300- to 800-ft wide and up to 15-ft deep. The low flow channel excavation would extend from approximately River Mile 203.5 to 211.5.

Model Geometry

The without project sediment transport analysis numerical models were modified to reflect the proposed geometry changes. The modification consisted mainly of excavating the low flow channel within the existing channel bed. The numerical models were then calibrated with the fixed bed (HEC-RAS) numerical models. Finally, the numerical models were rerun to simulate 50 years of sediment transport.

Results

The sediment transport analysis results are presented in terms of thalweg bed elevation by decade show on Figure 23 and Tables 14 to 16. The significant results are discussed below.

- In general, the end result of the simulation is a channel with a more homogeneous bed slope. The bed slope tends to parallel the proposed bed slope of the low flow channel.

- The channel reach between the 19th to the 27th Avenue Bridges would experience up to 5 ft of deposition. This is similar to what would occur for without project conditions.

- An area from the 27th to the 35th Avenue Bridges would have up to 6 ft of scour. This is most likely due to the deposition that occurred upstream and from the channel bed trying to obtain a stable slope.

- Downstream of the 35th Avenue Bridge up to River Mile 208, the channel would be generally stable with scattered areas of minor erosion and deposition.

- From River Mile 208 to the 51st Avenue Bridge, up to 5 ft of deposition would occur. Downstream from the bridge to River Mile 207, up to 8 ft of scour would occur.

- Downstream of River Mile 206, the channel would be generally stable with scattered areas of minor erosion and deposition.

- More sediment would leave the study area. After 50 years of simulated sediment transport, approximately 2,591,000 additional tons of sediment (20 ac-ft/year) would leave the study area, as compared to the without project conditions. This indicates that the study area, with the proposed low flow channel in place, would be more efficient in transporting sediment.

- During the simulations most of the bed changes took place in the first decade, with minor adjustments occurring in the remaining time. The first decade contained the flow events with the two largest peaks. In addition, it can be seen that the trend observed after the first decade is sometimes reversed after subsequent decades. This is a consequence of both changes in the cross section geometry with time, and changes in sediment dynamics associated with flows of very different magnitudes.

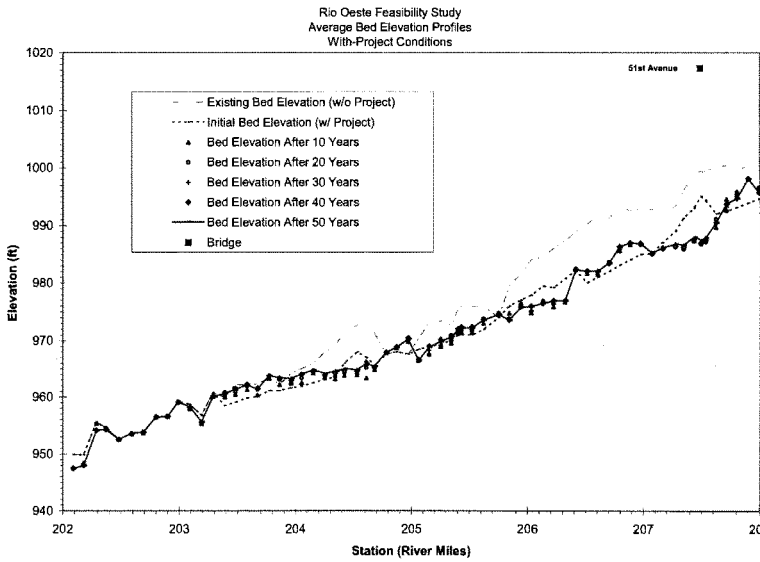

Figure 23: Average bed elevation profiles for with project condition.

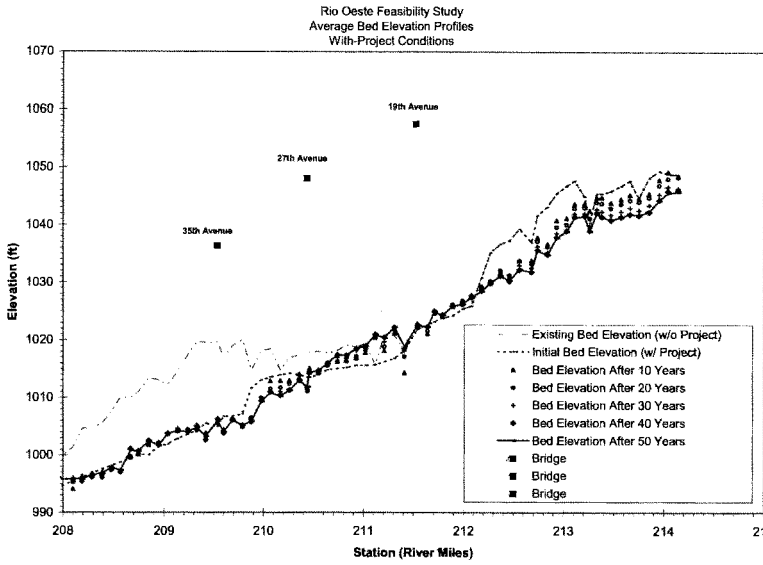

Figure 23: continued

Table 14: Average bed elevation profiles for with project condition.

River Station (miles)	Initial Avg. Bed Elev. (ft)	Avg. Bed Elev. After 10 Years (ft)	Avg. Bed Elev. After 20 Years (ft)	Avg. Bed Elev. After 30 Years (ft)	Avg. Bed Elev. After 40 Years (ft)	Avg. Bed Elev. After 50 Years (ft)
202.1	949.9	947.6	947.5	947.5	947.4	947.4
202.2	949.8	948.4	948.3	948.1	948.0	948.0
202.3	955.5	955.4	955.3	954.2	954.2	954.1
202.4	954.6	954.5	954.5	954.4	954.3	954.3
202.5	952.5	952.6	952.6	952.5	952.5	952.5
202.6	953.7	953.5	953.5	953.5	953.6	953.6
202.7	953.7	953.7	953.8	953.8	953.8	953.8
202.8	956.4	956.5	956.6	956.5	956.5	956.5
202.9	956.5	956.6	956.7	956.6	956.6	956.5
203.0	959.2	959.1	959.1	959.1	959.1	959.1
203.1	958.7	957.9	958.0	958.1	958.1	958.2
203.2	956.7	955.3	955.3	955.6	955.6	955.6
203.3	960.8	960.1	960.1	960.1	960.1	960.1
203.4	958.4	959.9	960.2	960.8	960.8	960.6
203.5	959.0	960.5	960.9	961.5	961.5	961.3

203.6	959.8	961.3	961.9	962.2	962.2	962.1
203.7	960.1	960.3	961.3	961.6	961.6	961.4
203.8	961.1	963.3	963.6	963.8	963.7	963.7
203.9	961.1	962.2	963.1	963.4	963.3	963.4
204.0	961.6	962.4	962.5	963.2	962.9	963.2
204.1	961.9	962.5	963.3	963.9	964.0	964.1
204.1	962.5	964.2	964.3	964.7	964.6	964.7
204.3	963.0	963.4	963.7	963.9	963.8	964.1
204.3	963.5	963.2	963.6	964.5	964.2	964.5
204.4	966.0	963.8	964.3	964.8	964.7	964.9
204.5	968.0	963.9	964.1	964.6	964.7	964.8
204.6	967.0	963.3	965.2	966.3	965.7	965.8
204.7	965.5	964.8	965.0	965.2	965.2	965.4
204.8	967.6	967.8	967.9	967.9	968.0	967.9
204.9	968.0	968.7	968.8	968.9	969.0	968.9
205.0	967.6	970.0	970.1	970.2	970.5	970.3
205.1	968.5	966.5	966.4	966.5	966.6	966.4
205.1	969.0	967.6	967.5	968.3	969.1	968.9
205.3	969.5	969.0	969.2	969.9	970.2	969.9
205.3	970.0	969.6	970.0	970.4	970.9	970.7
205.4	971.0	971.3	971.6	971.8	972.0	971.8
205.4	971.0	971.5	971.9	972.0	972.4	972.2
205.5	971.0	971.5	971.7	972.0	972.4	972.2
205.6	971.9	973.1	973.8	973.5	973.6	973.6
205.8	974.0	974.8	974.7	974.6	974.6	974.5
205.8	976.0	974.8	973.8	973.4	973.7	973.6
205.9	977.0	976.6	976.2	976.0	975.9	975.8
206.0	977.8	974.8	975.1	975.2	976.0	975.9
206.1	979.4	976.9	976.8	976.6	976.5	976.4
206.2	979.2	975.9	976.4	976.4	976.9	976.9
206.3	980.7	976.7	976.8	976.8	976.9	976.9
206.4	982.2	982.5	982.4	982.0	982.3	982.2
206.5	980.0	981.7	982.0	982.0	982.1	982.0
206.6	981.0	981.7	981.4	981.5	982.0	982.1
206.7	982.0	983.6	983.7	983.5	983.4	983.5
206.8	983.1	985.7	985.8	986.1	986.3	986.3
206.9	984.0	986.7	987.0	986.9	987.0	987.0
207.0	985.0	987.0	986.9	986.8	986.8	986.8
207.1	985.1	985.3	985.1	985.1	985.1	985.2
207.2	987.1	986.3	986.1	986.0	986.0	986.2
207.3	989.0	986.8	986.3	986.3	986.4	986.7
207.3	991.2	986.5	985.9	985.9	986.2	986.6
207.4	993.0	987.4	987.3	987.4	987.5	988.0
207.5	995.0	987.3	986.8	986.8	987.0	987.5
207.5	994.4	987.8	987.1	987.5	987.4	987.8
207.6	992.0	989.7	991.1	990.5	990.5	990.5
207.7	992.5	994.5	992.6	993.3	993.7	993.7
207.8	993.1	995.4	995.5	995.9	994.7	994.6

207.9	993.9	998.1	998.2	998.2	998.1	998.1
208.0	994.6	996.5	996.5	996.0	995.7	995.7
208.1	995.4	994.1	995.3	996.0	995.4	995.8
208.2	996.1	996.3	995.5	995.4	995.7	995.8
208.3	996.8	996.8	996.3	996.7	996.2	996.5
208.4	997.5	997.0	996.1	996.7	996.6	996.9
208.5	998.1	997.8	997.5	997.6	997.4	997.8
208.6	998.7	997.3	997.0	997.0	997.0	997.3
208.7	999.4	999.6	999.8	1001.2	1001.0	1000.8
208.8	1000.1	1000.2	1000.2	1000.3	1000.7	1000.7
208.9	1000.0	1001.8	1001.8	1002.2	1002.5	1002.5
208.9	1001.5	1002.2	1002.1	1002.1	1001.7	1001.7
209.0	1001.9	1003.8	1003.7	1003.8	1003.8	1003.8
209.1	1002.9	1004.3	1004.4	1004.6	1004.3	1004.2
209.2	1003.6	1004.4	1004.5	1004.4	1004.1	1004.1
209.3	1004.3	1004.7	1004.3	1005.2	1005.0	1004.8
209.4	1005.5	1003.9	1003.3	1003.2	1002.7	1003.3
209.5	1005.0	1005.7	1005.7	1006.2	1006.2	1006.0
209.6	1006.7	1004.5	1004.2	1004.2	1003.9	1004.0
209.7	1006.8	1006.1	1006.3	1006.4	1006.2	1006.1
209.8	1007.1	1005.0	1005.0	1005.2	1005.2	1005.2
209.9	1011.7	1006.5	1006.5	1006.2	1005.9	1005.9
210.0	1013.0	1009.7	1009.9	1009.7	1009.4	1009.3
210.1	1013.5	1012.9	1011.5	1011.1	1011.0	1010.8
210.2	1013.9	1012.9	1011.7	1011.0	1010.4	1010.3
210.3	1014.2	1012.9	1012.4	1011.3	1011.3	1011.2
210.4	1013.9	1014.1	1013.2	1012.9	1013.0	1013.0
210.4	1013.5	1011.7	1011.1	1011.3	1011.8	1011.8
210.5	1013.5	1015.0	1014.5	1014.1	1014.3	1014.3
210.6	1013.9	1014.3	1014.2	1014.4	1014.7	1014.6
210.6	1014.8	1015.7	1015.5	1015.6	1016.0	1015.9
210.7	1015.0	1016.2	1016.3	1017.0	1017.4	1017.4
210.8	1015.2	1016.5	1016.3	1016.9	1017.3	1017.3
210.9	1015.6	1016.9	1017.2	1018.2	1018.5	1018.5
211.0	1015.6	1017.8	1018.2	1018.6	1018.9	1018.9
211.1	1015.7	1020.4	1020.6	1020.8	1021.0	1020.9
211.2	1016.2	1018.1	1018.9	1019.7	1020.4	1020.4
211.3	1016.8	1021.2	1021.8	1022.1	1022.2	1022.2
211.4	1018.2	1014.3	1017.1	1018.1	1018.5	1018.8
211.5	1021.9	1022.6	1022.7	1022.8	1022.5	1022.6
211.6	1022.6	1021.2	1021.6	1022.3	1022.3	1022.3
211.7	1023.2	1024.7	1025.0	1025.1	1025.0	1024.9
211.8	1023.8	1024.1	1024.2	1024.5	1024.3	1024.3
211.9	1024.2	1025.8	1026.1	1026.1	1025.9	1025.9
212.0	1025.4	1026.7	1026.8	1026.6	1026.2	1026.2
212.1	1025.9	1027.5	1027.6	1027.7	1027.4	1027.4
212.2	1030.8	1029.2	1029.2	1028.7	1028.5	1028.4
212.3	1035.1	1029.9	1030.2	1030.0	1029.9	1029.9

212.4	1036.6	1032.1	1032.0	1031.5	1031.1	1031.1
212.5	1037.2	1031.0	1031.2	1030.6	1030.2	1030.3
212.6	1039.3	1033.8	1033.7	1032.9	1032.2	1032.2
212.7	1036.9	1033.8	1033.3	1032.5	1031.8	1031.8
212.7	1041.6	1037.8	1037.1	1036.2	1035.6	1035.5
212.8	1043.1	1036.6	1036.2	1035.2	1034.9	1034.8
212.9	1045.4	1040.8	1039.6	1038.5	1037.8	1037.7
213.0	1046.7	1041.2	1040.0	1039.1	1038.9	1038.8
213.1	1047.6	1043.6	1042.9	1041.9	1041.4	1041.2
213.2	1044.9	1043.7	1043.0	1042.0	1041.6	1041.5
213.3	1040.4	1042.5	1041.1	1039.8	1039.0	1038.9
213.3	1045.4	1044.7	1043.9	1042.7	1042.1	1042.0
213.4	1045.4	1044.8	1043.7	1042.3	1041.4	1041.4
213.5	1045.8	1043.9	1042.9	1041.7	1040.8	1040.8
213.6	1046.7	1044.5	1043.6	1042.3	1041.3	1041.3
213.7	1047.6	1045.2	1044.3	1042.9	1041.8	1041.9
213.8	1044.6	1044.5	1044.0	1042.6	1041.7	1041.7
213.9	1048.1	1045.4	1044.8	1043.4	1042.2	1042.2
213.9	1049.3	1047.8	1046.8	1045.3	1044.3	1044.2
214.0	1048.8	1049.2	1048.0	1046.6	1045.8	1045.5
214.1	1048.7	1048.5	1048.3	1046.3	1046.0	1045.7

Table 15: Change in average bed elevation profiles for with project condition.

River Station (miles)	Change in Avg. Bed Elev. After 10 Years (ft)	Change in Avg. Bed Elev. After 20 Years (ft)	Change in Avg. Bed Elev. After 30 Years (ft)	Change in Avg. Bed Elev. After 40 Years (ft)	Change in Avg. Bed Elev. After 50 Years (ft)
202.1	-2.0	-2.1	-2.2	-2.3	-2.3
202.2	-1.7	-1.8	-1.9	-1.9	-2.0
202.3	-0.1	-0.2	-1.3	-1.3	-1.3
202.4	0.0	0.0	-0.3	-0.4	-0.4
202.5	0.4	0.1	0.0	0.0	0.0
202.6	-0.1	-0.2	-0.2	-0.2	-0.2
202.7	0.1	0.0	0.0	0.0	0.0
202.8	0.1	0.2	0.1	0.1	0.1
202.9	0.2	0.3	0.2	0.2	0.2
203.0	0.0	0.1	0.1	0.1	0.1
203.1	-0.5	-0.5	-0.5	-0.5	-0.4
203.2	-0.3	-0.3	-0.5	-0.4	-0.3
203.3	-0.3	-0.3	-0.3	-0.3	-0.3
203.4	-0.3	-0.4	-0.5	-0.5	-0.8
203.5	-0.2	-0.2	-0.2	-0.2	-0.2

203.6	0.2	0.4	0.3	0.4	0.5
203.7	0.4	0.7	0.8	0.9	1.0
203.8	1.3	1.8	1.8	1.9	1.9
203.9	2.8	3.0	3.0	3.1	3.2
204.0	-1.6	-1.7	-1.6	-1.5	-1.4
204.1	-0.4	-0.4	-0.4	-0.4	-0.3
204.1	1.1	1.0	0.8	0.7	0.7
204.3	0.0	0.0	-0.5	-0.7	-0.7
204.3	-2.5	-2.9	-2.9	-2.9	-2.9
204.4	-3.1	-3.2	-3.7	-3.9	-3.9
204.5	-3.2	-3.4	-3.6	-3.7	-3.7
204.6	-4.0	-4.4	-4.8	-4.9	-4.9
204.7	-1.5	-1.6	-1.9	-2.1	-2.1
204.8	0.2	0.2	0.2	0.3	0.3
204.9	0.9	0.6	0.9	1.0	0.9
205.0	3.5	3.5	3.7	3.9	3.8
205.1	-0.1	-0.2	-0.1	0.0	-0.1
205.1	-4.4	-3.8	-3.8	-3.2	-3.3
205.3	-0.9	-0.7	-0.5	-0.6	-0.6
205.3	0.0	0.2	0.2	0.2	0.2
205.4	0.7	1.1	1.1	1.2	1.1
205.4	0.5	0.5	0.5	0.6	0.6
205.5	0.1	0.1	0.3	0.5	0.5
205.6	0.7	0.9	1.2	1.5	1.6
205.8	1.3	1.5	1.8	2.0	2.0
205.8	0.1	0.0	0.0	0.0	-0.1
205.9	-0.3	-0.3	-0.5	-0.5	-0.6
206.0	-1.2	-1.2	-1.5	-1.9	-1.9
206.1	-1.3	-1.4	-1.5	-1.7	-1.7
206.2	-1.5	-1.9	-2.0	-2.1	-2.2
206.3	-1.6	-1.7	-2.0	-2.1	-2.2
206.4	-1.6	-2.1	-2.3	-2.6	-3.0
206.5	-2.7	-2.3	-2.8	-3.3	-3.6
206.6	-2.1	-2.7	-2.9	-2.9	-3.3
206.7	-0.6	-1.5	-2.3	-1.8	-1.9
206.8	-1.8	-1.8	-2.4	-2.5	-2.7
206.9	-2.0	-4.9	-4.9	-5.0	-4.5
207.0	1.1	-1.8	-2.4	-1.6	-1.7
207.1	-0.6	-1.1	-1.5	-1.2	-1.2
207.2	0.5	-0.9	-0.7	-0.7	-0.6
207.3	-2.0	-2.1	-2.7	-2.9	-3.0
207.3	-2.7	-2.7	-3.8	-4.0	-4.2
207.4	-1.5	-1.5	-1.6	-2.1	-2.2
207.5	-0.9	-0.9	-1.6	-1.8	-1.9
207.5	-1.0	-0.9	-1.1	-1.4	-1.4
207.6	-2.6	-2.6	-3.2	-3.3	-3.3
207.7	-2.1	-2.0	-2.0	-2.1	-2.0
207.8	-1.6	-2.2	-2.1	-2.2	-2.2

207.9	-0.6	-0.9	-1.4	-1.4	-1.5
208.0	-1.0	-1.0	-1.0	-1.0	-1.0
208.1	-1.7	-2.1	-3.3	-3.3	-3.3
208.2	0.1	0.0	-0.7	-0.7	-0.7
208.3	0.2	0.1	-0.6	-1.4	-1.5
208.4	0.2	0.2	0.1	-0.6	-1.6
208.5	0.2	0.2	0.2	0.1	0.1
208.6	-0.9	-0.6	-0.5	-0.4	-0.5
208.7	-1.0	-0.7	-0.6	-0.4	-0.5
208.8	-0.2	-0.2	-0.9	-1.1	-1.2
208.9	-3.0	-3.0	-3.1	-3.1	-3.1
208.9	-1.9	-1.9	-1.9	-1.8	-1.9
209.0	-0.9	-0.8	-0.9	-0.9	-0.9
209.1	-2.1	-1.9	-2.0	-2.0	-2.0
209.2	-7.9	-8.1	-8.5	-8.5	-8.5
209.3	-8.3	-8.7	-9.0	-9.1	-9.1
209.4	-6.3	-6.6	-7.1	-7.1	-7.2
209.5	-5.8	-6.3	-6.4	-5.5	-5.5
209.6	-5.1	-5.1	-5.2	-5.2	-5.1
209.7	-2.2	-2.3	-3.0	-3.8	-4.0
209.8	0.0	0.0	-0.1	-0.2	-0.5
209.9	0.1	0.2	1.6	1.4	1.4
210.0	0.7	0.6	1.6	0.7	0.5
210.1	2.8	2.8	4.1	3.7	3.3
210.2	3.1	3.0	3.1	3.0	3.0
210.3	1.9	1.9	2.9	2.5	2.8
210.4	1.9	2.6	4.0	4.0	4.1
210.4	1.3	3.3	4.1	3.7	3.9
210.5	3.5	4.1	4.2	3.9	4.1
210.6	4.7	4.5	5.9	5.8	5.8
210.6	3.2	3.8	4.5	4.2	4.3
210.7	4.5	4.5	5.6	5.9	5.9
210.8	2.1	2.3	3.2	3.1	3.2
210.9	1.7	1.8	2.8	3.0	3.0
211.0	2.8	2.8	4.2	4.5	4.6
211.1	4.9	5.1	5.8	6.1	6.1
211.2	2.4	2.5	3.6	4.2	4.2
211.3	2.5	2.5	3.7	3.8	3.8
211.4	4.4	4.9	6.1	6.1	6.2
211.5	2.6	2.8	3.9	3.7	3.7
211.6	2.5	3.2	4.1	4.4	4.3
211.7	2.8	3.2	3.9	4.0	4.0
211.8	2.5	3.2	4.0	4.3	4.3
211.9	2.6	3.1	3.7	3.9	3.8
212.0	2.6	3.2	3.9	3.9	3.9
212.1	2.4	2.7	3.1	3.3	3.3
212.2	-0.6	-0.4	-0.1	-0.1	-0.1
212.3	-4.5	-4.1	-3.9	-3.8	-3.9

212.4	-4.0	-3.6	-3.7	-3.8	-3.8
212.5	-5.5	-5.3	-5.4	-5.5	-5.4
212.6	-5.1	-5.0	-5.4	-5.8	-5.6
212.7	-2.7	-3.0	-3.4	-4.0	-4.0
212.7	-3.5	-4.0	-4.5	-4.8	-4.8
212.8	-6.1	-6.4	-6.9	-7.1	-7.1
212.9	-4.6	-5.5	-6.1	-6.5	-6.6
213.0	-5.5	-6.2	-6.6	-6.6	-6.6
213.1	-3.7	-4.3	-4.9	-5.1	-5.3
213.2	-0.8	-1.5	-2.1	-2.2	-2.3
213.3	2.1	1.0	0.1	-0.4	-0.4
213.3	-0.5	-1.2	-2.0	-2.3	-2.4
213.4	-0.6	-1.5	-2.6	-3.1	-3.1
213.5	-1.8	-2.7	-3.6	-4.2	-4.2
213.6	-2.2	-3.0	-3.9	-4.6	-4.6
213.7	-2.3	-3.1	-4.2	-5.0	-5.0
213.8	0.0	-0.4	-1.5	-2.3	-2.2
213.9	-2.5	-3.2	-4.3	-5.1	-5.1
213.9	-1.5	-2.4	-3.8	-4.4	-4.4
214.0	0.4	-0.6	-1.7	-2.3	-2.6
214.1	-0.2	-0.3	-2.0	-2.1	-2.1

Table 16: Accumulated sand delivery for with project condition.

River Station (miles)	Accumulated Sand Delivery (tons)	Accumulated Sand Delivery (tons/year)	Accumulated Sand Delivery (cy/year)	Accumulated Sand Delivery (ac-ft/year)
202.1	17628630	352573	218073	135.2
202.2	17566704	351334	217307	134.7
202.3	17578326	351567	217450	134.8
202.4	17616204	352324	217919	135.1
202.5	17641616	352832	218233	135.3
202.6	17647478	352950	218306	135.3
202.7	17618552	352371	217948	135.1
202.8	17627956	352559	218064	135.2
202.9	17697854	353957	218929	135.7
203.0	17759152	355183	219687	136.2
203.1	17770982	355420	219834	136.3
203.2	17728772	354575	219311	135.9
203.3	17656010	353120	218411	135.4
203.4	17634948	352699	218151	135.2
203.5	17634116	352682	218141	135.2
203.6	17660976	353220	218473	135.4

203.7	17725830	354517	219275	135.9
203.8	17802298	356046	220221	136.5
203.9	17930276	358606	221804	137.5
204.0	17992160	359843	222570	138.0
204.1	17961880	359238	222195	137.7
204.1	18007294	360146	222757	138.1
204.3	18089458	361789	223773	138.7
204.3	18094522	361890	223836	138.7
204.4	18063454	361269	223452	138.5
204.5	18012190	360244	222817	138.1
204.6	17959644	359193	222167	137.7
204.7	17943648	358873	221970	137.6
204.8	17952666	359053	222081	137.7
204.9	18016020	360320	222865	138.1
205.0	18068326	361367	223512	138.5
205.1	18166800	363336	224730	139.3
205.1	18115050	362301	224090	138.9
205.3	18132840	362657	224310	139.0
205.3	18123232	362465	224191	139.0
205.4	18133152	362663	224314	139.0
205.4	18173510	363470	224813	139.3
205.5	18221230	364425	225403	139.7
205.6	18251780	365036	225781	139.9
205.8	18358150	367163	227097	140.8
205.8	18409544	368191	227733	141.2
205.9	18495754	369915	228799	141.8
206.0	18502134	370043	228878	141.9
206.1	18574610	371492	229775	142.4
206.2	18522596	370452	229131	142.0
206.3	18488262	369765	228707	141.8
206.4	18405322	368106	227681	141.1
206.5	18466258	369325	228434	141.6
206.6	18592264	371845	229993	142.6
206.7	18609980	372200	230212	142.7
206.8	18645066	372901	230646	143.0
206.9	18768976	375380	232179	143.9
207.0	18877108	377542	233517	144.7
207.1	18929182	378584	234161	145.1
207.2	18928294	378566	234150	145.1
207.3	18889876	377798	233675	144.8
207.3	18824338	376487	232864	144.3
207.4	18693176	373864	231242	143.3
207.5	18588570	371771	229947	142.5
207.5	18503374	370067	228894	141.9

207.6	18391202	367824	227506	141.0
207.7	18369146	367383	227233	140.8
207.8	18444202	368884	228162	141.4
207.9	18537142	370743	229311	142.1
208.0	18759652	375193	232064	143.8
208.1	18802348	376047	232592	144.2
208.2	18735716	374714	231768	143.7
208.3	18647152	372943	230672	143.0
208.4	18573832	371477	229765	142.4
208.5	18527040	370541	229186	142.1
208.6	18469774	369395	228478	141.6
208.7	18428648	368573	227969	141.3
208.8	18478280	369566	228583	141.7
208.9	18626658	372533	230419	142.8
208.9	18951092	379022	234432	145.3
209.0	19214994	384300	237697	147.3
209.1	19456122	389122	240679	149.2
209.2	19632624	392652	242863	150.5
209.3	19849070	396981	245540	152.2
209.4	19925544	398511	246486	152.8
209.54	19873520	397470	245843	152.4
209.6	19874018	397480	245849	152.4
209.69	19833710	396674	245350	152.1
209.79	19794046	395881	244860	151.8
209.88	19752222	395044	244342	151.5
209.98	19622552	392451	242738	150.5
210.07	19571026	391421	242101	150.1
210.17	19576600	391532	242170	150.1
210.26	19531080	390622	241607	149.8
210.36	19448810	388976	240589	149.1
210.44	19405058	388101	240048	148.8
210.46	19420082	388402	240234	148.9
210.55	19501814	390036	241245	149.5
210.64	19809372	396187	245049	151.9
210.74	20186708	403734	249717	154.8
210.83	20518542	410371	253822	157.3
210.93	20779750	415595	257053	159.3
211.02	21083192	421664	260807	161.7
211.12	21352598	427052	264140	163.7
211.21	21617646	432353	267418	165.8
211.31	21699780	433996	268434	166.4
211.41	21768300	435366	269282	166.9
211.54	21772100	435442	269329	166.9
211.64	21826002	436520	269996	167.4

211.71	21832558	436651	270077	167.4
211.79	21856348	437127	270371	167.6
211.89	21872180	437444	270567	167.7
211.99	21908828	438177	271020	168.0
212.08	22045154	440903	272707	169.0
212.18	22282030	445641	275637	170.8
212.27	22356534	447131	276559	171.4
212.37	22673536	453471	280480	173.9
212.46	22922546	458451	283560	175.8
212.56	22917512	458350	283498	175.7
212.68	22838462	456769	282520	175.1
212.74	22778198	455564	281775	174.7
212.84	22713836	454277	280979	174.2
212.93	22593486	451870	279490	173.2
213.03	22468946	449379	277949	172.3
213.11	22329284	446586	276222	171.2
213.21	22206750	444135	274706	170.3
213.26	22170514	443410	274257	170.0
213.33	22156638	443133	274086	169.9
213.38	22122092	442442	273658	169.6
213.47	22071350	441427	273031	169.2
213.57	21995908	439918	272098	168.7
213.66	21919336	438387	271150	168.1
213.75	21848124	436962	270269	167.5
213.85	21804714	436094	269732	167.2
213.95	21773480	435470	269346	167.0
214.04	21710996	434220	268573	166.5
214.14	21666602	433332	268024	166.1

Note: weight of sand = 120 pcf, 1 ton = 16.7 cubic feet
This is a table of the total weight of sand and larger transported past each cross section in the model plotted versus channel station.
Sediment inflow = 166 ac-ft/year

GEOMORPHOLOGY DISCUSSION

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).

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

Existing vegetation

No detail analysis was performed for any significant vegetation impacts on flood flows. As in the immediate upstream Rio Salado Phoenix and Va Shly'ay studies, major floods are expected to remove almost all the vegetation from the floodplain.

Erosion

Because of the complexity of estimating erosion and future erosion conditions it was decided that another approach would be to compare flow conditions at Rio Salado 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.

For the Future Without Project condition the average channel velocity remains relatively the same. With project conditions shows equal or lower channel velocity conditions, refer to alternative model results. Thus, for the Rio Salado area bank erosion was not a concern based on the feasibility analysis and no bank stabilization was proposed for this area.

RISK AND UNCERTAINTY ANALYSIS

Selection of index points

Reaches were developed through coordination with Econ to account primarily for differences in channel hydrology and hydraulics. A representative index location for each reach was selected. Table 17 is summarizes the different hydraulically similar reaches within the study area.

Table 17: Summarizes the different hydraulically similar reaches within the study area.

Reach	Index Station	Station Limits
1	203.29	202.09 to 204.25
2	204.78	204.34 to 205.34
3	205.75	205.40 to 207.07
4	207.90	207.16 to 208.29
5	209.14	208.39 to 209.42
6	209.88	209.53 to 210.36
7	210.64	210.43 to 211.02

Risk and Uncertainty Analysis

Procedures outlined in EM 1110-2-1619 "The determination of stage-discharge uncertainty requires accounting for the uncertainty associated with factors affecting the stage-discharge relationship. These factors include bed forms, water temperature, 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." The HEC-RAS program should be run with variations in roughness, bed forms if applicable, bridge scour, debris on piers, gravel mining, etc. to estimate the stage uncertainty.

For each modeled subset, two HEC-RAS models were developed for 500-, 200-, 100-, 50-, 20-, 10-, 5- and 3.1-year events, a "Lower Bound" model and an "Upper Bound" model. The range between the water surface elevations for the models is used to estimate standard deviation of stage uncertainty. In accordance with EM 1110-2-1619, the standard deviation is calculated as:

$$STDDEV = E_{mean} / 4$$

Where:
E_{mean}=mean stage difference between the "Upper Bound" and "Lower Bound" models.

Sensitivity to Manning's Roughness Coefficient

The selection of the roughness coefficients has been detail in previous sections. The selections are based on published data, calculation, and field observations, all subjective to engineering judgment. In the risk and uncertainty analysis, the "Lower Bound" models were developed using Manning's roughness values that were 20-percent lower than those contained in the base model. The "Lower Bound" model

was configured with no debris loading on the bridges piers but incorporated the effects of long term bed scour conditions. However, the "Upper Bound" model was constructed using a Manning's roughness values that were approximate 20-percent higher than the value in the base model. The "Upper Bound" model also incorporated debris loading on the bridges and long term bed aggradations in the channel. Finally, since the standard deviation for all reaches was determined to be 0.5 or less, (from Table 18 and Figure 9) the results were considered to be reasonable based on the designs guidance criteria found in EM1110-1619 Table 5-2 Minimum Standard Deviation of Error in Stage.

Figure 24 shows the results of this portion of the sensitivity analysis. Averages values and standard deviation values have been calculated by sub-reach.

A summary of the uncertainty analysis for the different alternatives at the index locations is presented in Table 18. The standard deviation for each alternative is tabulated under the column heading "Standard Deviation"

Table 18: Risk Analysis Standard Deviation

Reach	Frequency	Q (cfs)	High Bound Model	Low Bound Model	E mean	Standard Deviation
	500	237000	977.10	975.24	1.86	0.5
Reach 1	200	200000	975.99	974.35	1.64	0.4
Cross Section 203.29	100	164000	974.92	973.38	1.54	0.4
202.09 to 204.25	50	132000	973.87	972.45	1.42	0.4
	20	84000	971.99	970.72	1.27	0.3
	10	51000	970.16	969.07	1.09	0.3
	5	20000	967.51	966.68	0.83	0.2
	3.1	1	960.81	960.81	0.00	0.0
	500	237000	991.42	990.33	1.09	0.3
Reach 2	200	200000	990.44	989.40	1.04	0.3
Cross Section 204.78	100	164000	989.25	988.20	1.05	0.3
204.34 to 205.34	50	132000	987.80	986.72	1.08	0.3
	20	84000	984.76	983.65	1.11	0.3
	10	51000	981.29	980.41	0.88	0.2
	5	20000	976.48	975.84	0.64	0.2
	3.1	1	968.03	968.03	0.00	0.0
	500	240000	997.64	996.17	1.47	0.4
Reach 3	200	202000	996.43	994.99	1.44	0.4
Cross Section 205.75	100	166000	995.12	993.57	1.55	0.4
205.40 to 207.07	50	135000	993.57	991.85	1.72	0.4
	20	87000	990.24	988.53	1.71	0.4
	10	53000	987.18	985.89	1.29	0.3
	5	20200	982.47	981.53	0.94	0.2
	3.1	1	974.53	974.53	0.00	0.0
	500	240000	1015.63	1014.49	1.14	0.3
Reach 4	200	202000	1014.41	1013.39	1.02	0.3

Cross Section 207.9 207.16 to 208.29	100	166000	1012.93	1011.82	1.11	0.3
	50	135000	1011.42	1010.25	1.17	0.3
	20	87000	1008.48	1007.71	0.77	0.2
	10	53000	1005.87	1005.17	0.70	0.2
	5	20200	1002.04	1001.54	0.50	0.1
	3.1	1	998.13	998.13	0.00	0.0
Reach 5 Cross Section 209.14 208.39 to 209.42	500	240000	1022.31	1020.91	1.40	0.3
	200	202000	1020.74	1019.41	1.33	0.3
	100	166000	1019.09	1017.87	1.22	0.3
	50	135000	1017.57	1016.45	1.12	0.3
	20	87000	1014.67	1013.66	1.01	0.3
	10	53000	1011.90	1010.84	1.06	0.3
	5	20200	1008.50	1007.79	0.71	0.2
	3.1	1	1004.22	1004.22	0.00	0.0
Reach 6 Cross Section 209.88 209.53 to 210.36	500	240000	1036.02	1034.85	1.17	0.3
	200	202000	1033.95	1032.84	1.11	0.3
	100	166000	1031.75	1030.91	0.84	0.2
	50	135000	1029.83	1029.06	0.77	0.2
	20	87000	1026.31	1025.74	0.57	0.1
	10	53000	1023.02	1022.46	0.56	0.1
	5	20200	1017.97	1017.28	0.69	0.2
	3.1	1	1011.67	1011.67	0.00	0.0
Reach 7 Cross Section 210.64 210.43 to 211.02	500	240000	1041.38	1039.32	2.06	0.5
	200	202000	1039.33	1037.35	1.98	0.5
	100	166000	1037.22	1035.39	1.83	0.5
	50	135000	1035.31	1033.57	1.74	0.4
	20	87000	1032.13	1030.32	1.81	0.5
	10	53000	1028.97	1027.38	1.59	0.4
	5	20200	1024.26	1022.91	1.35	0.3
	3.1	1	1015.92	1015.92	0.00	0.0

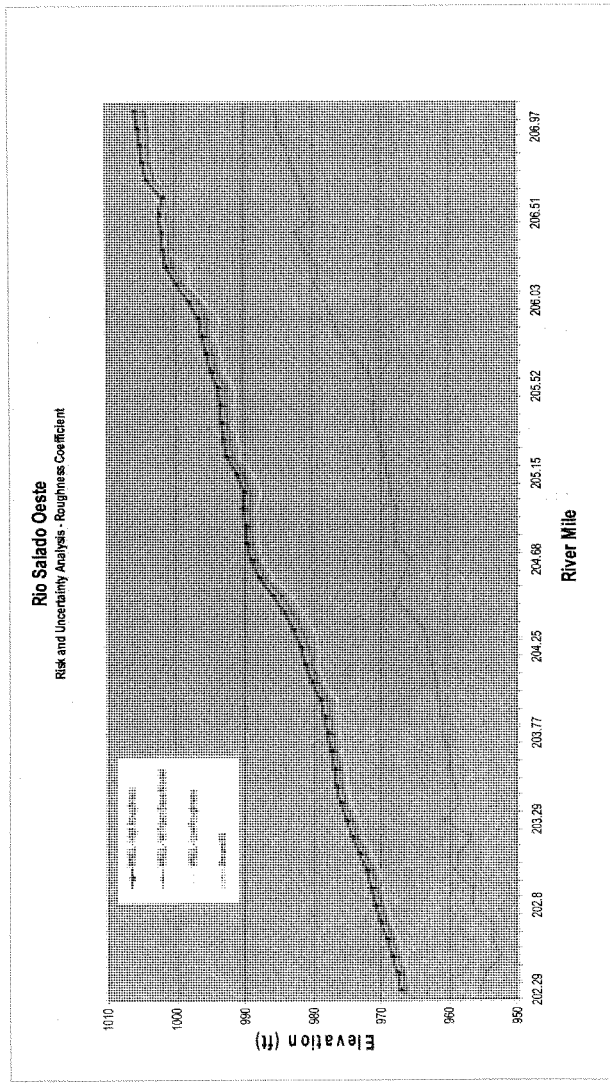

Figure 24: Risk and Uncertainty Analysis – Roughness Coefficient

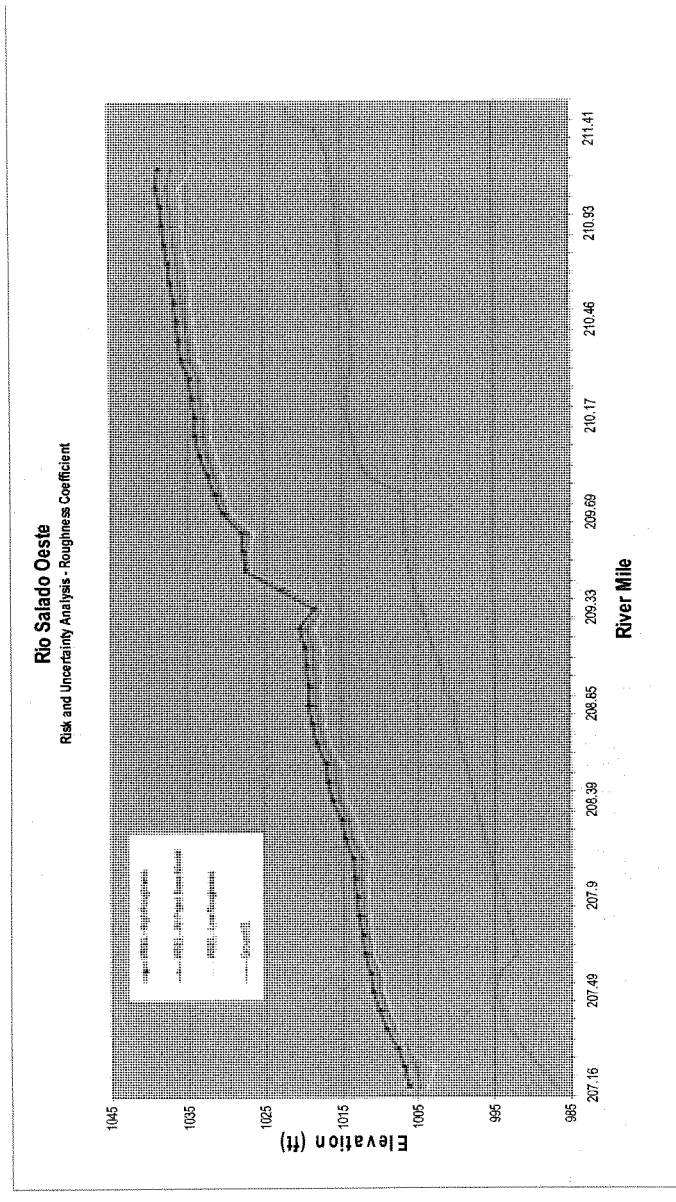

Figure 24: ***Continued***

OPERATION AND MAINTENANCE

The Baseline Without Project Condition and With Project hydraulic results and the Without Project sedimentation results were used to assess the operation and maintenance concerns for this project. During this F4 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. 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

As stated above, the With Project low flow channel was designed between River Mile Stations 203.39 to 207.43 and River Mile Stations 209.53 to 211.52. Inherent in the design objective to maintain the average channel velocities to a level as to not significantly exceed a maximum permissible velocity. These target velocities were tied to velocities associated with the 10-Year Frequency Event Peak Discharge. It was assumed that velocities resulting from flows higher than this particular discharge figure would disrupt the general channel equilibrium in terms of generating excessive erosion and deposition quantities. Further, since the low flow channel does not contain any bank stabilization features other than a grade control structure downstream of 35th Avenue, the same channel would most likely experience some minor degree of laterally migration. However, this anticipated movement of the low flow channel alignment would also be expected to stay within the historic channel thalweg footprint. Therefore, it is highly possible that there would be a requirement for some maintenance for flood events greater than the 20-Year Frequency event.

Vegetation Damage

It was assumed that approximately 25% of the vegetation would need to be replanted following a flood event. As described above, the 5- and 10-year areas of inundation exhibit the highest velocities in the river cross section. Although the adjacent terraces are also inundated during a 20-year frequency and greater events the velocities are less than 7 cfs over most of the floodplain. During the winter/spring of 2005, the Salt River discharges which reached flow rates of up to 39,000 cfs, caused minor damage to ongoing construction and recent plantings within the Rio Salado Project area. This recent experience within the Rio Salado Project reach tends to support the approximate 25% vegetation damage assumption.

In addition, further analyses were performed assuming that any flood flows with a velocity of 5 fps or greater would cause significant plant damage. Specifically, velocity grid data from 5-, 10-, and 20-year frequency events was exported from HEC-RAS into GeoRas and overlaid on to vegetation data to determine the percentage of damaged vegetation. The results supported the 25% replacement figure.

SUMMARY

Hydraulic

Initially, the Existing Condition Baseline hydraulic model was first modified to account for continuing and future mining activities within the study reach. This updated model was subsequently identified as the Future Condition Baseline model. Additional model simulations were then executed for With Project conditions, which included such features as environmental habitat areas, lakes, grade control structure, and a low flow channel design. The water surface With Project Future Condition was less the existing Without Project Condition model simulations as showing on figure 25.

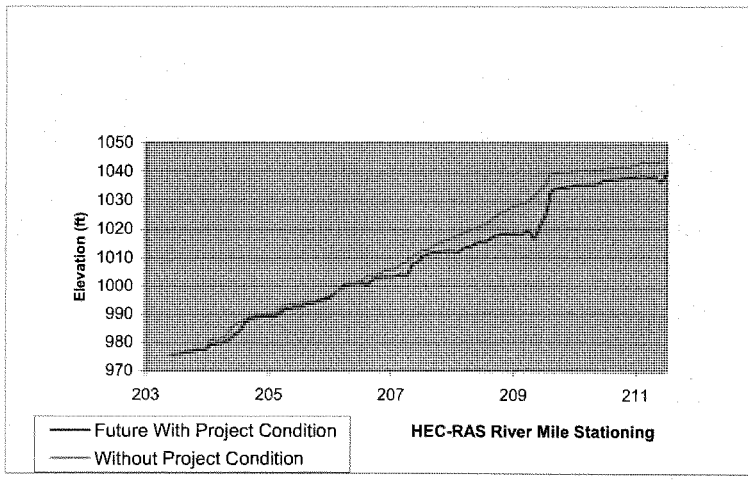

Figure 25: 100-year Water Surface Profile Between Future With Project Condition and Without Project Condition.

As indicated above, the With Project results show minimal water surface elevation variation over the Without Project Baseline condition.

Risk Assessment

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. Of that amount, only a portion is located along the riverbed where the highest stresses are found. 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

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WITHOUT PROJECT HYDRAULIC ANALYSIS REPORT

June 2002

Note: Appendixes not included but available upon request

Rio Salado Oeste Study

Without Project Final
Hydraulic Analysis Report

Contract Number: DACW09-00-D-0021

Prepared for:
U.S. Army Corps of Engineers
Los Angeles District

WEST
CONSULTANTS, INC.

Prepared by:
WEST Consultants, Inc
2151 East Broadway Road, Suite 116
Tempe, AZ 85282
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1. Introduction

1.1. Purpose

This without-project hydraulic and sedimentation analysis was conducted in support of the Rio Salado Oeste Feasibility – F3 Phase Study.

1.2. Scope

This report documents the hydraulic and sedimentation analysis conducted on a reach of approximately 9.5 miles of the Salt River, within the boundaries of the City of Phoenix, Arizona. The focus of the study was the identification of baseline hydraulic and sediment conditions, which will be used with later alternative condition studies to identify the preferred project alternative(s).

A hydraulic model was created based on "existing conditions", and the inundation boundaries associated with different return periods were delineated. Next, a sediment transport model was developed. Using a 50-year synthetic hydrology, the model was used to simulate long term river processes with results analyzed at 10 year intervals.

1.3. Study Area

The study reach extended from the upstream limit of 19th Avenue down to the lower limit of 91st Avenue. The downstream boundary of the study reach was approximately 2.5 miles upstream of the confluence of the Salt and Gila Rivers. Scattered along the reach were several pits, the result of active and inactive sand and gravel mining operations, both within the channel and in the overbank areas.

2. Existing Conditions Hydraulic Analysis

2.1. General

The objectives of the analysis were to identify an existing conditions hydraulic model, delineate flood inundation boundaries for the 5-, 10-, 20-, 50-, 100-, and 500-year events, and provide the initial geometry for the sediment transport analysis.

2.2. Background

An existing Flood Insurance Study (FIS) HEC-RAS model from the confluence with the Gila River (RM 199.82) to about 12th Street (RM 214.14) was provided by the Flood Control District of Maricopa County (FCD). This model will be referred to as the FEMA model. The FCD also provided aerial photographs from 1993 and 1999, an ArcInfo coverage with contours with a 4-ft interval developed for the Salt/Gila River Master Plan (1992), an ArcInfo coverage with the cut lines of 100 of the FEMA model cross sections, and an ArcInfo TIN (Triangular Irregular Network) of the study area including raw data in point files and breakline format also created for the Salt/Gila River Master Plan (1992). The line coverage included cross sections from RM 202.09 to RM 211.12. Cross section 202.09 is located approximately 1100 ft downstream of 91st Avenue, while cross section 211.12 is about 2150 ft downstream of 19th Avenue.

2.3. Existing Conditions Hydraulic Model

A 1-dimensional model of the reach was created using HEC-RAS and the HEC-GeoRAS extension in ArcView 3.2a (Environmental Systems Research Institute, Inc.). The cross section geometry for this model was obtained from the TIN using the same cut lines utilized in the FEMA model.

First the TIN file, aerial photographs, contours coverage and cross sections coverage (containing the cut lines from the FEMA model) were inspected in ArcView. The cross sections coverage was converted into an ArcView shapefile to facilitate editing the cross sections. Seven new cross section lines were added at the downstream end of the reach (ID numbers 1 through 7). These new cross sections were inserted to prevent the downstream boundary condition from affecting the hydraulics in the project area. In addition, two more cut lines were inserted to model the conveyor bridge in the vicinity of the 27th Avenue alignment. These cross sections were located immediately downstream and upstream of the conveyor bridge, and were identified as River Mile 210.43 and 210.44 respectively.

Using the TIN, the contour coverage and the aerial photographs as reference, new shapefiles were created identifying the location of the bank stations, stream centerline, and flow lines in the channel, left overbank and right overbank.

Using the HEC-GeoRAS extension, a HEC-RAS input data file was generated. The data file contained the geo-referenced stream line and cross section lines, and the cross section station/elevation data. In addition, it included flow lengths in the channel, left overbank and right overbank.

The data file was then imported into HEC-RAS and the cross sections IDs were modified to match those from the FEMA model. Next, cross sections 211.21 through 214.14 from the FEMA model were appended at the upstream end of the reach. Although these cross sections were not geo-referenced they provided the geometry in the vicinity of 19th Avenue (the project's upstream end) and add a 2.5 mile segment at the upstream end of the reach. This segment would not have any effect on the hydraulics of the project area since a subcritical flow regime was expected throughout the reach, but were needed to provide an equilibrium inflowing sediment concentration to the study reach in the sediment transport model.

Next, the cross section geometry was reviewed to ensure proper location of channel bank stations. Roughness coefficients in the FEMA model were evaluated and, based on the field visit and the examination of the aerial photographs, deemed to be acceptable for general use. Some of the n coefficients were adjusted based on inspection of the aerial photographs. The appropriateness of these values for the sediment transport model was further evaluated during a subsequent sensitivity analysis. Typical values used in the model are shown in Table 2.1.

Bridge information and modeling procedures from the FEMA model were reviewed and included with some changes into the current HEC-RAS model. There was a new bridge in place at the 51st Avenue crossing. Plans for this bridge were obtained from the City of Phoenix Engineering Department and used to code the bridge geometry. Plans for the bridges at 19th Avenue and 35th Avenue were also obtained to verify their geometry. Plans for the conveyor bridge near the 27th Avenue alignment were obtained from United Metro Materials.

Contraction/expansion loss coefficients were set to 0.3 and 0.5 respectively in the cross sections near the bridges. The bridges in 35th Avenue, 51st Avenue and 27th Avenue were modeled using the "Multiple Opening Analysis" option in HEC-RAS, with the overbanks modeled as conveyance areas. This selection prevented the use of the weir equation to compute flow on the overbanks for the large flood events simulated.

Table 2-1 Manning's *n* values used in the existing conditions hydraulic model.

LAND USE	*n* VALUE
Sand/gravel mine	0.037
Open shrub	0.04 – 0.043
Agricultural	0.025 – 0.037
Urban/industrial	0.043
Disturbed	0.037 – 0.043
Channel open vegetation	0.037
Channel sand/gravel	0.032 – 0.037

Finally, all the cross sections were inspected to identify the location of ineffective flow boundaries. The area occupied by sand and gravel pits was set ineffective for

conveyance calculations or, where this was not possible, the pits were "filled" using blocked obstructions before computing the steady state profiles. This procedure eliminates the excess conveyance in the pit and therefore results in higher water surface elevation, which is a conservative approach for flooding studies. Consideration of in-channel sand and gravel operations is more important in sediment transport studies. Pits can act as sediment traps and induce headcutting in the upstream direction and/or tailcutting downstream.

The discharges used in the hydraulic analysis were obtained from a report by the U.S. Army Corps of Engineers (USACE, 1996), and are shown in Table 2-1. The discharge at Central Avenue was assigned to cross section 214.14, and the discharge at 67th Avenue was assigned to cross section 205.52.

Table 2-2. Discharge frequency values used in the existing conditions model.

LOCATION	RETURN PERIOD					
	5-yr	10-yr	20-yr	50-yr	100-yr	500-yr
Peak Discharges (ft^3/s) in the Salt River at:						
Central Avenue	20,200	53,000	87,000	135,000	166,000	240,000
67th Avenue	20,000	51,000	84,000	132,000	164,000	237,000

The model was run under this configuration and it was observed that several of the cross sections were not able to contain the 500-year flood. In fact, some cross sections could not contain even the 100-year flood. Under these circumstances HEC-RAS extends vertically the end points of the cross section and carries out the flow calculations, but clearly that does not yield the correct water surface elevation.

New elevation data points were needed to extend the terrain model so that the cross sections would be able to contain all floods. The FCD provided additional contour lines (2 ft interval) for the area south of the study reach, between 19th Avenue and 75th Avenue (from Laveen ADMP, 1989). Elevation data for other areas was obtained from the USGS 30m resolution DEM (generated from digitized contours from 1/24,000 USGS topographic maps). The area added through this process is primarily in the far overbank areas of the model where the DEM vertical accuracy is not as critical.

The USGS DEM was converted first from grid format to TIN format to remove points that did not add terrain information. The TIN was then converted into a point shapefile which was then clipped to cover only the area that was not covered by the original TIN or the additional contour map. Finally, a new TIN was generated using the original point and breakline files, the additional contour coverage from the FCD, and the new point shapefile obtained from the 30m DEM.

Using the new TIN as a reference, the cross section cut lines were extended in ArcView and a new HEC-RAS input file was created using HEC-GeoRAS. The input file was imported into HEC-RAS and manipulated in the same manner as before. Cross section plots are shown in Appendix A.

The new model was then executed using the six flood events. The results show that the 100-year flood is now contained in all the cross sections, and the 500-year flood is contained in most of them. The majority of the cross sections that do not contain the largest flow are located near the confluence with the Gila River. It was decided not to extend these cross sections farther to the south because then they would become part of the Gila River floodplain. In any case, the end points of the cross sections that do not contain the 500-year flow are located far from the main channel in ineffective flow areas, and therefore have no effect on the computed water surface elevation.

2.4. Floodplain Delineation

The model was executed for the 5-, 10-, 20-, 50-, 100- and 500-year flood events with the discharges from the Corps report shown in Table 2-1 (for post Roosevelt Dam modifications). Water surface elevation profiles are shown in Figure 2-1. Appendix A shows the 10-, 100- and 500-year water surface elevation in the cross section plots. In addition, Appendix B shows some other variables from the hydraulic model output file.

The model results were exported from HEC-RAS into ArcView to automatically delineate the inundation boundaries using HEC-GeoRAS. The resulting inundation boundaries were then inspected and edited to remove spurious polygons and to ensure that all polygons contained other polygons with smaller return period. Existing conditions floodplain delineations are shown in Appendix C.

The resulting 100-year profile from the Existing Conditions (EC) model was compared to the FEMA model (Figure 2-2). Both profiles are practically identical from the downstream end of the study reach up to river mile 204.25, where the cross sections from the two models show some differences in their geometry. At this location the water surface elevation in the EC model is 0.45 ft higher than in the FEMA model. Upstream of this cross section, between river miles 204.34 and 205.15, the differences between the two models increase, with the FEMA profile 0.6 to 2.54 ft higher than the EC profile. The reason for this divergence is the different location of the ineffective flow limits in the two models. The ineffective flow limits are located closer to the main channel in the FEMA model, constricting the conveyance area resulting in a rise in the water surface elevation. The location of the ineffective flow boundaries differs between the two models because they were developed with different purposes. The FEMA model was developed to define the floodplain only for the 100-year flow. On the other hand, the EC model was created to map flow boundaries for flows with return periods between 5 and 500 years, and then converted into a single sediment transport model driven by measured flows which varied between 20 and 200000 cfs. Therefore, the existing conditions geometry needs to be valid for a wide range of discharges.

From river mile 205.25 to 206.51 the differences between the profiles become small again (0.4 ft or less). The reach between river miles 206.6 and 207.07 has mining pits within the channel. The EC model blocked completely these pits, while the FEMA model raised the bottom of the pits up to a lower elevation than the EC model blockage. As a consequence, the profiles show some differences, with the EC profile being 0.53 to 2.07 ft higher than the FEMA profile.

The cross section in river miles 207.34 shows a difference of 0.78 ft (EC higher than FEMA). The cause is a change in cross section geometry and the election of different locations for the ineffective flow limits. The channel bed is lower for the bridge cross sections (207.48 and 207.49) in the FEMA model, but that did not produce significant difference in the profiles. However, at river mile 207.53 (immediately upstream of the 51st Avenue Bridge) the EC profile is again 0.49 ft higher due once more to the different location of the ineffective flow limits.

The disparity between the profiles is minimal between river miles 207.62 and 208.75. From river mile 208.85 to 209.24 there are again mining pits located within the channel and in the overbank area. The geometry of the blocks used to fill the pits and the location of ineffective flow boundaries are responsible once more for differences in water surface elevation between 0.46 and 2.15 ft. The FEMA model does not block the pits in the channel and blocks the pits in the overbanks to a higher elevation.

The remaining part of the study reach (from river mile 209.42 to 211.54) displays a complete divergence of the two model profiles. The cause for this discrepancy can be found after examination of the cross sections in the vicinity of the 35th Avenue Bridge (209.53 and 209.54). This is a bridge with a very narrow opening. At the same time, the bed slope upstream of the bridge is nearly flat. Therefore, backwater due to the bridge obstruction propagates all the way to the upstream end of the study reach. The bridge cross sections in the FEMA model are much deeper (thalweg elevation ≈ 993 ft) than in the EC model (thalweg elevation ≈ 1020 ft), increasing the conveyance through the bridge opening and producing a lower water surface upstream of the bridge.

The origin of the 35th Avenue Bridge cross section in the FEMA model is not clear. The cross sections in the EC model were extracted from the TIN using the procedure previously described. In general, all the EC cross sections matched well their FEMA counterparts except those bounding the 35th Avenue Bridge. These cross sections are located in an area of the Salt River with permanent water, where no visual verification was possible. Preliminary runs of the sediment transport model revealed that after 50 years of sediment transport the thalweg under the bridge becomes stable at a depth between 1005 and 1010 ft regardless of the initial conditions,. When the sediment transport model was run with river mile 209.54 from the FEMA model (a deep scour hole under bridge), the cross section experienced deposition, and when it was run using river mile 209.54 from the TIN (representing a shallow depth under bridge), the cross section experienced erosion. It is possible that the TIN elevations represent the water surface under the bridge when the mapping was performed but verification would require an on site survey of the area near the bridge.

The TIN river mile 209.54 geometry was selected because it resulted in a more conservative approach for the existing conditions hydraulic analysis but may be overly conservative for a detailed FEMA study. The FEMA study is likely too optimistic in regards to flow area under the bridge based on the sediment results obtained during this study. The future without-project hydraulic analysis results were similar using both geometries so the more conservative initial conditions were used as the basis for this study.

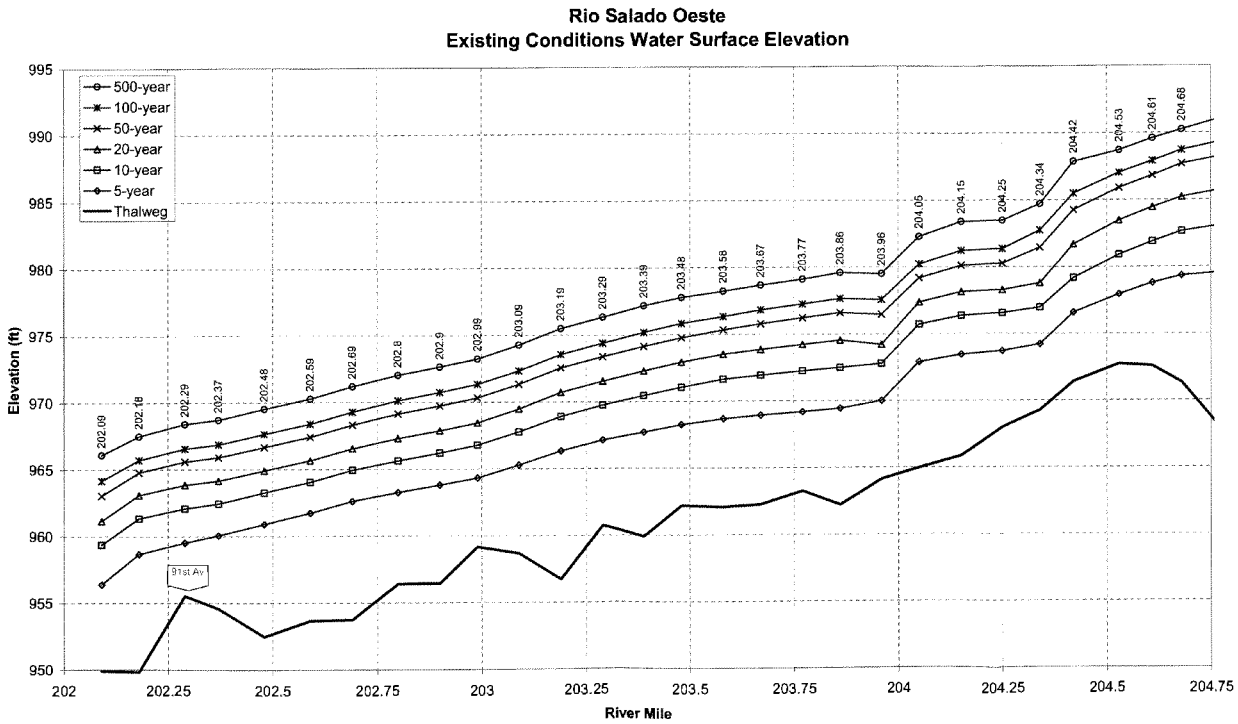

Figure 2-1. Existing conditions water surface elevation profiles.

759

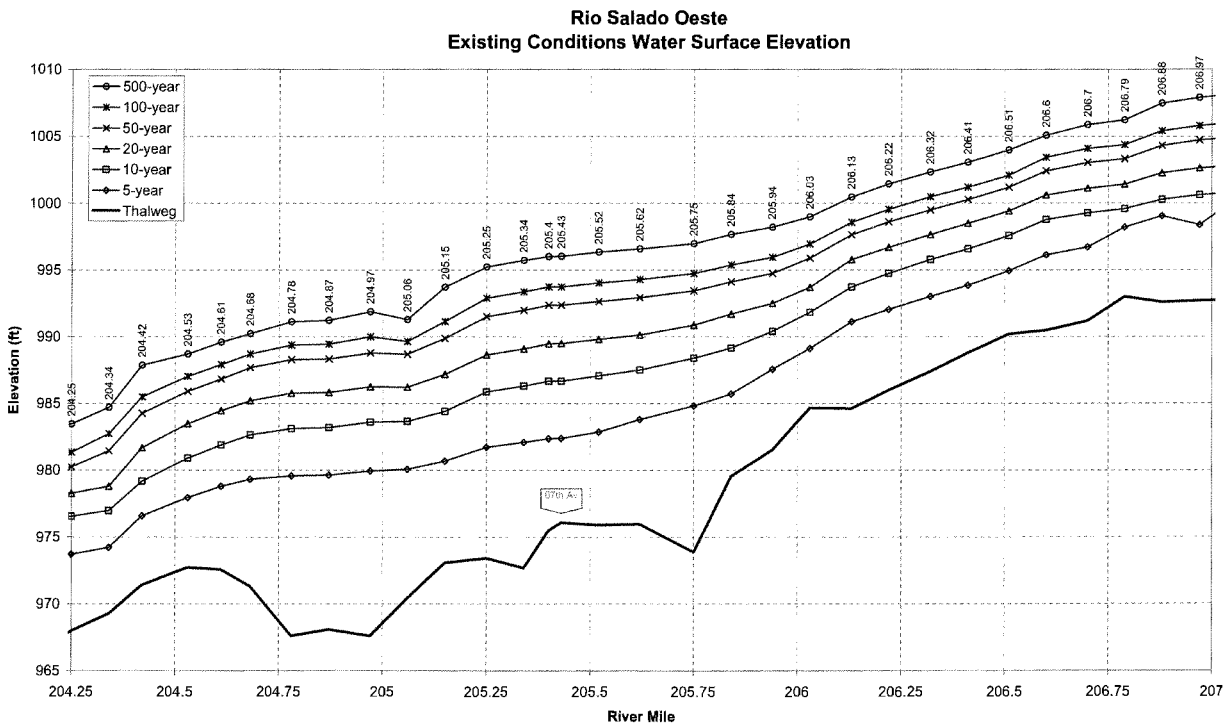

Figure 2-1. ***Continued.***

760

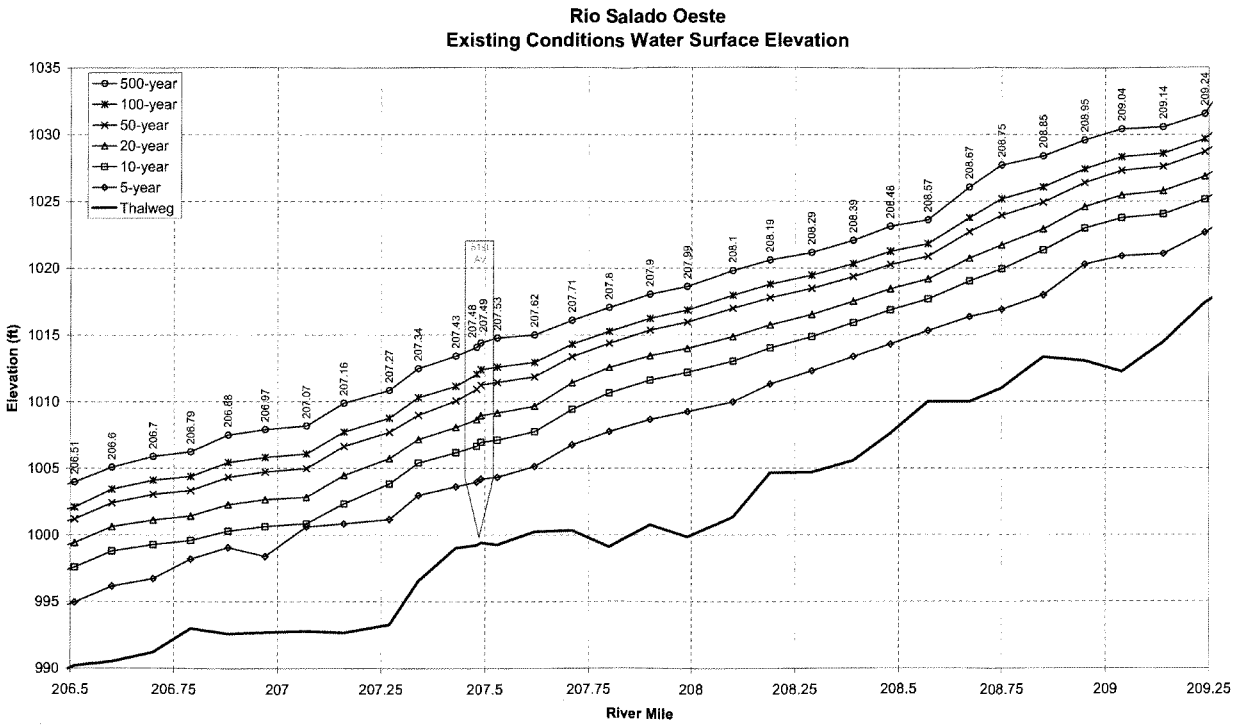

Figure 2-1. *Continued.*

761

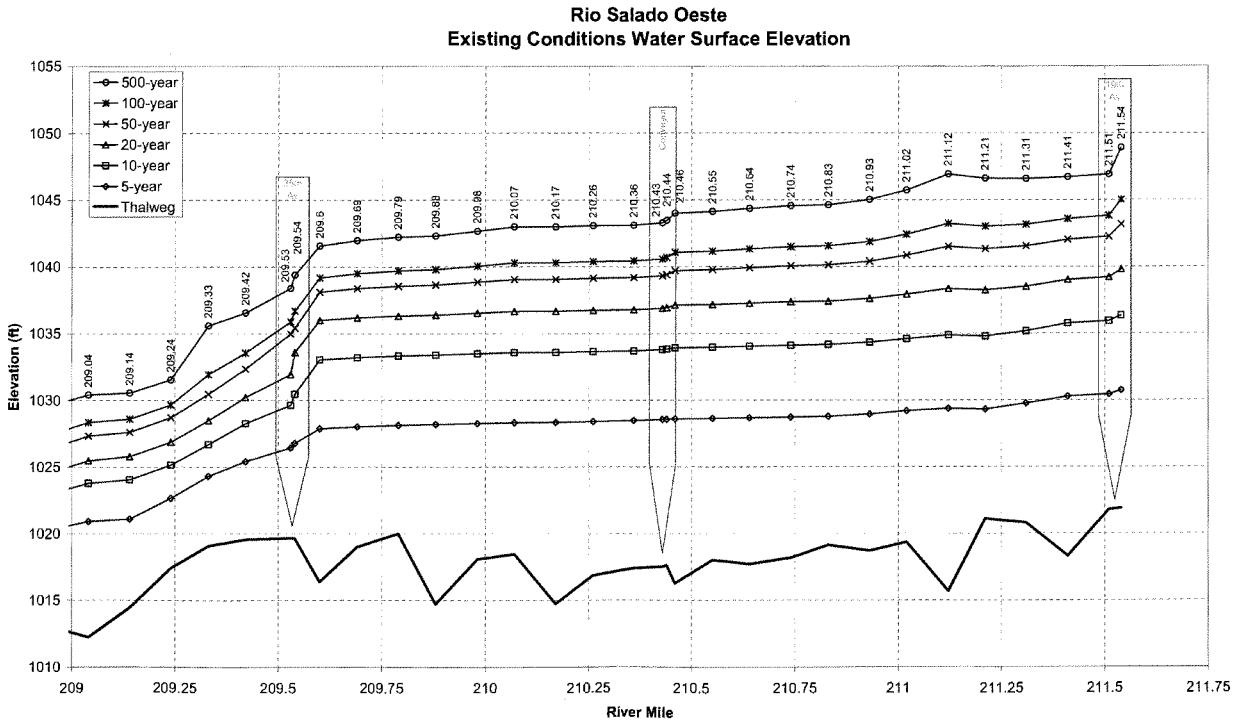

Figure 2-1. ***Continued.***

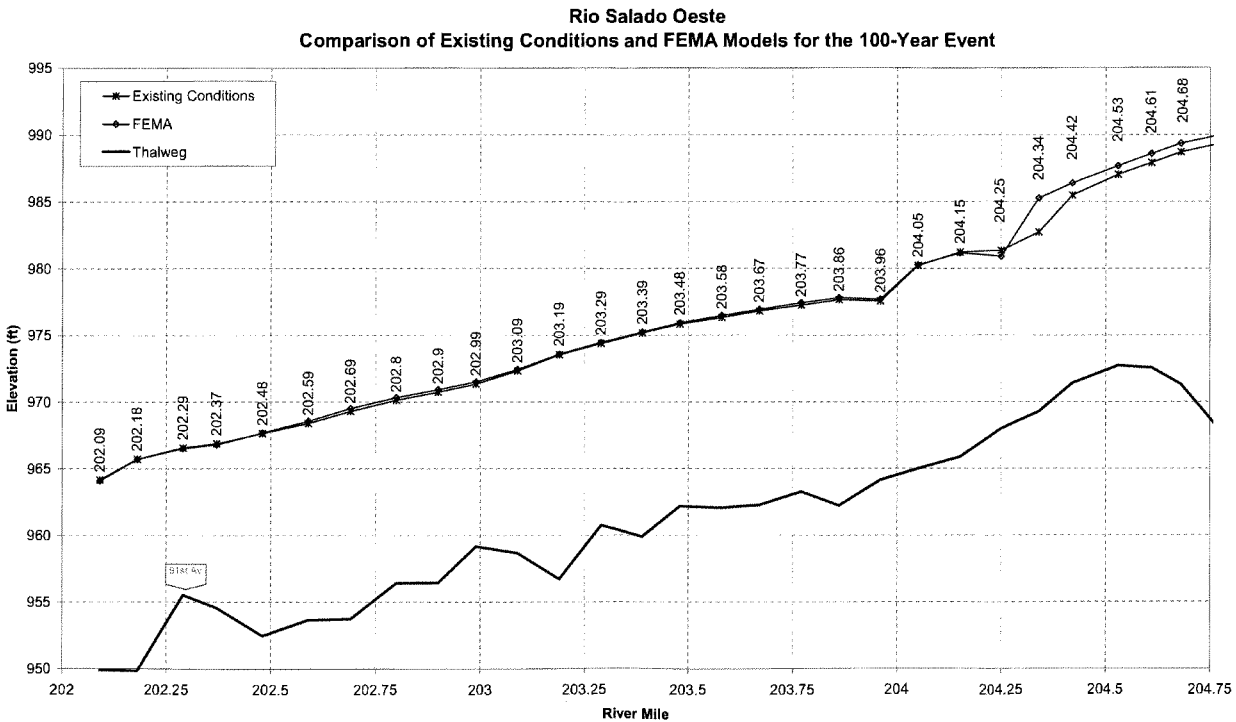

Figure 2-2. Comparison of existing conditions and FEMA models for the 100-year profile.

763

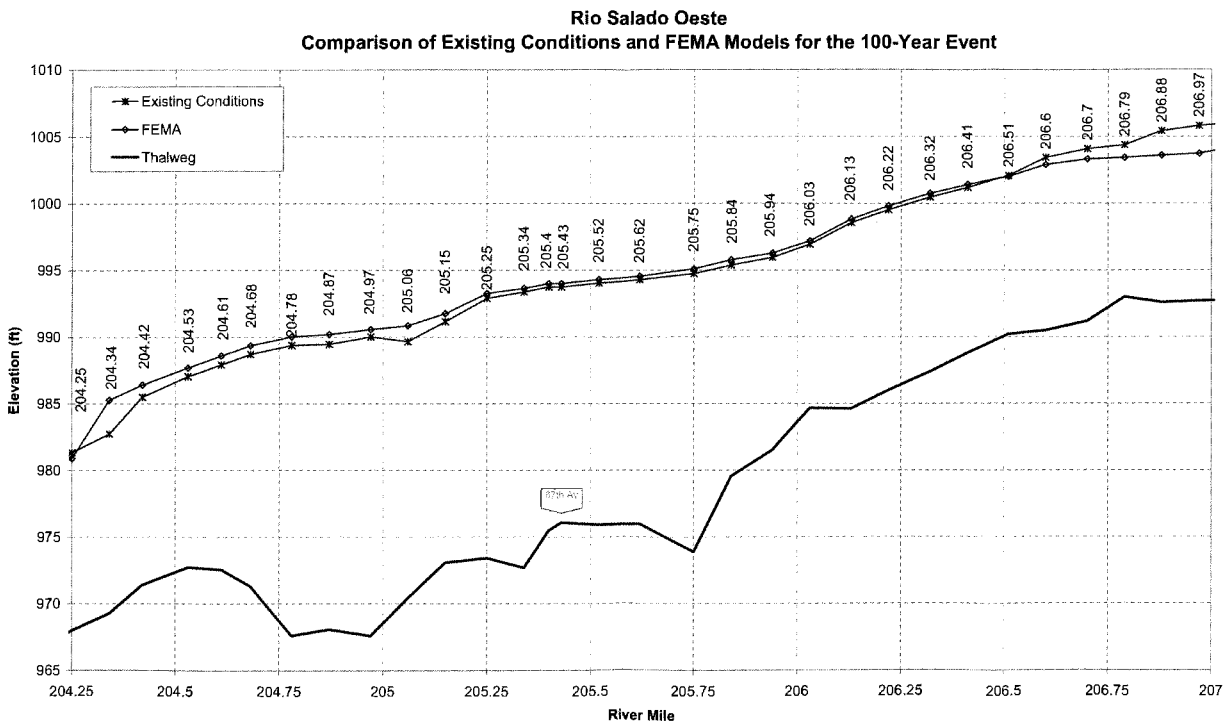

Figure 2-2. ***Continued.***

764

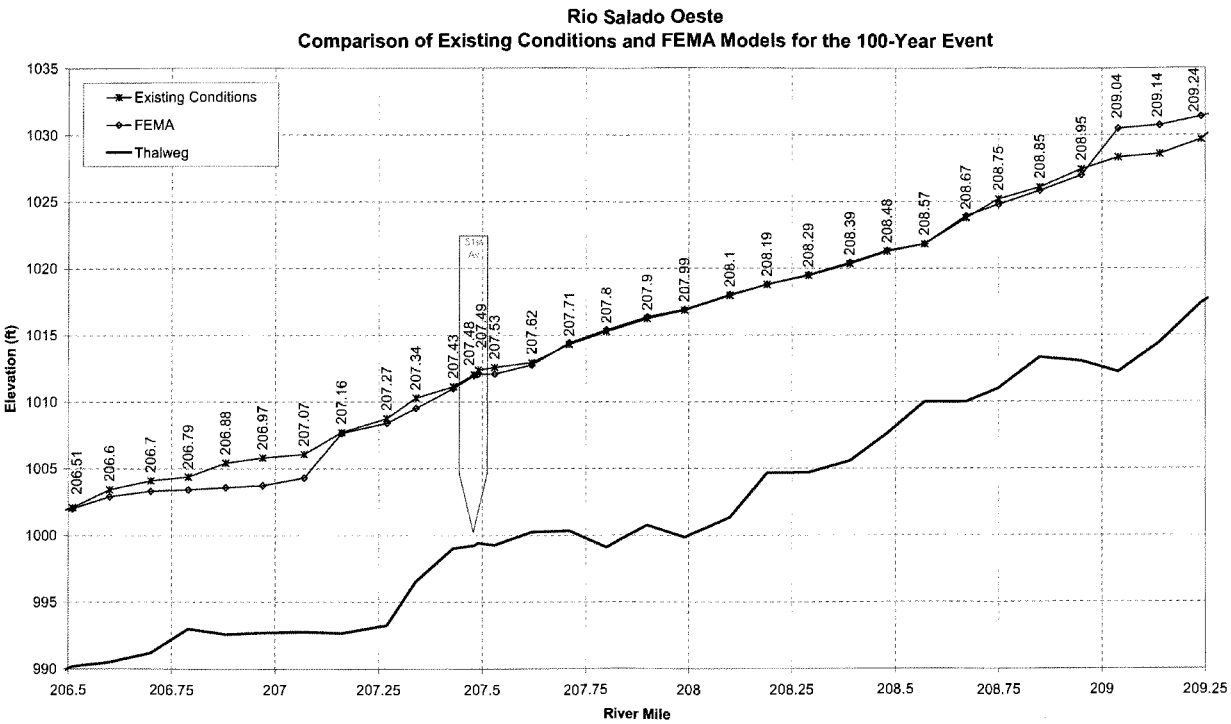

Figure 2-2. *Continued.*

765

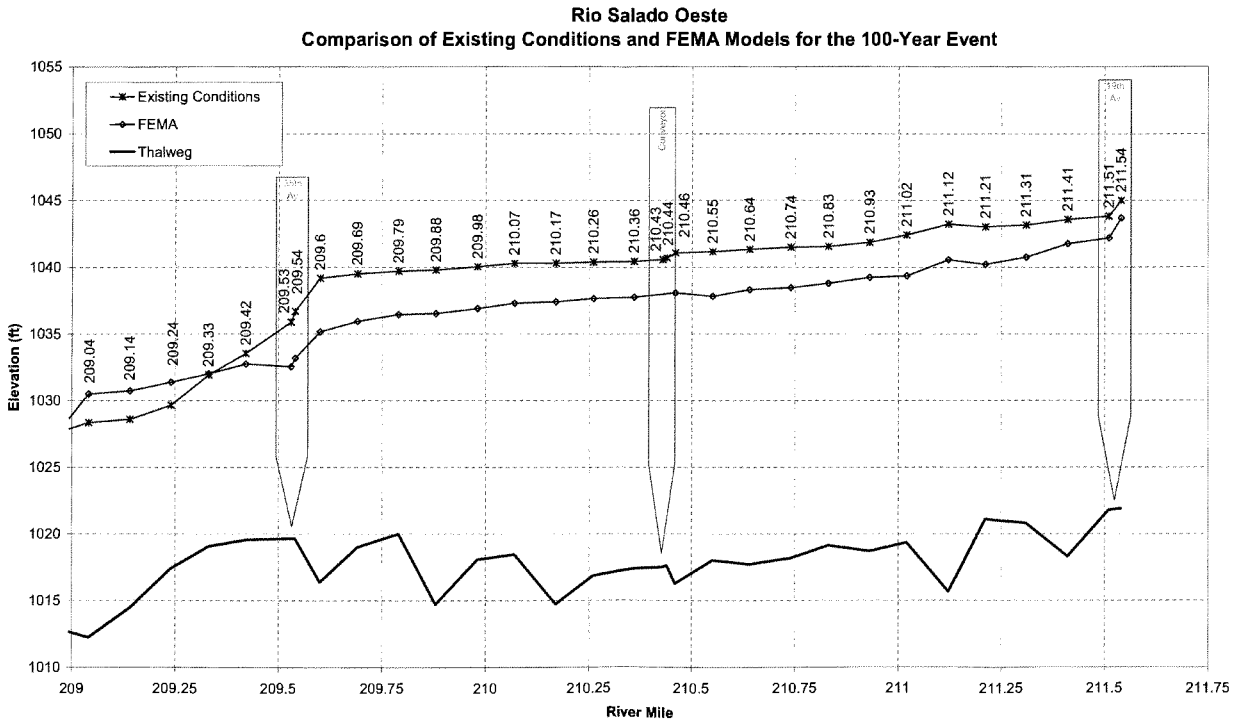

Figure 2-2. *Continued.*

3. Sediment Transport Analysis

3.1. General

The objective of the sediment transport analysis is to identify baseline sediment conditions, which will be used with later alternative conditions studies to identify the preferred project alternatives. A base conditions sediment transport model was created using the geometry from the existing conditions hydraulic model described in the previous chapter.

The computer program HEC-6T "Sedimentation in Stream Networks", version 5.13.15 of May 24, 2001, was used to conduct the numerical sediment transport modeling in this study. HEC-6T was developed by Mr. William A. Thomas of Mobile Boundary Hydraulics, Clinton, Mississippi.

3.2. HEC-RAS Model Conversion

3.2.1. Model Geometry

The geometry of the hydraulic model was converted into a text file with the format required by the HEC-6T program. Roughness coefficients in several cross sections of the hydraulic model vary horizontally with distance in the cross section. HEC-6T does not allow as much horizontal variation of Manning's n, so an alternative method of expressing the roughness coefficient was required. After running the 5-, 10-, 20-, 50-, 100- and 500-year flood events in HEC-RAS, the profile output tables were used to request conveyance weighted Manning's n values for the channel, left and right overbanks for the different discharges. These data were then entered into the HEC-6T input file using NV records. A default value of 0.04 was used to fill blanks when the conveyance in an overbank area was zero. The result was a configuration of roughness coefficients changing in the vertical by discharge rather than in the horizontal by distance.

Conveyance limits defined in HEC-RAS using ineffective flow boundaries were coded using XL records in HEC-6T. The advantage of using XL records is that they allow deposition to occur in the ineffective flow areas. The effect of bridges crossing the river in the study area was accounted for using a single cross section with the pier geometry superimposed as recommended in the HEC-6T manual. Of the two bounding cross sections used to define each bridge in HEC-RAS, only the upstream one was retained in HEC-6T. The two bounding cross sections are very close to each other and keeping both in HEC-6T could cause numerical instabilities.

3.2.2. Fixed Bed Simulation

An elevation-discharge rating curve was developed at the downstream boundary (cross section 1) for starting water surface elevations. Water surface elevations were computed at this location assuming normal depth and a slope of 0.0019 ft/ft, for discharge values ranging from 7500 cfs to 285000 cfs, at 7500 cfs increments (Figure 3-1).

HEC-6T was then run with a fixed bed using the 5-, 10- and 100-year flood events, and the resulting water surface elevations were compared to the HEC-RAS

existing conditions model. In order to guarantee the quality of the sediment model, the water surface elevations computed by HEC-6T for each of the three events were examined at each cross section to ensure that they did not differ from the HEC-RAS results by either 10% of the maximum depth or 1 foot, whichever was less. The results of this analysis are shown in Appendix D.

3.3. Sediment Parameters

The Corps computer program SAMAID was used to select the most appropriate sediment transport relationship. SAMAID results indicated that Madden's 1985 modification of Laursen's equation and Yang's equation were respectively best and second best sediment transport relations for the characteristics of the study reach. Schoklitsch's equation came out in third place. WEST has used Yang's equation in the past on the Salt River upstream and downstream of the project site. In general, this equation performs well for mid sized rivers transporting large amounts of sand, which is typical of many streams in Arizona. Therefore, the sediment transport equation selected for this study was Yang's unit stream power.

3.3.1. Bed Sediment Characteristics

Nineteen locations were identified for sediment sampling and development of gradation curves. Sampling sites were located approximately 0.5 miles apart, from 19th Avenue to 91st Avenue. Samples were collected from 0 to 2 feet, and laboratory grain-size analyses were performed on the samples. In addition, an in-situ particle count consisting of 100 particles spaced at 1 foot intervals was performed. Bed gradation data were entered into the HEC-6T input file using PF records. Sediment gradations and sample locations are shown in Appendix E.

3.3.2. Inflowing Sediment Rating Curve

Recorded information about sediment loads in the Salt River upstream of the study reach is not available. There are however previous studies reporting sediment transport simulations. One of these studies is the Low Flow Channel Design Analysis for Rio Salado (2000) performed by WEST for the Corps. This study presented a sediment transport model of the Salt River from approximately the I-10 Bridge to the 27th Avenue alignment, based on the Toffaleti, Meyer-Peter and Muller combination transport method. The model used an estimated sediment inflow at the upstream end of the reach based on an equilibrium bed material load analysis performed on a 0.5 mile reach upstream of I-10.

The simulated loads from this previous study were not considered appropriate inflow loads to our model because they were not developed using any of the sediment transport equations identified as suitable for the current study (Yang's equation or Madden's 1985 modification of Laursen's equation). If a sediment inflow based on a different equation was used in the current model, depending on the amount of the sediment loads, there is a possibility that it could lead to either unrealistic erosion or deposition in the upstream end of our study reach.

Since we were confronted with a lack of adequate data on inflowing sediment loads into our study reach, an equilibrium bed material load was assumed. The inflowing load at the upstream end of the model was determined on a reach approximately 3 miles

long at the upstream end of the study reach (from RM 211.21 to RM 214.14) with the gradation information from the two most upstream sediment sample locations. Equilibrium sediment loads for this reach were determined for a range of discharges from 20 to 200000 cfs. To determine the equilibrium load, HEC-6T was run using clear water inflow as the initial condition and the recirculation option on ($RE record). The recirculation option instructs the program to use the sediment discharge at the downstream end of the reach as the sediment inflow at the upstream end for the following time step. When equilibrium is attained, sediment load entering the reach is about equal to the load leaving the reach. For discharges between 20 and 50000 cfs, the simulations were run typically for 10 to 100 days with time steps in the order of 0.01 to 0.1 days. For larger discharges (100000 to 200000 cfs), typical durations were between 5 and 10 days with time steps of 0.001 to 0.01 days.

The inflowing sediment loads defined with Yang and Laursen-Madden relationships are shown in Figures 3-2 and 3-3. The gradation of the inflowing load from the equilibrium analysis is shown in Figures 3-4 and 3-5. This information was entered into the HEC-6T input files using LQ, LT and LF records.

3.3.3. Movable Bed Limits

In general, sediment dynamics tend to be more significant within the active channel, where the bed can either degrade or aggrade in response to erosion or deposition. The overbank areas tend to be more stable and normally are free of erosion, but can experience deposition. HD records were used to specify a bed sediment depth of 20 feet for all cross sections but one. At river mile 211.54 the sediment depth was set to zero to account for the grade control structure located immediately downstream of the 19th Avenue Bridge. Movable bed limits were not identified in the HD records, implying that deposition could occur anywhere in the wetted perimeter. In addition, HE records were used to limit erosion within the channel bank stations.

In order to develop a sound hydraulic model, the mining pits, in particular those located in the channel, were blocked to ensure a solution with a subcritical water profile along the reach. However, when flooded, the mining pits will likely act as sediment traps. For that reason, the sediment deposited on top of the blocked areas within or next to the channel was removed from the system using the dredging options in HEC-6T. HI records were used to identify the areas where sediment should be removed in the case that deposition took place, and the $DREDGE record was used to instantaneously take away the deposited sediment after each time step. In addition, when mining pits were located in the channel, the HE limits were relocated to exclude the pit from the area of potential erosion.

3.4. Hydrology

A continuous 50-year hydrograph consisting of historical flows between 1889 and 1938 was provided by the Corps. This flow series corresponds to the "worst case" continuous 50-year period, in terms of both peak flows and storm volumes, within the 105 years of record, from 1889 to 1993. Discharges less than 20 cfs were removed from the hydrology since no sediment was transported for flows of 20 cfs or less.

Simulations were performed with the 50-year hydrograph, with simulation results requested by decade. Figure 3-6 shows the complete 50-year hydrologic input and identifies the end of each decade. The individual hydrographs used to compile the 50-year long hydrograph are shown in Appendix F.

3.5. Results

The sediment transport analysis results are presented in terms of average bed elevation by decade (Figure 3-7 and Appendix G). The average bed elevation corresponding to a 10,000 cfs discharge of very short duration (0.00001 days) was computed in HEC-6T at 10-year intervals. This discharge was selected to generate average bed elevations because, in general, it provided coverage of the channel bottom (HEC-6T computes average bed elevations only from "wetted" points of the cross sections). The 10,000 cfs discharge is used only to generate output, and the short duration minimizes sediment movement.

The results show two distinct areas with respect to sediment dynamics. Downstream of 35th Avenue the reach mainly experiences degradation, with deposition limited to just a few cross sections. One of the depositional areas is defined by cross sections 203.58 to 203.86, and corresponds to an abandoned mining operation. The end result is a channel with a more homogenous bed slope. There are two areas downstream of 35th Avenue where the model predicts severe erosion:

- The first one is defined by cross sections 206.7 to 206.97. This is an area with active mining pits in the channel and a small berm to prevent low flows into the pit. The small flows (the majority in the hydrologic input) are then confined to a channel just about 200 feet wide resulting in severe degradation. Due to the limitations of the model (1-D steady state) it is not possible to simulate the complex interaction that may occur between the mining pit and the channel. The flows could very well breach the berm and enter the pit, limiting degradation in the channel but creating a headcut that would progress upstream.
- The second area corresponds to cross sections 209.24 to 209.54. This is another mined reach with pits on the right overbank and channel in cross sections 209.24 and 209.33. Cross section 209.54 represents the small bridge opening at 35th Avenue. Erosion in this case is associated with the cross sectional area reduction and velocity increase caused by the bridge.

Upstream of the 35th Avenue Bridge the bed slope is milder. That, along with the backwater effect of the bridge, creates the conditions for sediment deposition in most of the cross sections.

In general, average bed elevation changes are more significant in regions of the reach that are currently affected by mining operations in the channel. Where mining is not an issue, average bed changes reach a maximum of 5.8 ft after 50 years of sediment transport, with an average change of 1.9 ft.

During the simulations most of the bed changes took place in the first decade, with minor adjustments occurring in the remaining time. The first decade contained the flow events with the two largest peaks. In addition, it can be seen that the trend observed

after the first decade is sometimes reversed after subsequent decades. This is a consequence of both changes in the cross section geometry with time, and changes in sediment dynamics associated with flows of very different magnitudes.

Appendix H shows plots comparing the cross sections before and after the sediment transport analysis.

3.6. Sensitivity Analysis

The purpose of the analysis was to explore the sensitivity of the sediment transport model to variations in the parameters, in an attempt to determine the appropriateness of the selected values. Sensitivity runs were performed on the base conditions HEC-6T input file to determine the relative effect of changes to Manning's n, inflowing sediment load, and transport equation to the average bed elevation profiles. Results in tabular and graphic format are provided in Appendix I.

3.6.1. Hydraulic Roughness

The sensitivity of the sediment transport model to the hydraulic roughness coefficients was examined. The base conditions sediment transport model results have been compared to simulation outputs resulting from increasing and reducing all Manning's n coefficients in the input file by 25%.

After 50 years of simulating sediment dynamics, the high roughness profile is generally higher than the base condition profile. This is the result of deposition or reduced scour due to reduced flow velocities caused by the higher roughness coefficients. On the other hand, the low roughness profile is generally lower than the base conditions profile because of higher flow velocities. The average bed profile change was 0.7 ft for high roughness and 1.2 ft for low roughness, implying that small errors in the roughness coefficients selected for the base conditions model probably will not have a significant effect on the results.

The largest differences occur in mined reaches, where a 25% increase in Manning's n can reduce erosion by as much as 3.7 ft, and a 25% decrease in Manning's n can augment erosion by as much as 5.9 ft.

3.6.2. Inflowing Sediment Load

The effect of the inflowing sediment load has been assessed by comparing the base conditions sediment transport model with simulation results after increasing and reducing the sediment discharge to twice and half the equilibrium load determined with Yang's equation.

The most important differences can be observed upstream of the 35th Avenue Bridge. In the reach between cross sections 210.07 and 211.34 the double-inflow profile elevation increases an average of 0.6 ft with respect to the base condition, while for the half inflow profile it decreases an average of 0.5 ft. Downstream of 35th Avenue the differences are reduced as the sediment load reaches equilibrium.

3.6.3. Sediment Transport Equation

Simulation results generated with Yang's unit stream power equation have been compared to the simulation results produced with Madden's 1985 modification of Laursen's sediment transport equation.

The two equations yield bed profiles with the same trends in terms of degradational and agradational areas, with slight differences in the depth of eroded or deposited material. The main differences appear at the upstream end of the study reach. The upstream end of the reach is a transition between a narrow segment with levees in both banks and a wider segment severely disturbed by mining operations. It is not surprising that the model results show some instability in this area, until a new equilibrium is reached a little distance downstream. Laursen's equation, as modified by Madden, seems more susceptible to this effect than Yang's equation.

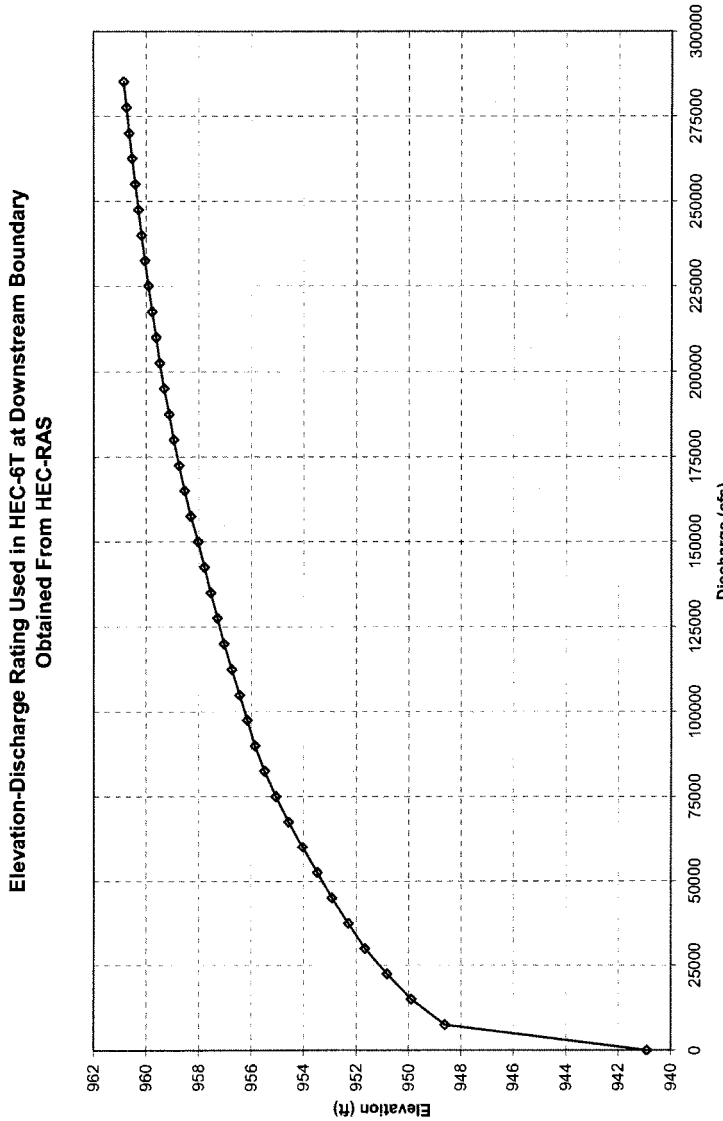

Figure 3-1. Rating curve at downstream end of sediment transport model.

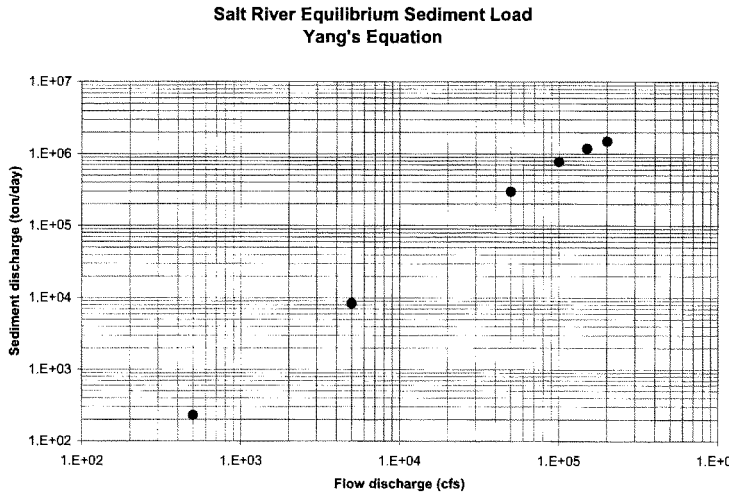

Figure 3-2. Equilibrium sediment load with Yang's equation.

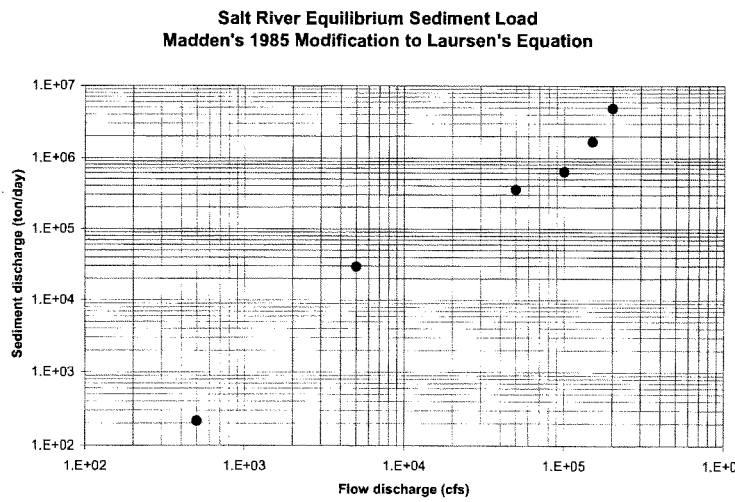

Figure 3-3. Equilibrium sediment load with Laursen-Madden's relation.

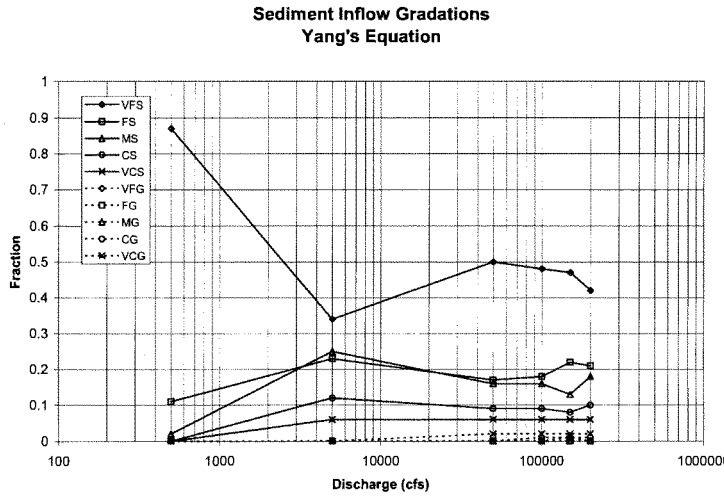

Figure 3-4. Sediment inflow gradations with Yang's equation.

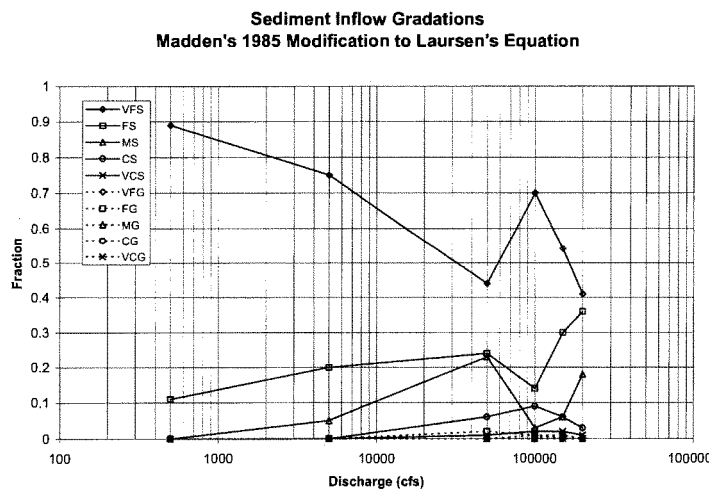

Figure 3-5. Sediment inflow gradations with Laursen-Madden's relation.

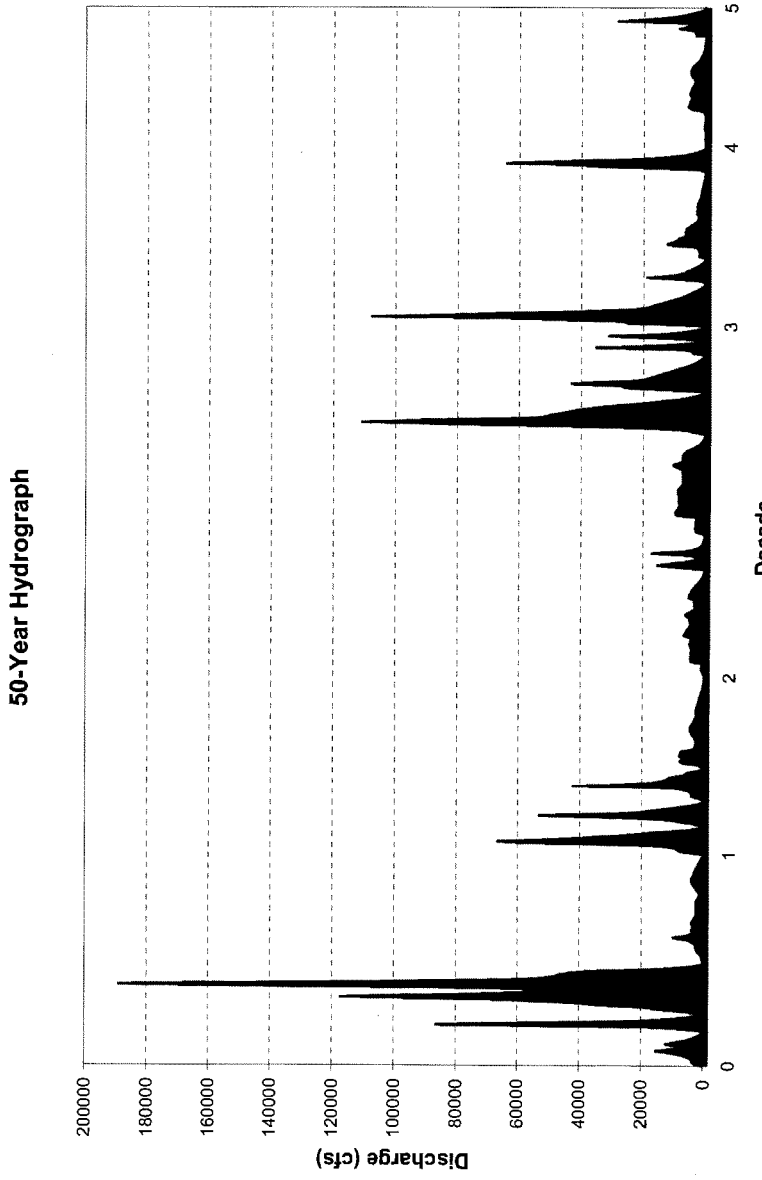

Figure 3-6. 50-year hydrograph used to run the sediment transport model.

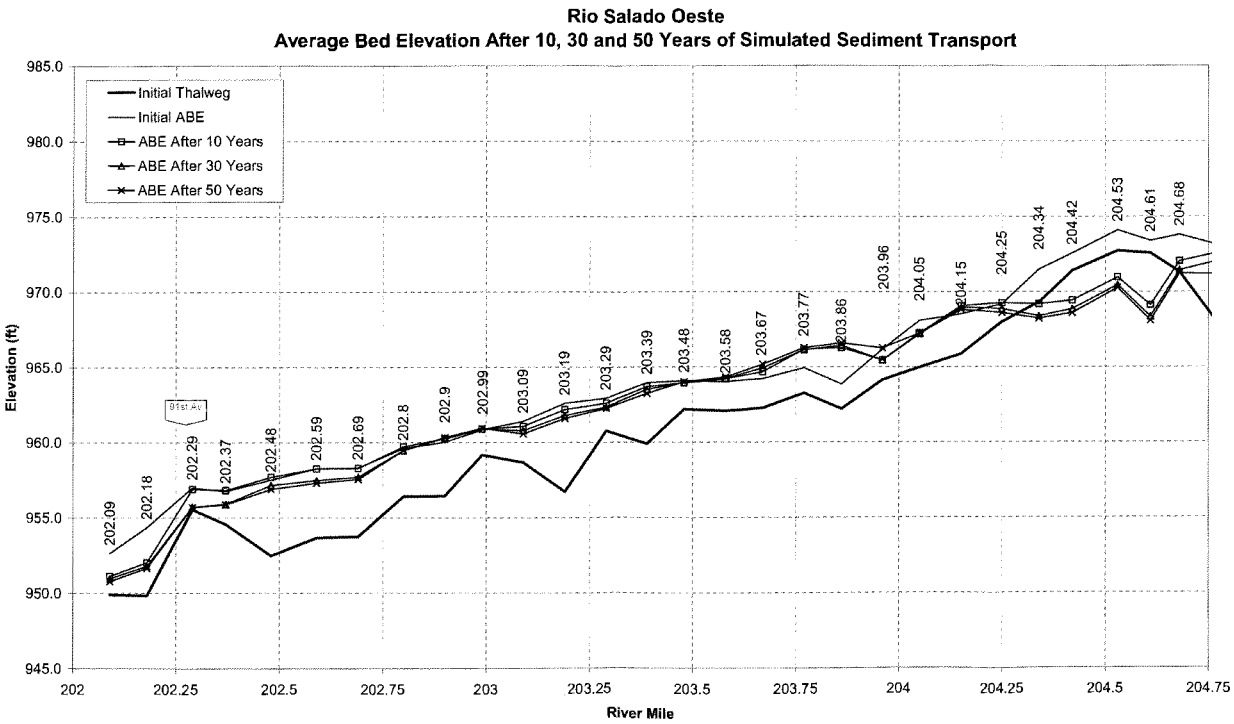

Figure 3-7. Simulated average bed elevation for selected decades.

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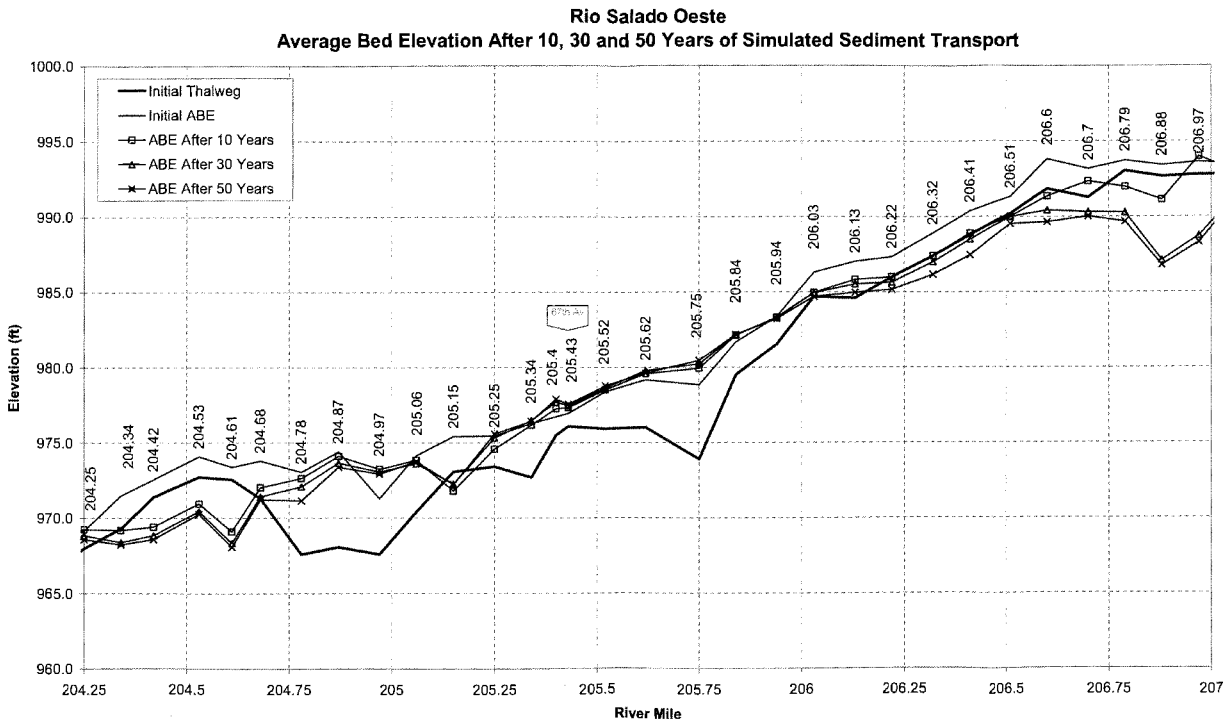

Figure 3-7. *Continued.*

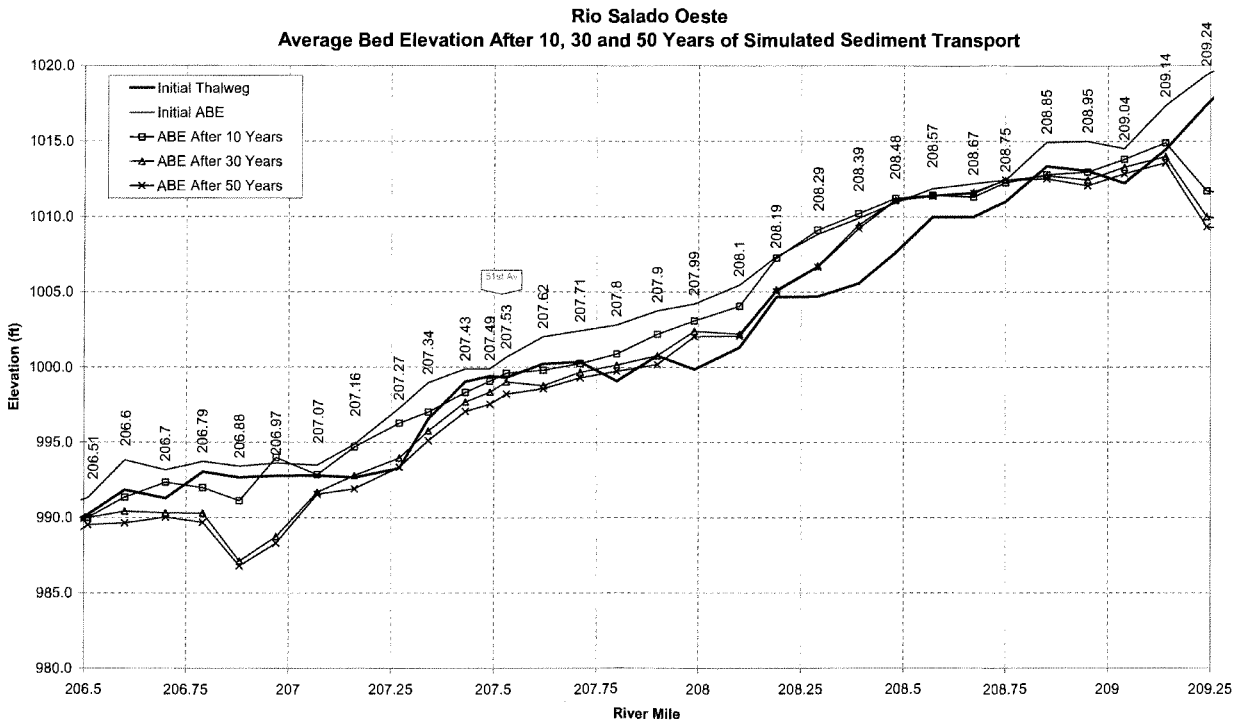

Figure 3-7. ***Continued.***

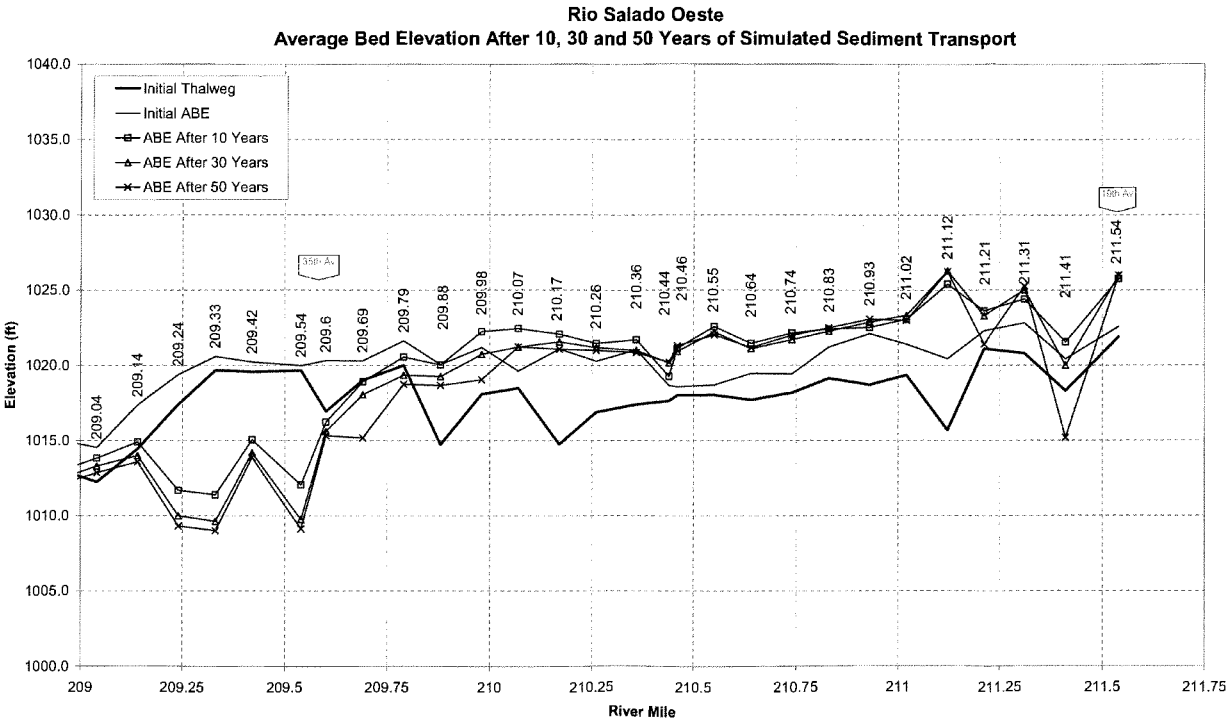

Figure 3-7. ***Continued.***

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4. Geomorphic Analysis

The primary goal of the geomorphic analysis is to identify historical behavior of the subject river system by the collection and review of historical aerial photographs and the application of geomorphic relationships. The principle objective is to evaluate lateral channel migration, historical bank lines as well as low flow channel locations and sediment aggradation/degradation potential. A qualitative analysis of historical changes to river morphology is followed by a quantitative analysis for basic geomorphic factors of the subject river system.

4.1. Historical Setting

The Salt River was a perennial stream prior to construction of upstream water supply dams in the period 1908-1930. Historical accounts and photographs indicate that the Salt River was a wide, braided channel that supported significant vegetation but was also prone to major flood events. Since completion of the upstream dams on the Salt and Verde Rivers, the study reach has experienced significant periods of virtually no flow.

4.2. Analysis of Historical Photographs and Maps

WEST obtained historical aerial photographs of the project reach for the years 1937, 1958, 1979, and 1999 (approximately every 20 years). In addition, maps from the original land surveys filed in 1870 showing the outline of the river were obtained. The photos and maps were scanned and geo-referenced so as to be compatible with the recent aerial photographs and GIS coordinates. Based on the map and photographic images, a number of analyses were performed and are described in the following sections.

4.2.1. Bank Lines and Lateral Migration

The historical bank lines and channels were reviewed from 1870 to 1999. The historical bank lines, superimposed on the 1999 aerial photography, are shown in Figure 4-1. The Salt River through this reach has been relatively stable but still the river banks have moved laterally by as much as one-half mile in some locations during the 130 year record. Much of the lands along the south side of the river have been recovered from the active braided channel system during the period of historical photos. Delineating the active channels and banks was made much more complex by the reclamation of fields with active channel scars both upstream and downstream of the new fields as well as expansion of mining pits. Some of the reclaimed areas have subsequently been developed by industrial users.

The lines marked Recent Geologic Banks were determined from reviewing the aerial photos from 1937 to 1999 and viewing the shape of the topographic lines along the river. The boundaries were initially set to include all areas where abandoned meander features were found as well as extending to the areas where the contour lines changed direction from following the regional slopes to being perpendicular to the river channel. This coverage should be fairly close to the maximum historical meander belt for the river in this reach. It varies from approximately two miles in width at 19th Avenue to approximately four miles in width at 91st Avenue.

The river is constrained upstream from 19th Ave by levees constructed as part of earlier projects. The soil cement levees end just downstream from the 19th Ave Bridge and the river is unconstrained by levees until just above the 91st Ave water treatment plant. River alignment is fixed to some extent by bridges located at 35th Ave., 51st Ave. and additional proposed bridges for a future freeway crossing at approximately 61st Ave. The 35th Ave Bridge is very short and provides a significant constriction to flows. The other bridges have much larger openings and provide little, if any, flow constriction.

4.2.2. Low Flow Channel

The historical centerline of the low flow channel, or thalweg, was determined by using the same information previously described. Identification of the main flow channel was sometimes difficult as the system is braided and multiple flow paths can usually be seen at any given time around islands and bars. The thalweg lines from 1870 to 1999 are shown in Figure 4-2. Similar to the bank lines, one can observe that the thalweg consistently shifts its position within the meander belt (compare the thalweg location with the bank lines shown in Figure 4-1). This shifting is typical of braided river systems. The thalweg locations are, however, all within 2000 feet of one another from the downstream boundary of the study at 91st Avenue up to about 35th Avenue. Upstream of this point, the thalweg locations diverge. Available evidence indicates that the river used more northerly channels up until the 1950's, with a shift in the thalweg location to a more southerly location from that time to the present.

4.2.3. Vegetation

Sparse vegetation can still be seen in the 1937 aerial photographs. However, the other sets of aerial photos (1958-1999) show no significant amounts of vegetation in the study reach.

4.2.4. Mining Activities

Mining activities in the Salt River play a significant part in the sediment balance of the river system. In the 1937 photographs, no significant mining activities are seen in or near the river channel. In 1958, two large pits can be seen at the upper end of the study reach (upstream of 35th Avenue). The increase in observable mining activities continues in the 1979 photographs where more pits are observed. These are still located primarily in the upstream part of the study reach. The 1999 photographs show at least 12 pits in and near the river channel more evenly distributed along the reach than in previous years (although still predominantly in the upper portion of the study reach). Since some of these pits are located near the main channel and the river currently flows through some of these pits, they have significant impacts on local flows. These impacts include the redirection of flows through the pits and away from former channel alignments, erosion upstream and downstream from the pits as well as deposition of sediment in the pits.

4.3. Channel Response to Flood Events

To accurately gage the changes wrought by the river to its channel during major flood events, photographs immediately prior to and after the event should be compared. Such a detailed comparison is not part of the present study and photos immediately prior to the floods are not available. However, some information may still be gleaned from the

photos used in this study. For example, in each period in between the dates of the aerial photography (1937-1957, 1958-1979, 1979-1999) a major flood occurred on the Salt River, with the exception of the period 1937-1958. Observing the bank lines and aerial photographs for the period with out large floods reveals that very little change occurred in the channel in the absence of large flood events. During the period between 1973 and 1999 (includes the 1993 Flood) for example the banks in the upstream reach were impacted primarily by gravel mining while areas near 67th Ave and 83rd Avenues widened significantly due to flood events. The widening of selected sections can be seen in comparing the banklines from the various time periods in Figure 4-1.

4.4. Geomorphic Relationships

The current channel geomorphic properties were analyzed in order to quantitatively examine channel stability and potential for lateral migration.

4.4.1. Channel Planform

Leopold, Wolman, and Miller (1964) adopted the sinuosity ratio, defined as the channel (thalweg) length divided by the valley length of the stream, as a criterion which could be used to classify river patterns. Through the observation of several natural river systems, they concluded that systems with a sinuosity greater than or equal to 1.5 would be classified as meandering, while those less than 1.5 would be braided or straight. The average sinuosity for the study reach was approximately 1.4.

Also, Lane (1957) and Leopold & Wolman (1957) developed relationships between channel pattern, channel gradient, and mean discharge based on field data. Figure 4-3 shows these relationships graphically. The significance of this figure is that rivers situated close to the meandering-braided threshold would be expected to experience transitions between one channel form and the other. Utilizing the 5- and 10-year discharges (20,200 and 53,000 cfs, respectively) as indicators of either the mean (Lane) or bankfull (Leopold & Wolman) discharge, error bars are shown for the study reach. The error bar indicates the range of slopes found in geomorphically similar subreaches within the study reach. It can be seen that the study reach plots well into the braided region for both criteria.

4.4.2. Width / Depth Ratio

Width/depth ratios were computed for the study reach using the HEC-RAS model results for both the 5- and 10-year discharges. Results are shown in Table 4-1. It is seen that the channels are very wide and shallow, reflecting the observed braided system (several researchers have defined ratios of 40 or above as "very high", e.g. Rosgen, 1994).

Table 4-1. Width / depth ratios.

	5-Year Flow	10-Year Flow
Maximum	800	561
Minimum	44	31
Average	193	176

4.5. Sediment Aggradation/Degradation Potential

It is common in geomorphic studies to identify "equilibrium" conditions that the channel would experience if inflowing and outflowing amounts of sediment were perfectly in balance. Then areas expected to experience aggradation (deposition) or degradation (erosion) could be identified for areas not conforming to the predicted equilibrium conditions. However, this type of analysis is usually performed either as a precursor to, or in place of, a more detailed sedimentation modeling study. Because such a modeling effort forms part of the current study, and results in predictions of erosional or depositional areas, a separate and more general geomorphic analysis will not be performed here with the exception of a review of recent historical thalweg elevations.

An historic HEC-2 model was obtained from the FCD that contained cross section and thalweg elevations for 1982. This data was compared with the data collected by Baker in 1994 that served as the basis for the current study. These data were also compared with the thalweg from the 50 year simulation as plotted in Figure 4-5. It can be noted that there are some differences between the 1982 (pre-flood) and 1994 (post-flood Baker) data. One of the primary differences is at the 35th Ave bridge where the Baker data shows an extremely deep scour hole under the bridge due to the flood. The 1982 and the future condition thalwegs in this area are nearly in agreement indicating that the channel is relatively stable in this reach for the conditions modeled with large floods scouring deep holes under the bridge to facilitate passage of their high flows.

The channel topography in the TIN supplied for analysis appears to be based on the water level in the river under the bridge rather than the bed elevation as can be seen in Figure 4-6. It was noted, however, that the bed adjusted to the same elevation in the future conditions model regardless of whether the channel elevations from the Baker model (deep scour hole under bridge) or the water surface was used as the initial channel invert.

The 1982 and future thalweg elevations are within approximately 5 ft of each other with most of the larger differences in areas that were mined in prior to the 1982 topography. Differences can be seen at RM 209 and 210.5 for example where mining pits appear to have filled during the 1993 flood.

The correlation between the historical and predicted future conditions again indicates that the river is in a state of dynamic equilibrium and tends to return to its pre-existent state if adequate flow and sediment is available. The impact of gravel mining, at least since 1982, does not appear to have impacted the overall stability of this reach although impacts near the pits are significant.

4.6. Geomorphic Summary

The entire study reach is classified as a braided channel system, conforming to observations in the field and from historical documents and photographs. Braided systems generally have wide main channels in which multiple low flow channels cross, resulting in the braided channel.

Braiding is believed to result primarily from random deposition of materials (sediment) transported during high flows in quantities or sizes too great for continued transport during low flows. Accordingly, as the stream discharge is reduced, larger sediment particles begin to drop to the bed as the stream "sorts" or leaves behind those sizes of the transported sediment (load) which it is unable to transport. The accumulation of these particles on the channel bed initiates the formation of a bar which serves to trap even more sediment particles. Although the depth of flow over the growing bar is gradually decreased, velocity over the bar tends to remain undiminished or even to increase so that some particles moving along the bar are deposited beyond the downstream end where a significant decrease in velocity is associated with the marked increase in depth of flow. Thus, the bar grows by successive addition of sediment particles at its downstream end and some additional growth along its sides. Additional bars will then be propagated through the same process described until the channel obtains its characteristic braided pattern. Growth of the bars will eventually reach a size that will significantly alter the channel conveyance capacity at which time the channel will seek a new equilibrium condition.

The shifting, changing nature of braided channels and the fact that they are often generated by sediment deposition and bed aggradation has led many engineers and river scientists to associate them almost exclusively with disequilibrium in the fluvial system. However, as Leopold et al. (1964) pointed out, braided river systems are a distinct and viable category of dynamically stable planform, along with straight and meandering systems. The recent historical evidence examined here indicates that the project reach is in quasi-equilibrium, although adjustments to bank and thalweg lines within the historical meander belt are possible.

4.7. Lateral Bank Migration Rates

It is extremely difficult to predict bank retreat or lateral migration rates in braided river systems. A braided river system regularly attacks its banks and moves them back as the braided meander patterns shift across and along the river. Once a braid of the river directly attacks a bank it normally will retreat rapidly until the meander shifts and the attack terminates. The rate of bank retreat may thus be several hundred feet for a single event but over the historical record be only a few feet per year. Thus a bank that appears stable can retreat very rapidly while under attack and yet appear stable for long periods of time while the river is attacking the bank in other locations. Other banks are relatively resistant and can withstand a direct impact of a braid with little retreat. The limited number of flows in the Salt River only increases the difficulty of estimating long term rates of retreat.

The fact that a bank has been stable for the historic record may only mean that the full force of the river has not, as yet, been redirected toward that bank. If the historic record of bank lines is reviewed in the context of limits presented in Figure 4-2 as the

Recent Geologic Banks, it can be noted that the river has moved widely on the floodplain over its geologic past. Given the proper flows, meander bends, braid patterns, and bank conditions, the river could again move to its geologic limits or even beyond. Given the exiting constraints the movement of the river to its Recent Geologic Banks is unlikely however.

Notwithstanding the difficulty in the estimation of retreat rates, some estimate of probable bank movement can be made based on current constraints, existing patterns within the river and historical bank lines. Based on the historical record as well as geomorphic principles, it is probable that the river will stay within the limits shown in Figure 4-4 as the Probable Lateral Migration Limits. That is not to say that without protection that the river will stay within these limits indefinitely but only that for flows up to and including the 100 year event the river would not be expected to move dramatically beyond the limits shown in a single or short series of events. These lines take into account the historical bank lines as well as the expected bank attacks during high flows.

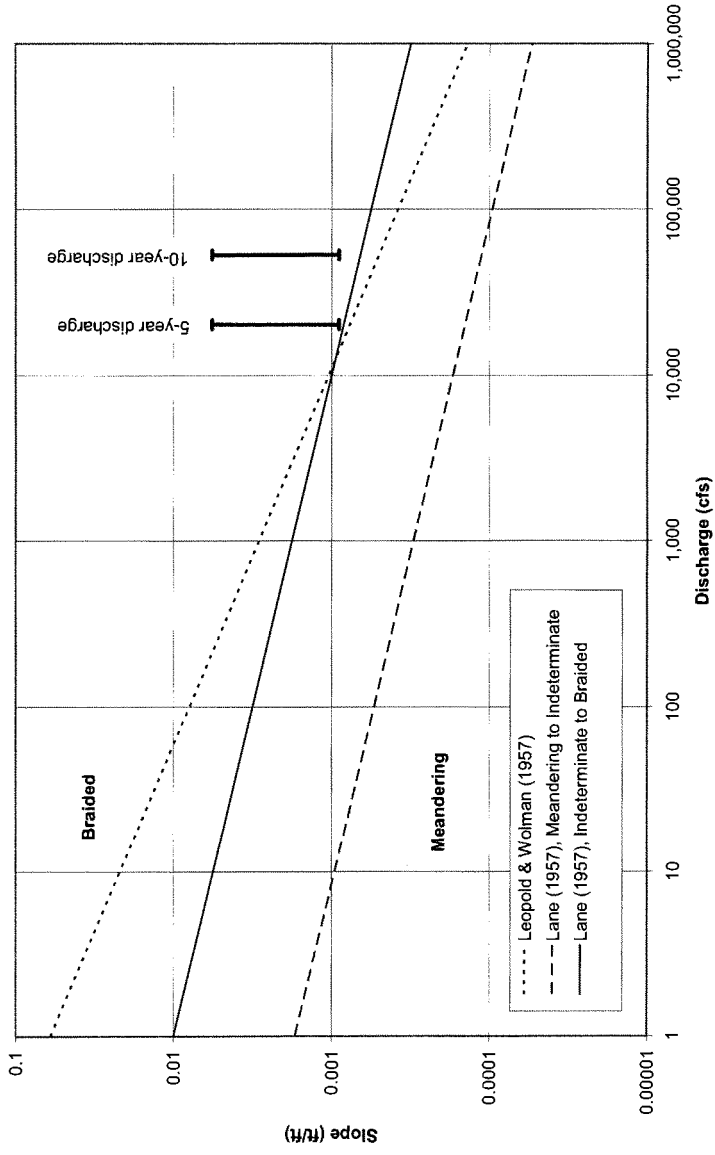

Figure 4-1. Project reach predicted channel form.

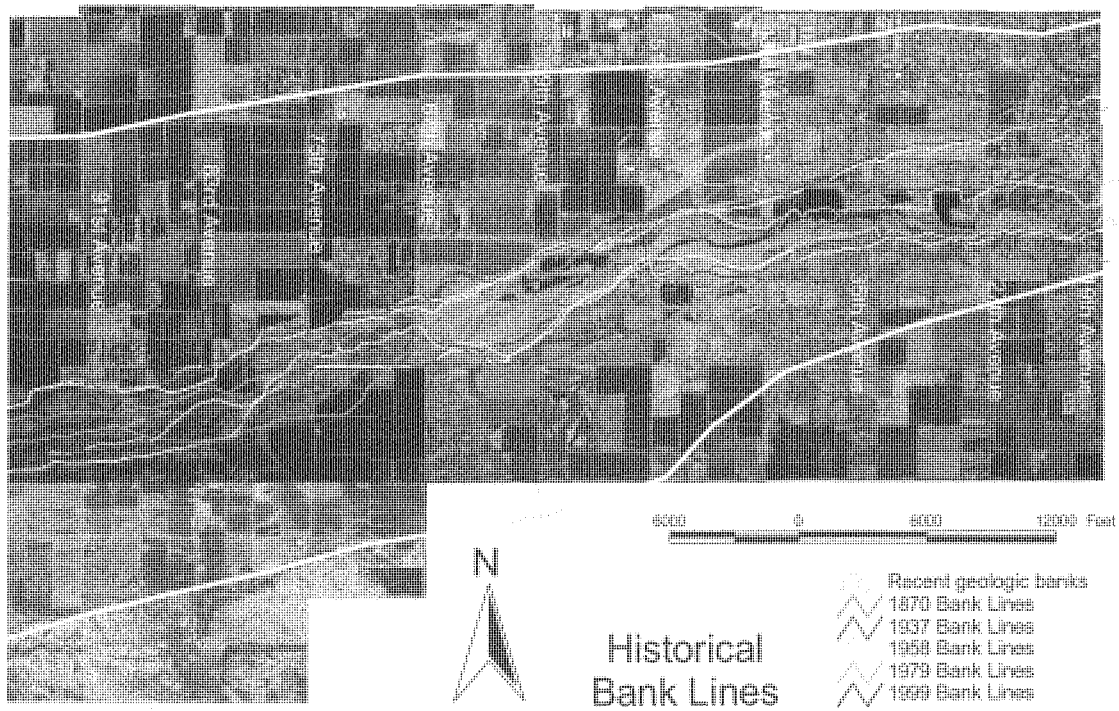

Figure 4-2. Historical bank lines.

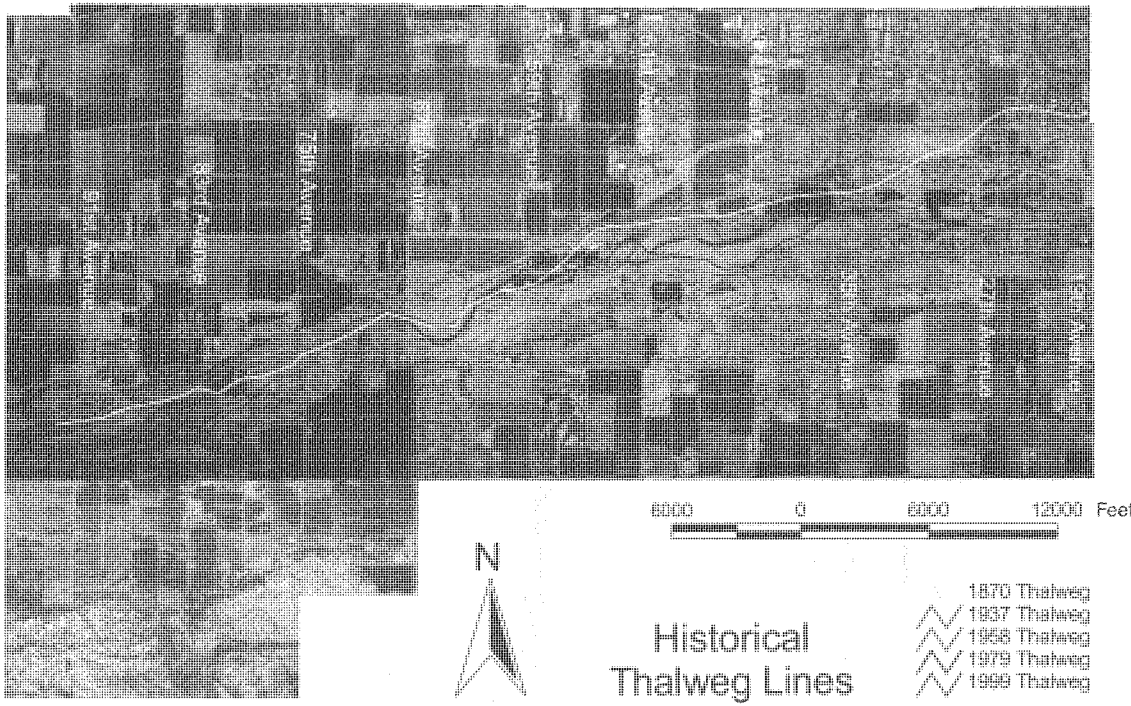

Figure 4-3. **Historical thalweg lines.**

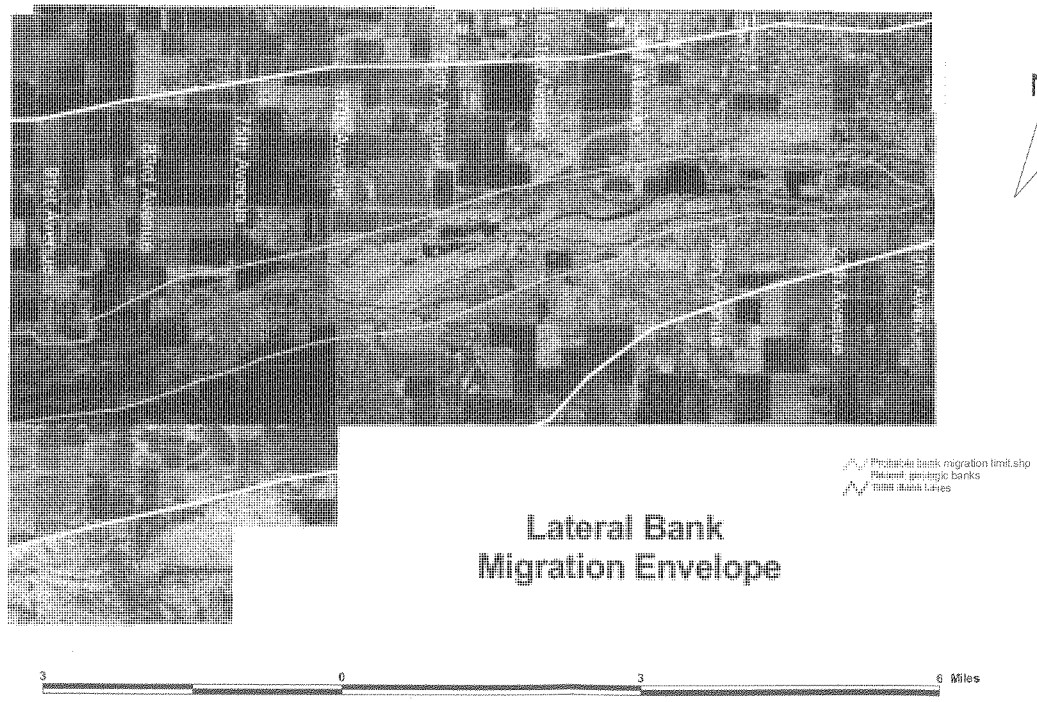

Figure 4-4. Estimated Lateral Bank Migration Limits.

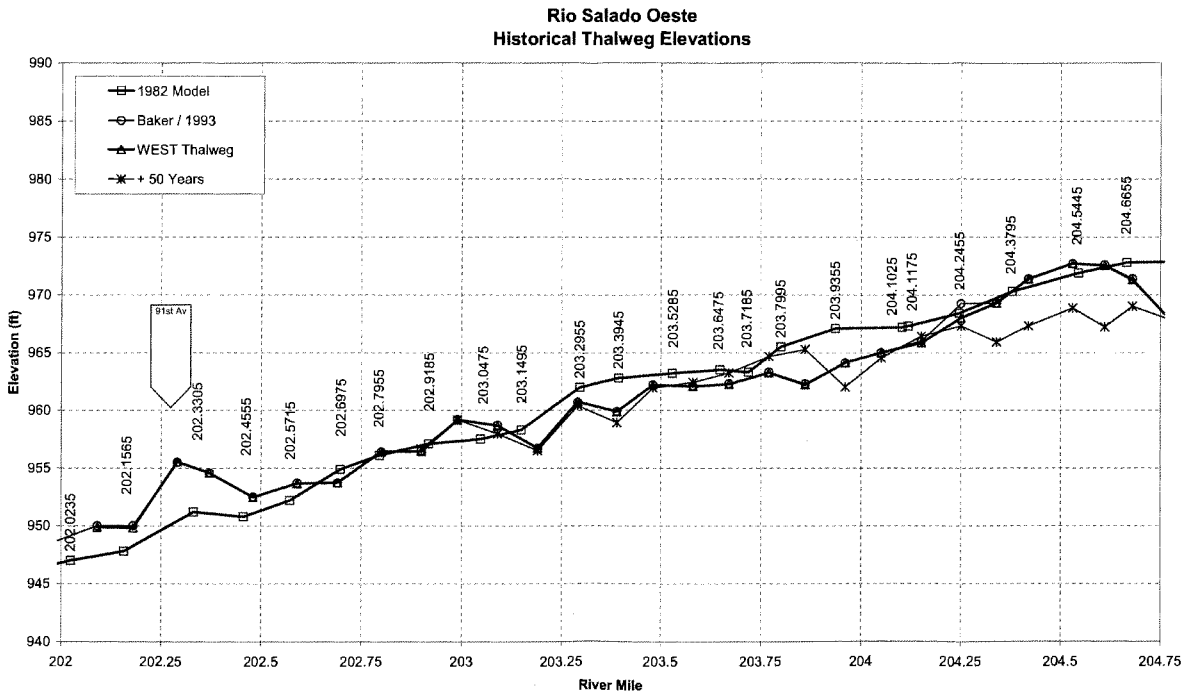

Figure 4-5. Recent Historical Thalweg Elevations of Salt River from 19th Avenue to 91st Avenue.

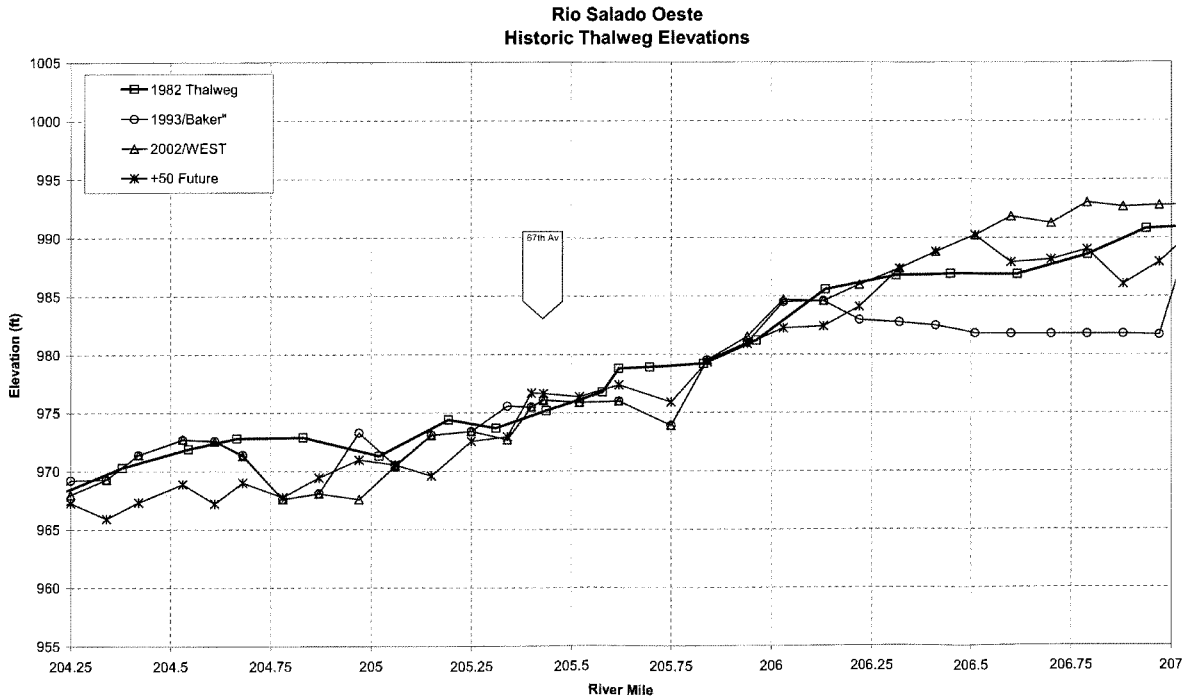

Figure 4-5. *Continued.*

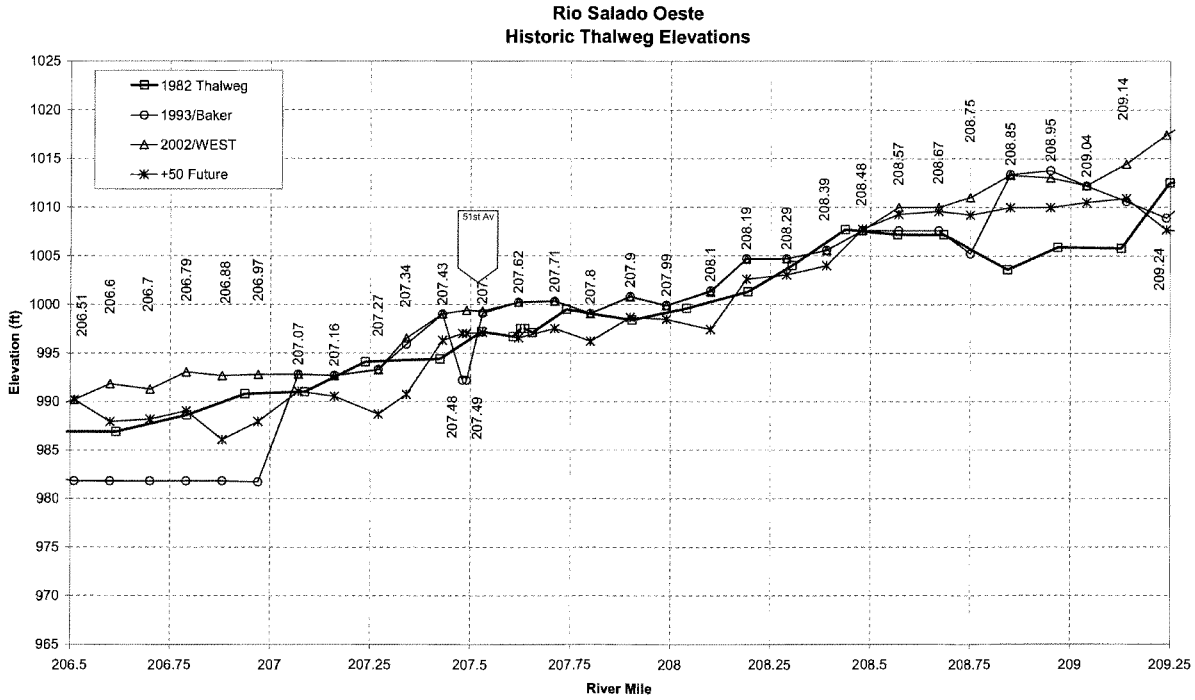

Figure 4-5. *Continued*

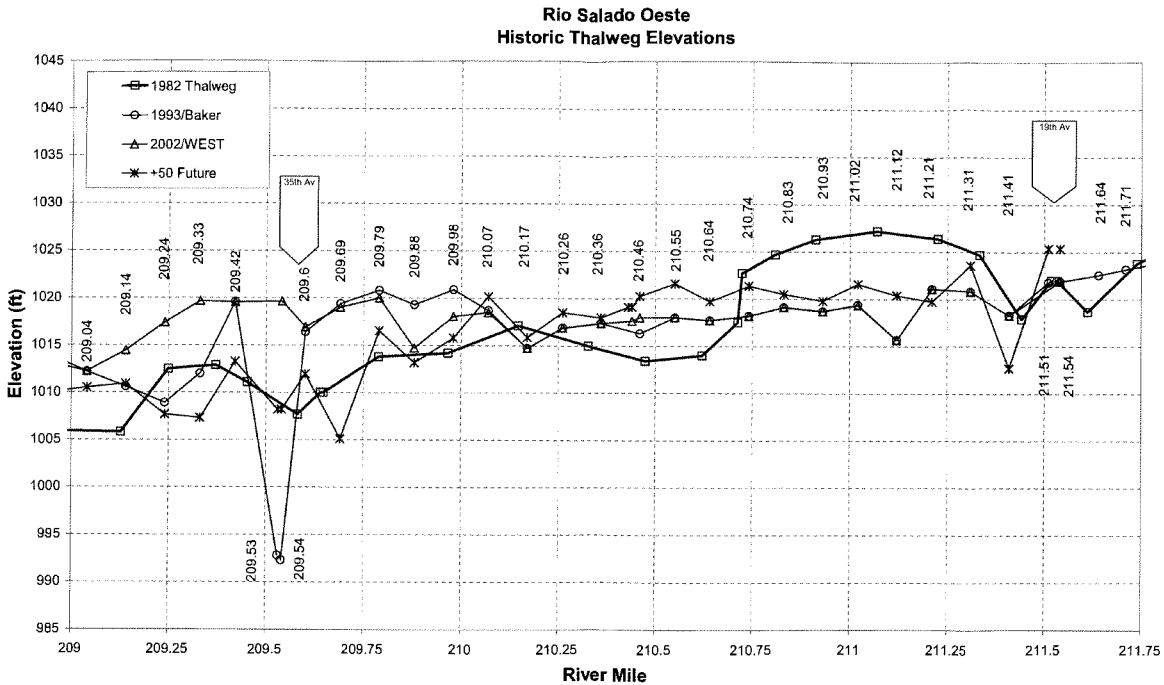

Figure 4-5. *Continued.*

5. Future Without-Project Hydraulic Analysis

HEC-6T generates an output file with the extension T12 where it stores the model geometry at the end of the simulation. The cross section geometry after 10, 20, 30, 40 and 50 years of sediment transport simulation was used to create five new hydraulic models in HEC-RAS. The new cross sections reflect the erosion or deposition that occurred during the sediment transport simulation.

The bridge geometry from the existing conditions model was added to the future conditions model, but first some manipulation of the T12 file was required. HEC-6T uses just one cross section with the superimposed pier geometry to represent each bridge, while HEC-RAS uses two cross sections with bridge geometry specified between the cross sections. Therefore, it was necessary to remove the piers from the bridge cross sections in the T12 file, and a copy of each bridge cross section in the T12 file (with the piers already removed) was placed downstream of each bridge in the HEC-RAS model. The stations of the new downstream cross sections were then adjusted laterally to match the end points and banks of the cross sections downstream of the bridges in the existing conditions model. These new cross sections, placed at the downstream side of the bridges, preserved the distances in the existing conditions model, and the bridge geometry was then imported from the existing conditions HEC-RAS model to complete the future conditions HEC-RAS model.

Hydraulic simulations were performed using the roughness coefficients (Manning's n) in the existing conditions model. Channel and overbank roughness values were then increased 10, 20 and 30% to reflect vegetation growth assuming no clearing is carried out during the 50-year simulation period. Complete simulation results are provided in Appendix J.

Water surface profiles by decade were generated for the 5-, 10-, 20-, 50-, 100- and 500-year discharges in HEC-RAS. Figures 5-1, 5-2 and 5-3 show the water surface profiles for the 10-, 100- and 500-year flood events after 10, 30 and 50 years of sediment transport simulation.

The future conditions water surface profiles are smoother than the existing conditions profiles, as expected for a bed profile with a more homogenous slope. The main differences appear upstream of the 35th Avenue Bridge. The bridge opening in the future conditions model is bigger due to the erosion of the cross section, and therefore the backwater effect diminishes. As a consequence, the inundation boundaries for the future conditions model upstream of 35th Avenue would not extend as far from the channel as for the existing conditions model. If the topography in the TIN shows the water surface under the bridge the initial water surface elevation would be lower and flooding would not be as widespread as indicated in the initial conditions model. A verification of the actual bed elevations should be performed if the bridge is not scheduled for replacement.

The effect of increasing the roughness coefficients to simulate vegetation growth is shown in Table 5-1. The table shows the average increase in water surface elevation caused by an increase of 10, 20 or 30% in Manning's n from the values in the Existing Conditions model.

Table 5-1. Future conditions hydraulic analysis: sensitivity to roughness coefficients.

Flood Event	Average increase in water surface elevation (ft)		
	10% increase in Manning's n	20% increase in Manning's n	30% increase in Manning's n
5-year	0.3	0.5	0.8
10-year	0.4	0.8	1.1
20-year	0.4	0.9	1.3
50-year	0.5	1.0	1.5
100-year	0.5	1.1	1.5
500-year	0.5	1.0	1.5

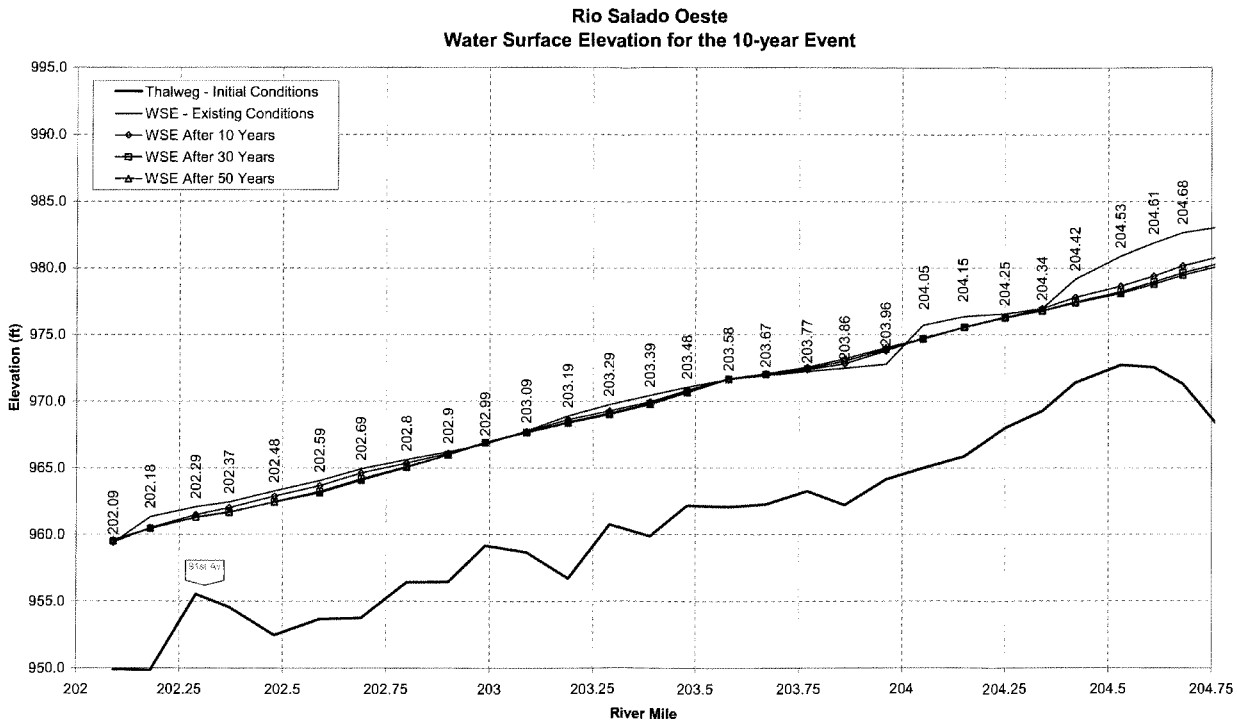

Figure 5-1. Future conditions hydraulic analysis: 10-year flood event.

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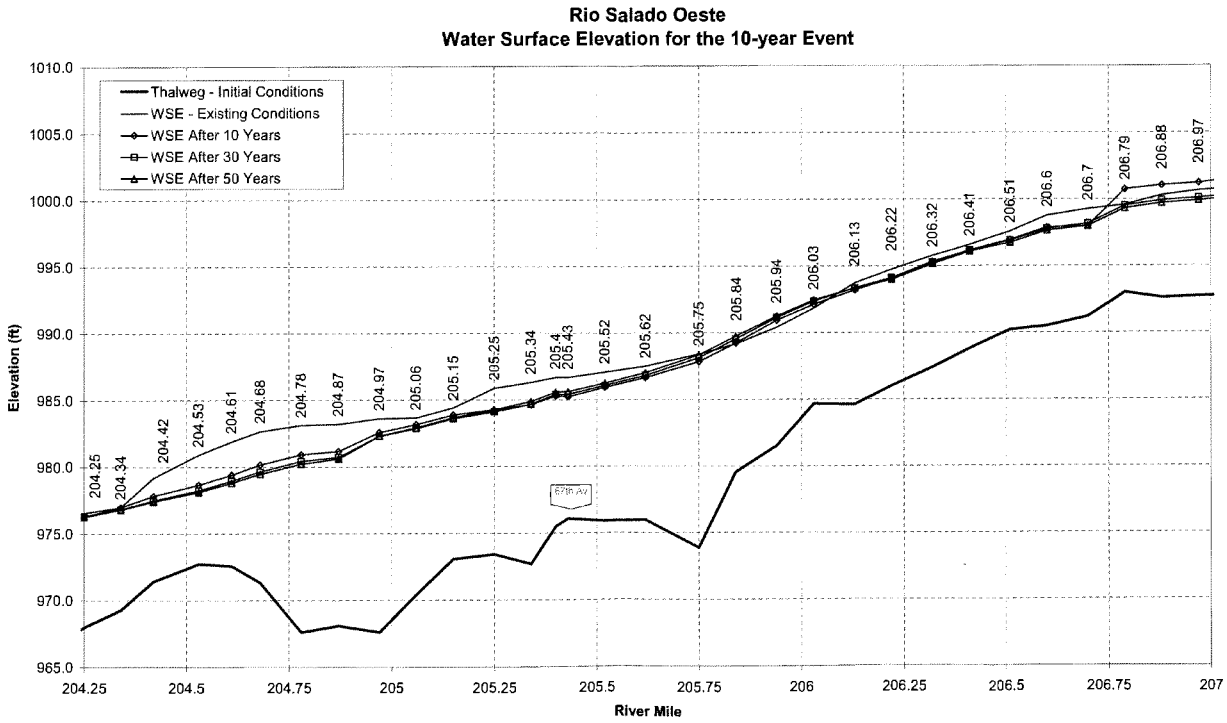

Figure 5-1. ***Continued.***

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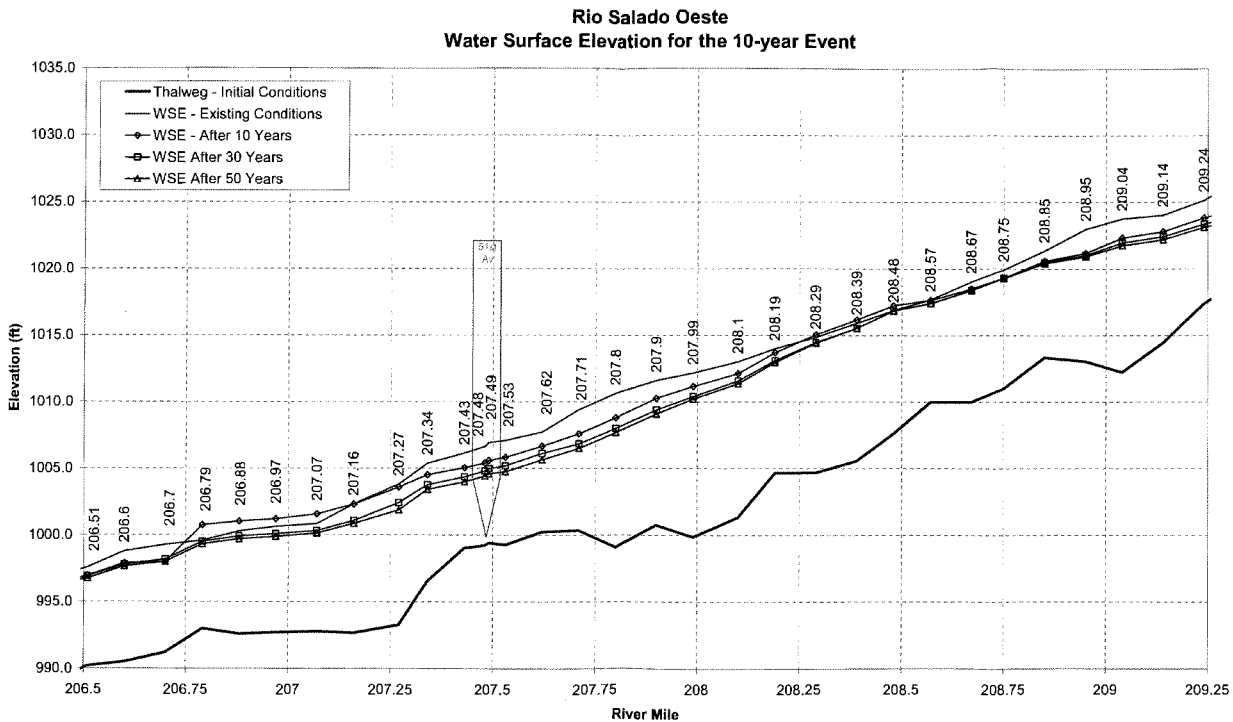

Figure 5-1. *Continued.*

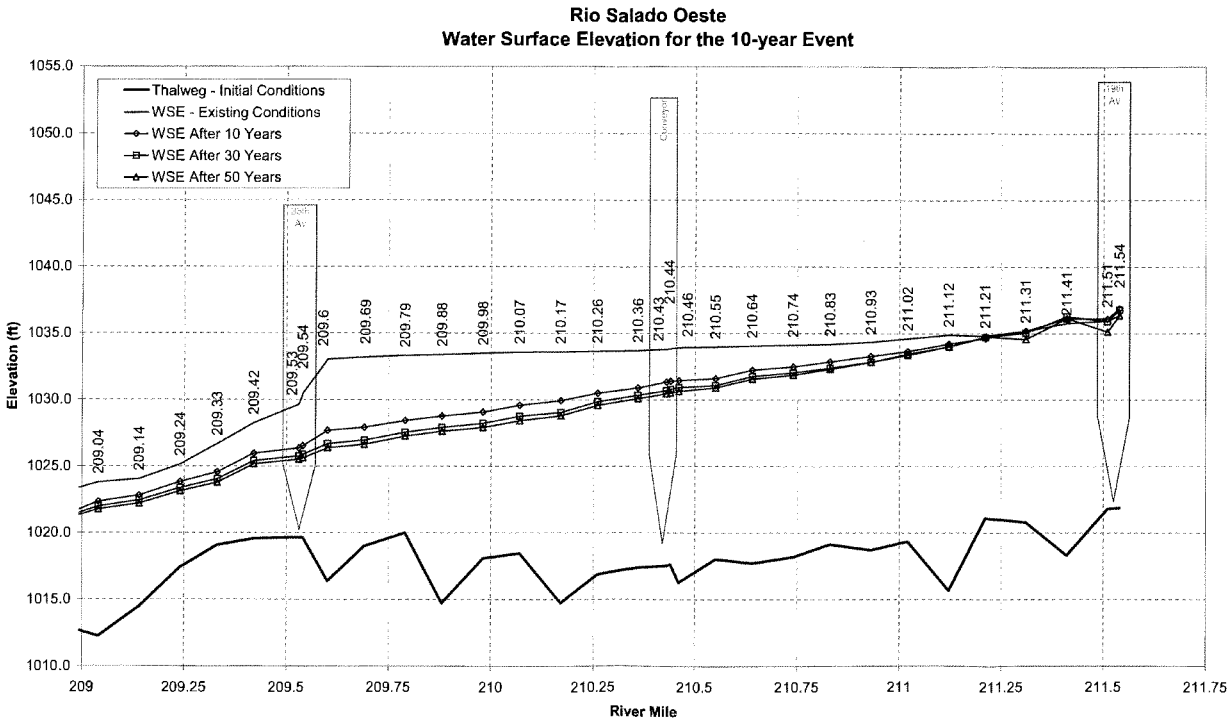

Figure 5-1. ***Continued.***

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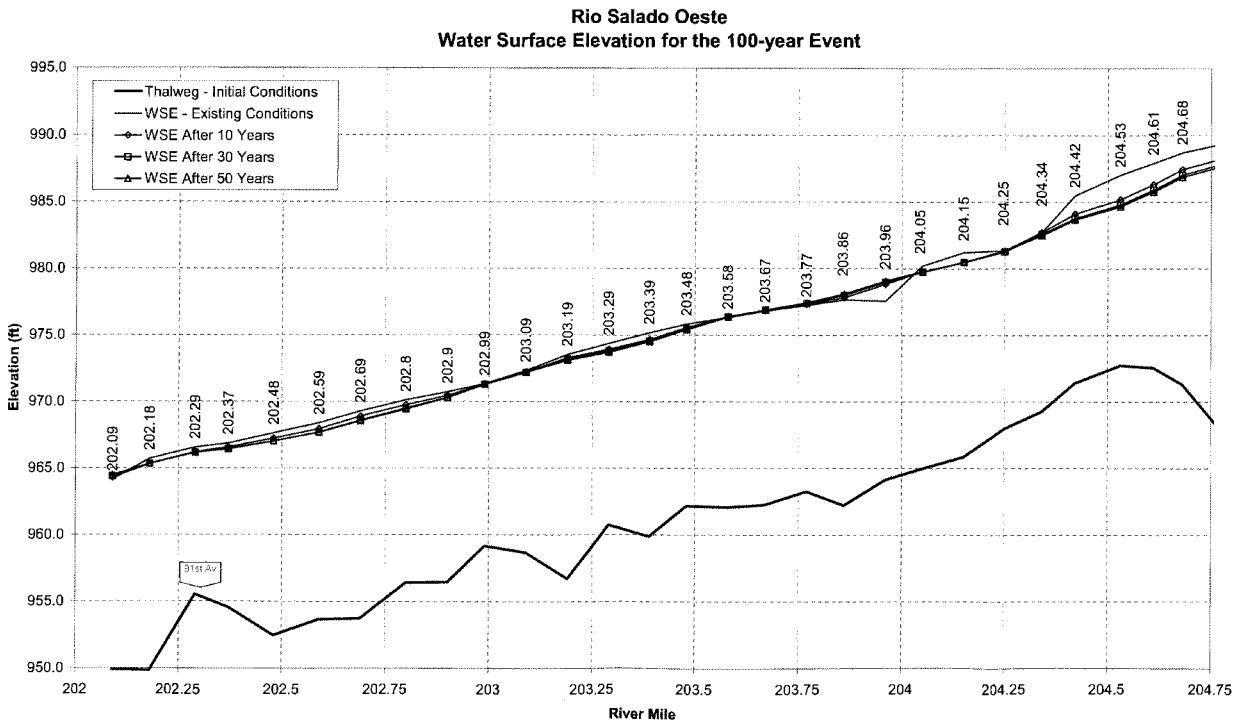

Figure 5-2. Future conditions hydraulic analysis: 100-year flood event.

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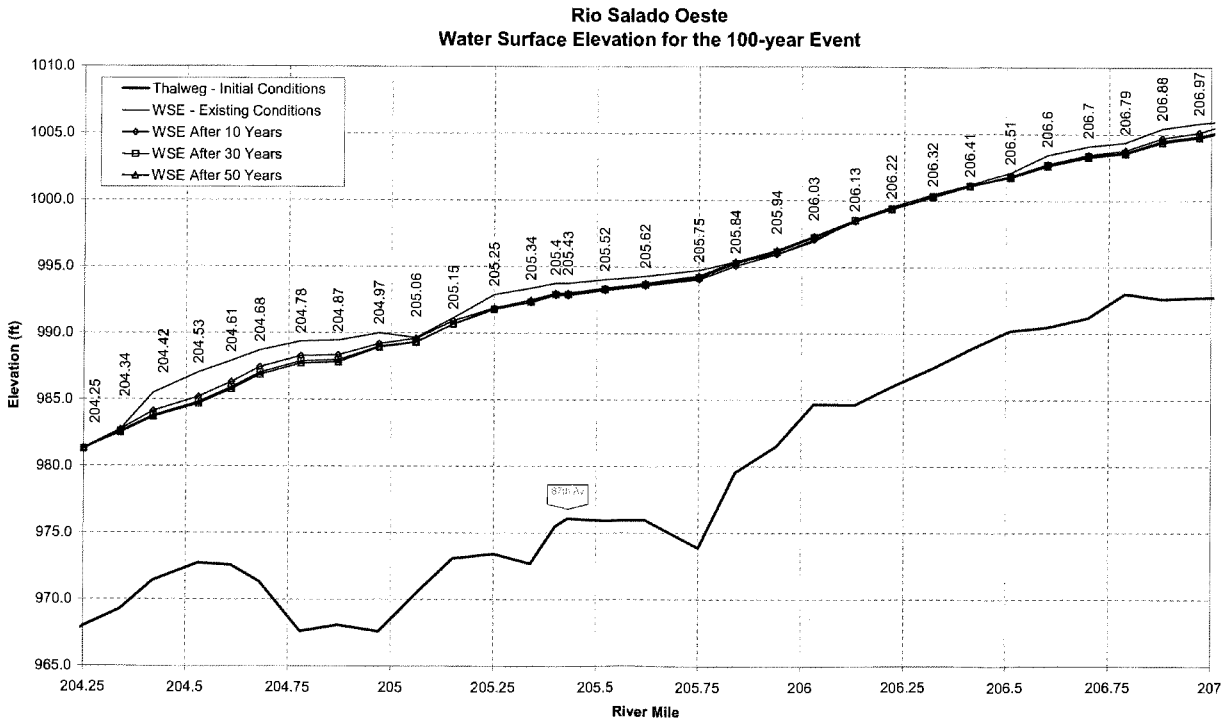

Figure 5-2. *Continued.*

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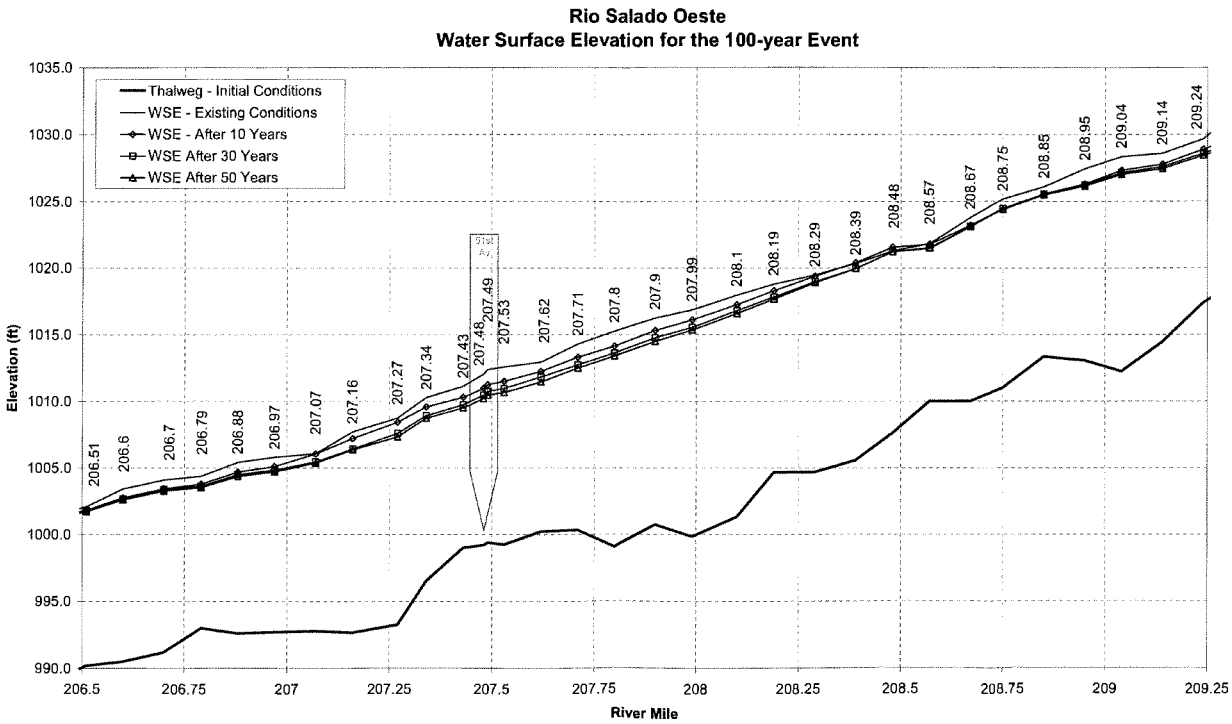

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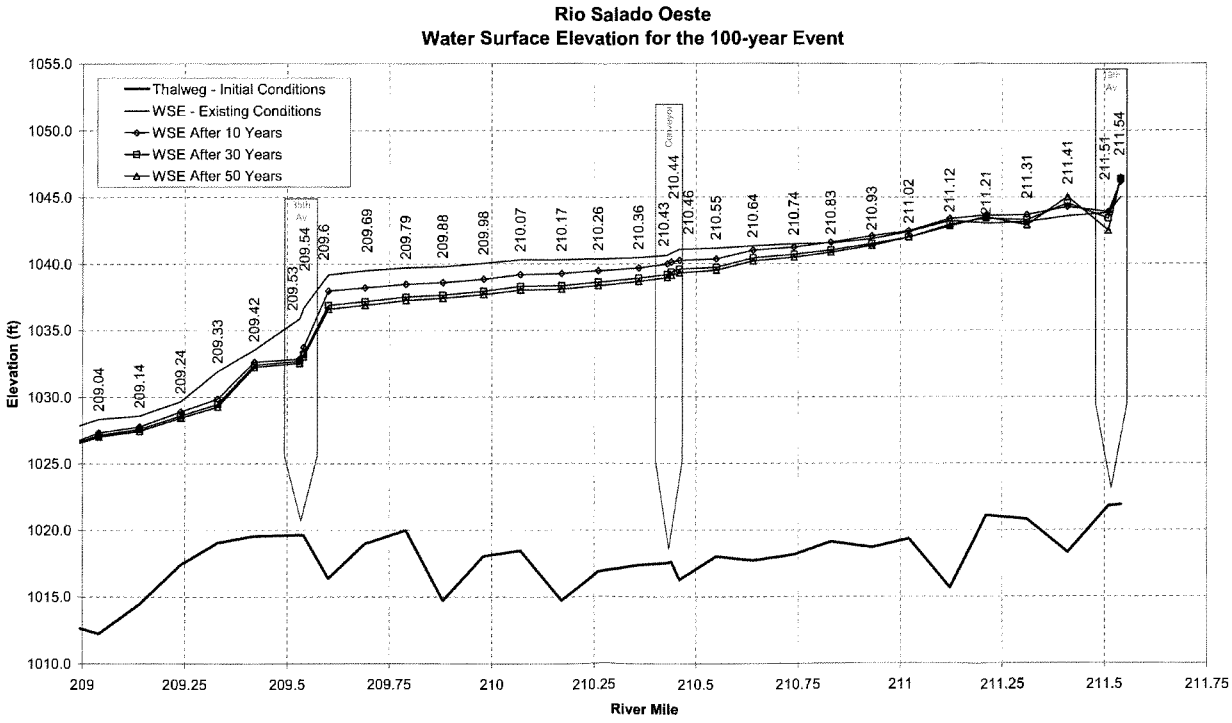

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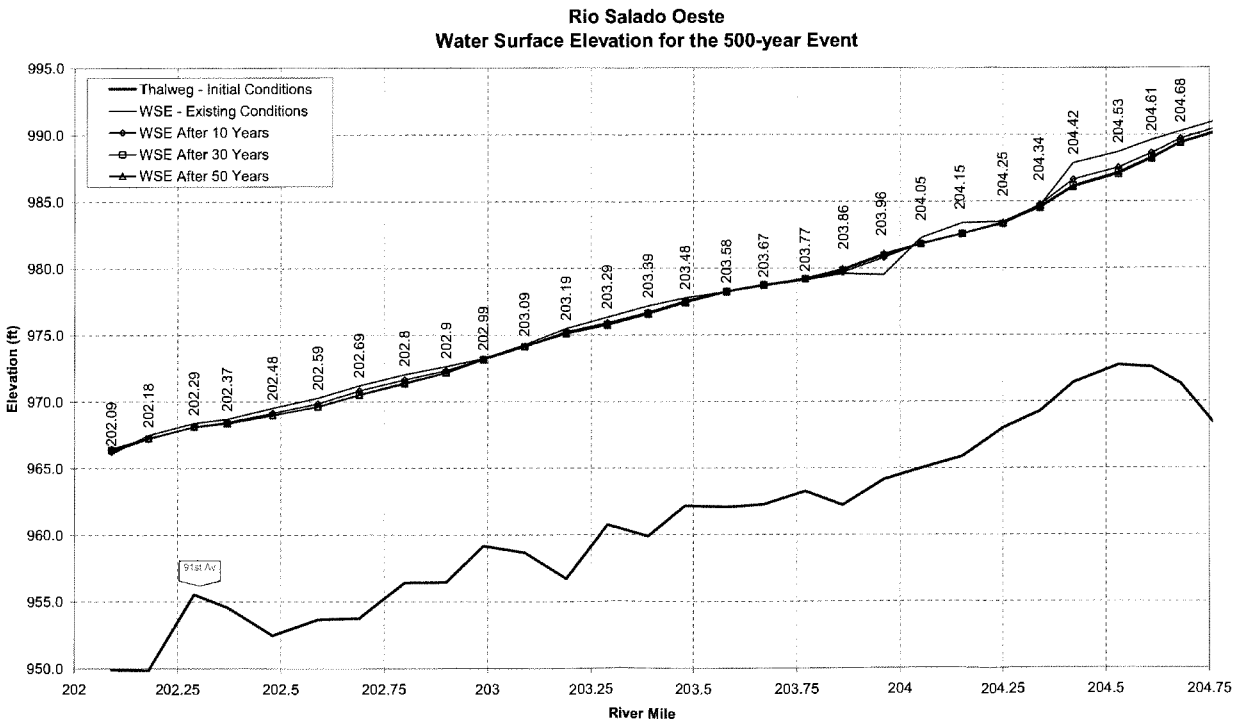

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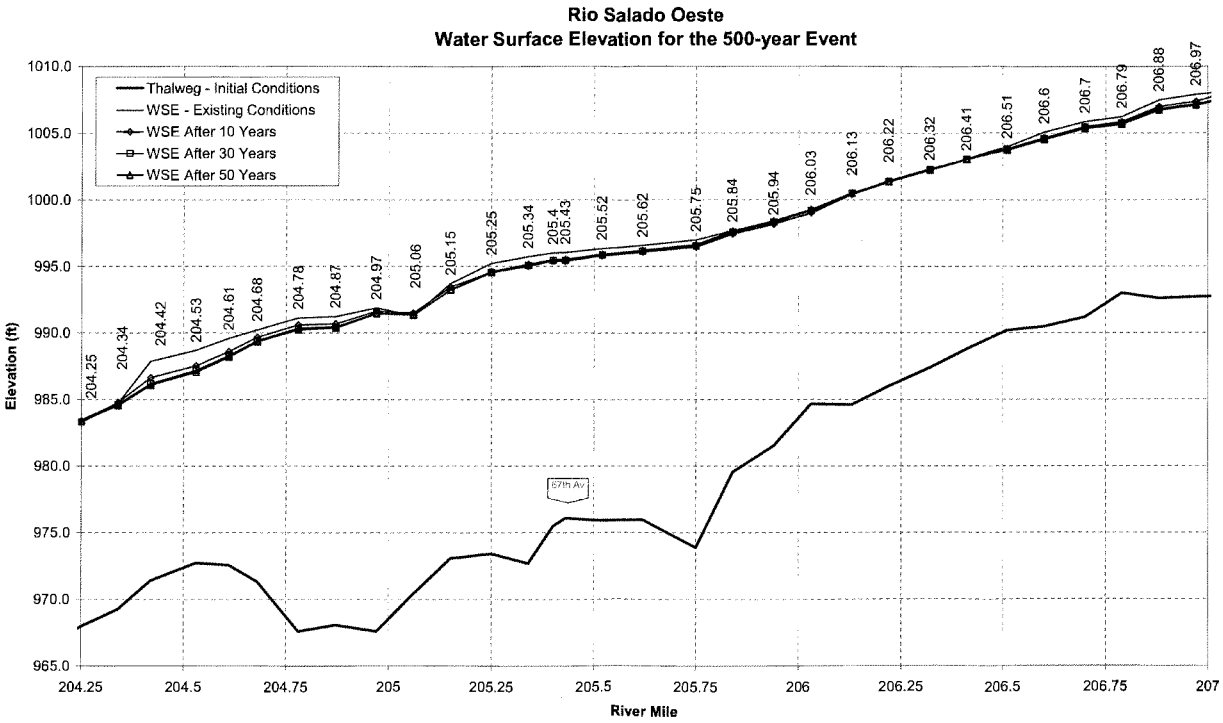

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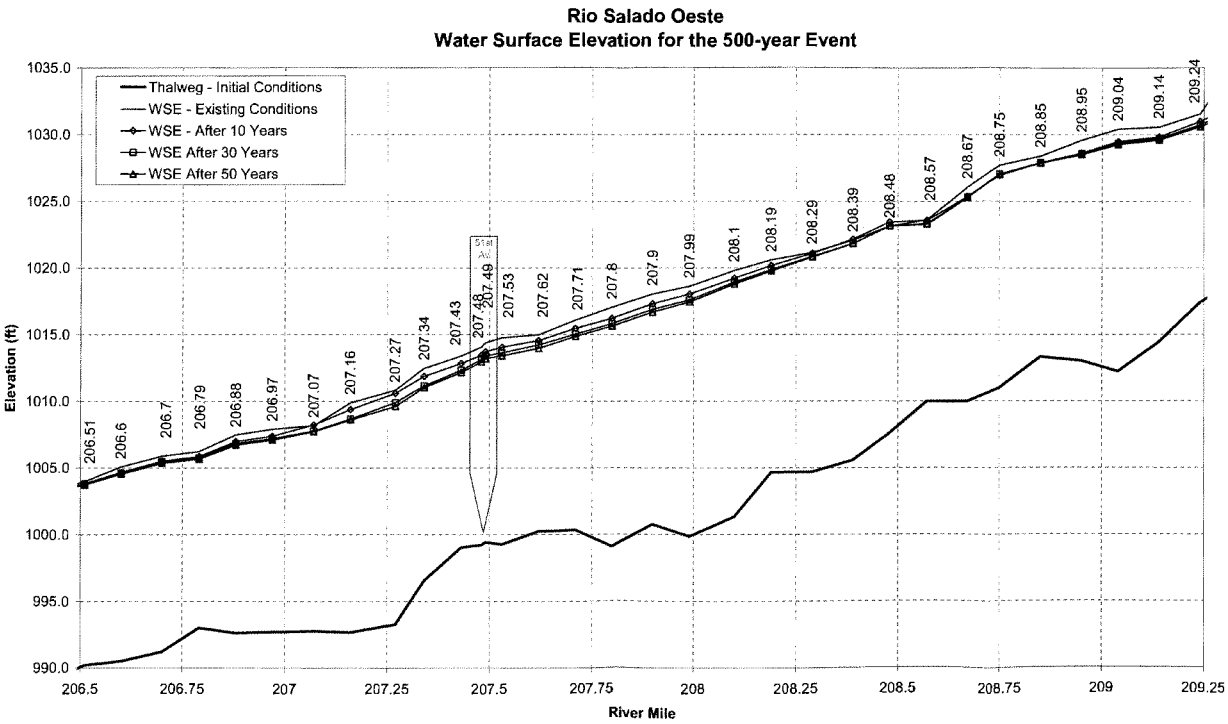

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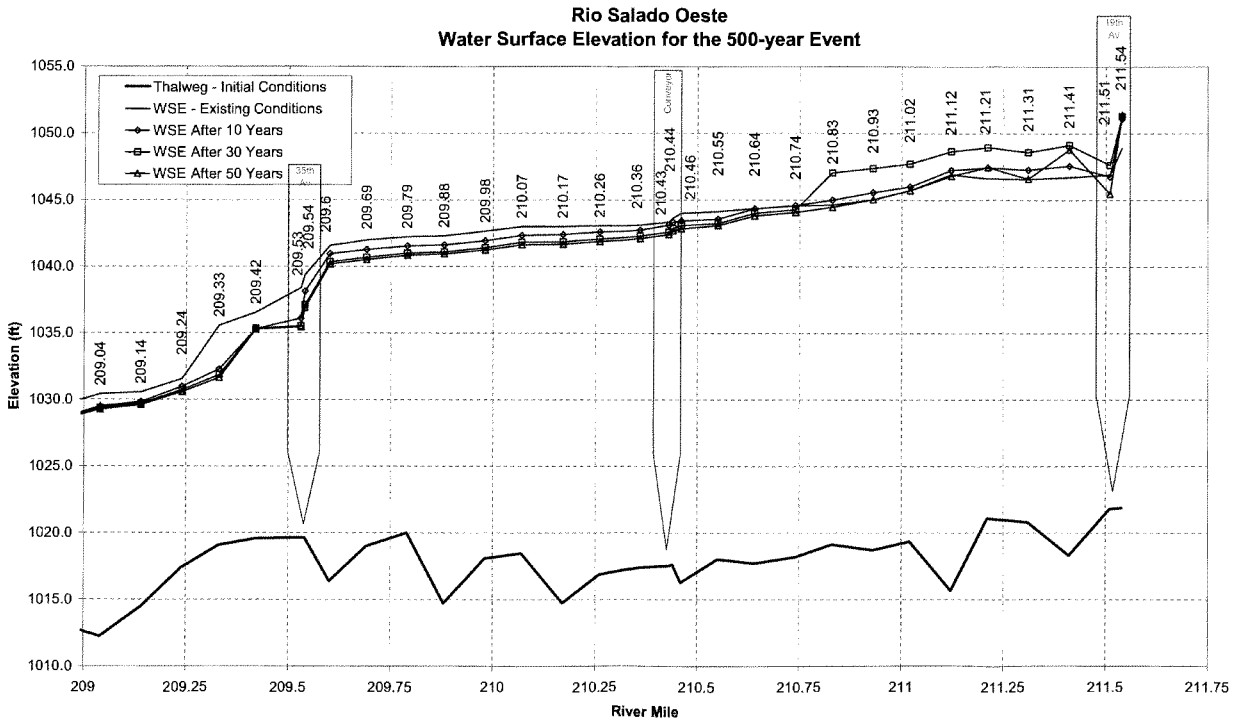

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6. Summary and Conclusions

The results of this hydraulic and sedimentation analysis are intended to support the U.S. Army Corps of Engineers Rio Salado Oeste Feasibility – F3 Phase Study.

A hydraulic model was developed in HEC-RAS to represent existing conditions in the Salt River from 19th Avenue to 91st Avenue. The hydraulic model was used to generate water surface profiles and inundation boundaries for a series of frequency flood events ranging from 5- to 500-year return periods. Small flows are generally contained in the main channel, and only the large flows (100-year and 500-year) occupy significant portions of the floodplains. All the bridges in the study reach but one seem appropriate to pass these large flows without important problems. The exception is the 35th Avenue Bridge, which has a very narrow opening and causes significant backwater and inundation on the overbanks.

The hydraulic model was converted to a sediment transport model in HEC-6T, which was used to simulate sediment dynamics in the study reach during a 50-year time frame. The hydrologic input consisted of flows measured in the Salt River from 1889 through 1938, and corresponds to the "worst case" continuous 50-year period, in terms of both peak flows and storm volumes, in 105 years of record. Results of the sediment transport analysis show that sediment dynamics are more significant in the proximity of mining operations. The study also revealed that downstream of 35th Avenue the reach experienced mainly erosion, while upstream of 35th Avenue the main process was deposition. The bridge cross section suffered severe degradation due to the increase in flow velocity caused by the small size of the bridge opening. In general, most of the changes to the existing conditions geometry took place in the first 10 years of the sediment transport simulation.

The output geometry of the sediment transport model was imported back into HEC-RAS and used to carry out a future conditions without-project hydraulic analysis. The future conditions water surface profiles were then compared to the existing conditions profiles. Results showed the most important differences upstream of the 35th Avenue Bridge. Degradation in the bridge cross section made it possible to increase the conveyance through the bridge opening and reduce the backwater. As a consequence, in the reach upstream of the bridge, the inundation boundaries in the future without-project conditions are expected to stay closer to the channel.

The study includes also a basic geomorphic analysis of the study reach, including historical changes to the river morphology based on the review of historical aerial photographs, and the application of geomorphic relationships. The historical evidence examined here indicates that the project reach is in quasi-equilibrium, although adjustments to bank and thalweg lines within the historical meander belt are possible.

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US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX B

WATER BUDGET AND INTERIOR DRAINAGE

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

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1.0 Introduction and Summary

1.1 Purpose and Scope

The Rio Salado Oeste Restoration Project (Oeste Project) addressed the feasibility of environmental restoration, flood damage reduction, and recreation along the Salt River in Phoenix, Arizona. The success of the Oeste Project is largely dependent on the water budget. 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 the water demands and quantify the amount and timing. 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 seasonally. 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 report presents the water budget analysis with project condition for the Oeste Project. Specific objectives of this report are:

1. Collect and research on water use/loss data and plant root zone depth in the project area.
2. Collect water sources information in the project area. Evaluate water sources in term of water quantity, water quality, water rights, availability, and other conditions.
3. Analysis of water budget under the proposed project alternatives. This includes mass balance calculations based on inflow (infiltration and effluent), and plant consumptions (evapotranspiration) for each project alternatives.

1.2 Project Area

The Salt River drains 14,500 square miles of mountains desert terrain in central and eastern Arizona (Figure 1-1) 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.

The project site is located within the Salt River between 19th Avenue on the east and 83rd Avenue on the west in the City of Phoenix (COP), Maricopa County, Arizona. The north and south study boundaries are located between approximately Durango Street and Southern Avenue for the eastern portion, and Broadway Road and Baseline Road for the western portion. Specifically, the northern and southern boundaries were defined by including all areas between 19th and 83rd Avenues that are within one mile of any segment of the Salt River centerline. Figure 1-1 presents the general study area map. Upstream of the study area is the Phoenix Rio Salado Project area, while downstream of the study area is the Tres Rios Project area. Because the geographic location of these three projects are so close, the water budget related data collected from the Tres Rios and Phoenix Rio Salado Project will be used for the current water budget analysis. Figure 1-2 presents the aerial photo between 19th Avenue and 83rd Avenue and the surface water features. As shown in the map, there are several water ponds along with dry riverbed areas in the study reach of the Salt River.

1.3 Expected Future Without-Project Conditions

Under the Future Without-Project Condition, there will be significant negative changes within the study area. Without agreements to the contrary, there will be insufficient water to support existing areas of riparian and associated floodplain fringe habitats. As development continues throughout the study area and larger Salt River watershed and effluent flows are reallocated, loss of riparian and floodplain fringe habitat is likely to accelerate, and many native species may be increasingly confined to highly isolated pockets. Habitat is expected to decline significantly in both extent and value. The lack of native riparian and associated floodplain fringe habitat will mean the extirpation of many species of native wildlife from the study area.

Flood threats to adjacent unprotected properties are expected to rise as the channel itself becomes more likely to migrate or erode because of reduced vegetation.

1.4 Summary of Future With-Project Conditions

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 Oeste Project. 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 Maricopa County, COP, Salt River Project (SRP), or Central Arizona Project (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 Oeste Project.

Also, preliminary water demand estimates were calculated for each of alternatives based on hydrologic balance equation with the monthly and annual precipitation, evapotranspiration, evaporation, and infiltration data. A summary of water budget for each restoration alternatives is described below (Table 1-1).

Table 1-1. Summary of Water Budget Analysis

Water Supply Sources	Water Sources (acre-feet/yr)	Water Sources (mgd) (COP)	Water Sources (mgd)
Pumped Groundwater	Pending	1.85	Pending
Stormwater Discharge	~4,503	2	~4.02
Effluent	~17,256	15.1	~15.41
Irrigation Return Flows	~9,905	8	~8.84
Irrigation Drains	~5,320		~4.75
Residual Water Flows from Upstream (Rio Salado Project)	~3,966	3.35	~3.54
Water Demands for Alternatives	**Water Demand (acre-feet/yr)**		**Water Demand (mgd)**
Alt. 2	1,583		1.41
Alt. 3	4,524		4.04
Alt. 4	4,701		4.20
Alt. 5	7,752		6.92
Alt. 5A	9,293		8.30
Alt. 5B	9,234		8.24

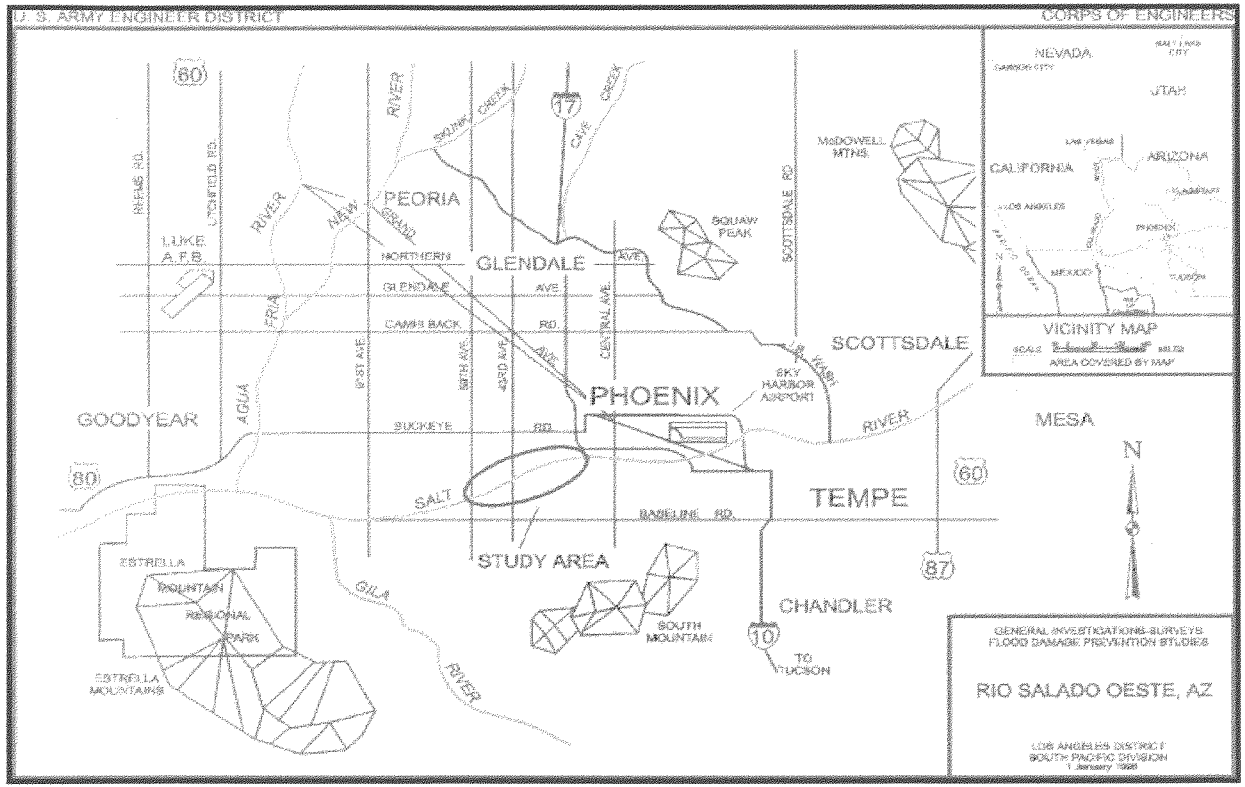


Figure 1-1. Rio Salado Oeste Project General Study Area Map

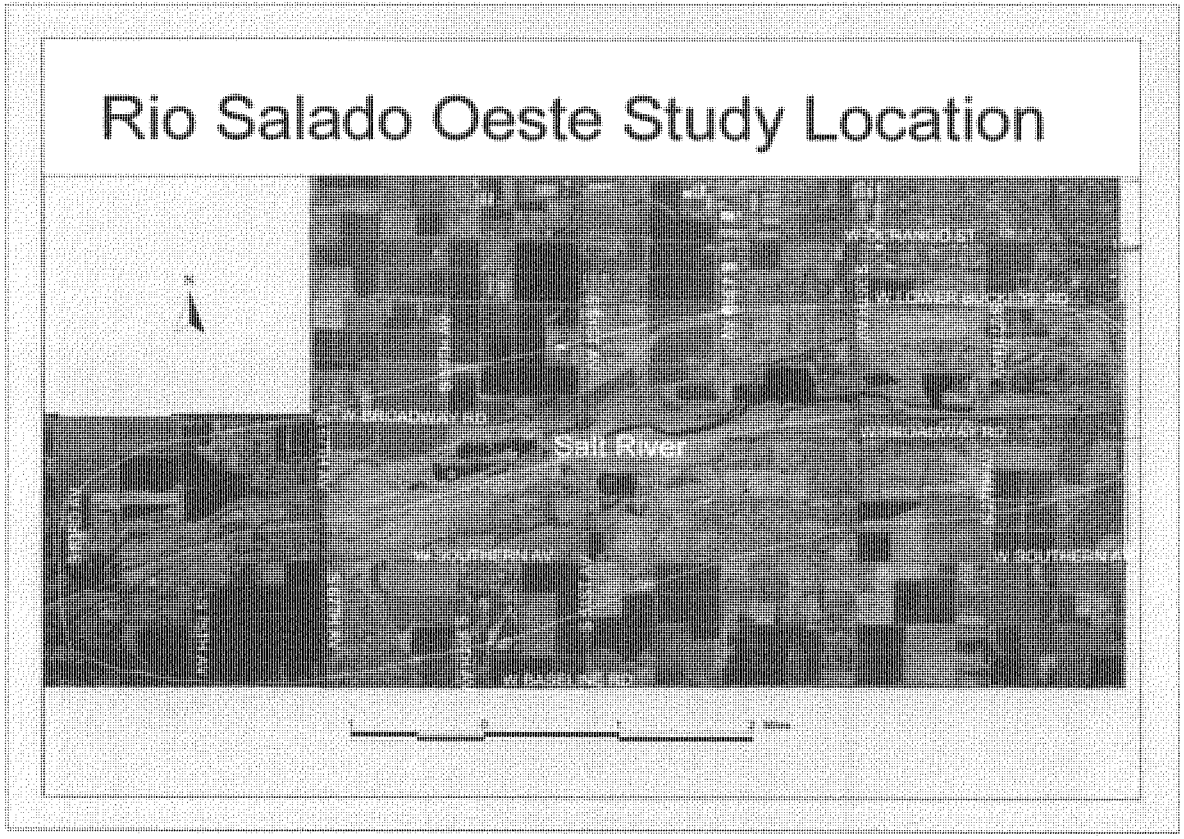


Figure 1-2. Rio Salado Oeste Study Location Aerial Photo

2.0 Water Uses and Plant Root Zone Depth

The hydrologic balance at the Rio Salado Oeste site can be evaluated using the following equation.

$$Q_{in} + Q_{rain} = Q_{out} + Q_{evp} + Q_{eto} + Q_{inf}$$

In the equation, Q_{in} and Q_{out} are surface water inflow and outflow; Q_{rain} is rainfall; Q_{evp} is evaporation by the open water; Q_{eto} is evapotranspiration by the plant (i.e., the water required by plants for growth, the water that is evaporated by plants, and the evaporation of water from the soil on the immediate area surrounding the plant); and Q_{inf} is groundwater infiltration.

As shown in this equation, three primary water demands were identified that are associated with a river restoration project. 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, multiplying the per-acre demands by the number of acres for each land use category can project the total demands.

2.1 Evapotranspiration Loss

The water demand of vegetation varies depending on the individual and combination of plant species within a habitat unit. The riparian vegetation in the Salt and Gila River was inventoried as part of the Baseline Ecological Characterization Study (1997). This study, also called the ETI study, inventoried the habitat types and acres of habitat types in the river reach from 67th Avenue on the Salt River downstream to the Buckeye Irrigation Company (BIC) diversion on the Gila River. The ETI study inventoried 4,263 acres within their study area and identified the vegetation communities (Cottonwood-Willow (12.04%), Salt Cedar (32.82%), Marsh (0.38%), Honey Mesquite (3.66%), and Quailbush-Saltbush (5.19%)), desert (3.71%), desert wash (0.14%), open water area (10.39%), and cobble (31.68%, bare riverbed). In the Tres Rios project, the average annual evapotranspiration of river vegetation communities 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. Table 2-1 presents the evapotranspiration the Salt River Habitat based on the Tres Rios Project. As shown in Table 2-1, from April through August the plants consume 65% of the annual water usage. The consumptive value shown in Table 2-1 is an average combined value for the Salt River Habitat. The plant evapotranspiration rates associated with the selected vegetation communities are presented on Table 2-2. As shown in Table 2-2, the range of evapotranspiration rate for Marsh is 7.5-16 feet/year and the average evapotranspiration rate for Marsh is 9 feet/year. The average evapotranspiration rates for Cottonwood Willow and Salt Cedar are 6.3 feet/year and 6.1 feet/year respectively.

Table 2-1. Evapotranspiration for Salt River Habitat

Month	Percent of Annual Demand (%)	Evapotranspiration (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

Source: Knight Piesold, Va Shly'ay Akimel Salt River Restoration Project Feasibility Study, Water Budget Report

Table 2-2. Vegetation Evapotranspiration Values

Vegetation Type	Evapotranspiration Range (feet/year)	Evapotranspiration Average (feet/year)
Cottonwood Willow	4.1 – 8.5	8*
Salt Cedar	3 – 9.2	6.1
Honey Mesquite	3	3
Marsh	7.5 – 16	9*
Quailbush-Saltbush	3.2	3.2
Desert	2	2
Desert Wash (Xericriparian)	2	2

Source: Greeley and Hansen, 1998, Tres Rios, Arizona Feasibility Study Salt/Gila Groundwater Analysis
* -COE adjusted for this project.

2.2 Evaporation Loss

The Oeste Project 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 (Table 2-3). 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.

Table 2-3. Evaporation from Open Water

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

Source: Knight Piesold, Va Shly'ay Akimel Salt River Restoration Project Feasibility Study, Water Budget Report

2.3 Infiltration Loss

The Tres Rios Project included wetland design. Two demonstration wetlands were constructed during the Tres Rios Project, the Cobble Site and Hayfield Site. The long-term average infiltration rates of the Tres Rios Cobble and Hayfield Site wetland cells are shown in Table 2-4. As shown in the table, cell 1 of the Cobble Site is an unlined cell; all other are lined cells use soil liner. The Cobble Site cells are 2.2 acres each and the Hayfield Site cells are 3 acres each. Compared to evaporation, infiltration is a major water loss in the system. The infiltration rates presented in Table 2-4 are long-term average values. Infiltration losses

are solved for from the water balance. At the Hayfield Site Basins, infiltration losses have been extremely stable since startup. This site is characterized by fine sediments deposited during flood events of the Salt River. Long-Term average infiltration loss from Basin H1 = 0.06 ft/d, while Basin H2 = 0.09 ft/d. These rates are very similar to that experienced by the lined Cobble Basin C2 = 0.06 ft/d. The other Cobble Basin (C1), located within the Salt River Floodway and constructed on well-draining sand, gravel, and cobble has behaved differently. In the long-term, C1 has lost an average of 0.74 ft/d to subsurface flow. This was substantiated in April 1997 when subsurface sampling devices were installed by U.S. Geological Survey (USGS) and Tres Rios staff. At that time, the subsurface was saturated to approximately 3 feet below the sediment surface, and then unsaturated to the local groundwater table (approx. 13 feet below ground surface.). Figure 2-1 presents an infiltration rate history from October 1995 to April 1997 for the Tres Rios Cobble Site.

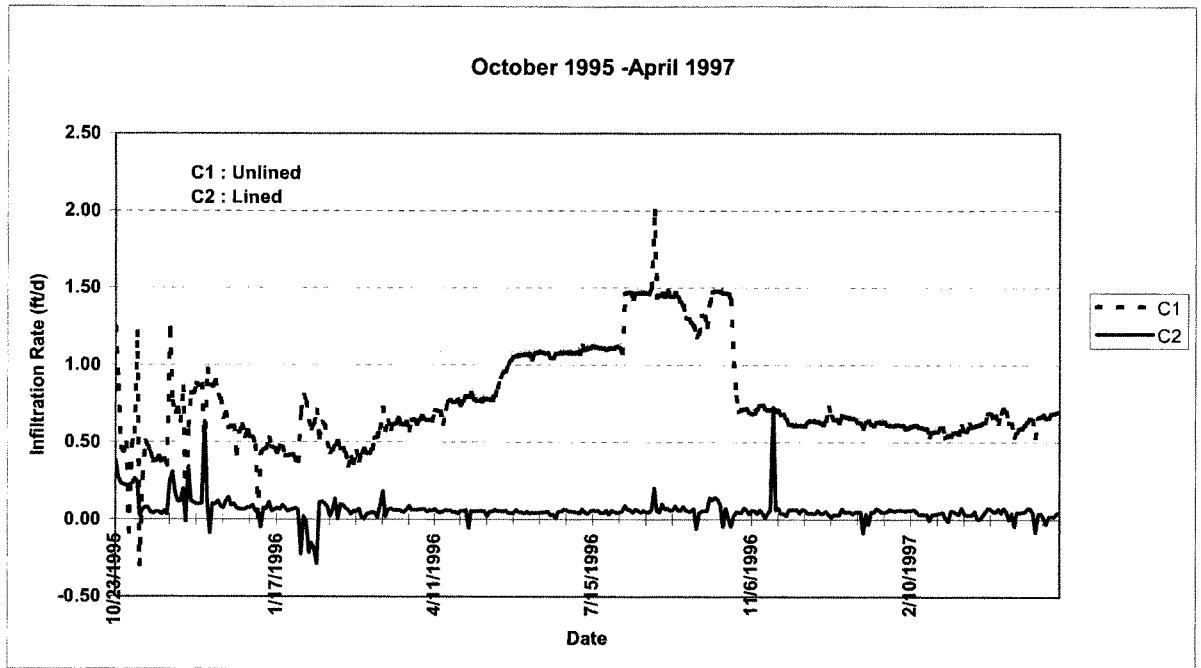
Table 2-4. Infiltration Rates for Tres Rios Demonstration Wetland Cells

	Cobble Site		Hayfield Site	
Cell	C1	C2	H1	H2
Lining	unlined	lined	lined	lined
Size(acre)	2.2	2.2	3.0	3.0
Long Term Average Infiltration Rate (ft/d)	0.74	0.06	0.06	0.09

Source: Tres Rios Demonstration Constructed Wetland Project, 1997

2.4 Plant Root Zone Depth

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 2-5 (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.



Source: WASS Gerke + Associates, Inc

Figure 2-1. Tres Rios Cobble Site Infiltration Rate History

Table 2-5. Riparian and Constructed Wetland Vegetation Requirements

Vegetation Type		Seedling Establishment	Sapling Growth	Mature Survival
Trees (Groundwater Depth[1] 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[1] 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

Depth[1]: Depth from ground surface to water table.
Source: WASS Gerke + Associates, Inc.

3.0 Water Sources

The success of a habitat restoration project such as the Oeste Project 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 Oeste Project area; two relate to groundwater resources and six 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, stormwater discharges, effluent, irrigation return flows, irrigation drains, and discharges from sand and gravel mining operations. 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 Oeste 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.

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 (Figure 3-1) 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 and, in turn, have decreased the amount of water that gets recharged into the alluvial aquifer. Today static water level is relatively shallow, ranging from 20 to 50 feet below ground surface (bgs) within the Salt River channel to 60 to 80 feet bgs north and south of the river. Data indicate that over the past 25 years groundwater elevations in the study area have decreased approximately 15 to 20 feet. In a few areas 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 the habitat restoration project.

3.1.2 Quantity Analyses

Depth to groundwater has fluctuated greatly since development of the Salt River Valley began in the late 1890s. 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.

The City of Phoenix operates the 23rd Avenue Waste Water Treatment Plant (WWTP). Reclaimed water produced by this plant is reused by the Roosevelt Irrigation District (RID), and Peterson Farms for irrigation water. When RID is taking the reclaimed water, there is no flow discharged to the Salt River. RID diversions are seasonal, following the demand for irrigation. During winter, the reclaimed water from the WWTP is discharged into the Salt River. Though Peterson's use is only about 1mgd, approximately 10 mgd must now be diverted via a canal to meet Peterson's demand. The excess water now infiltrates along the canal or is discharged back to the Salt Rivet between 43rd and 51st Avenue. The discharge percolates into the riverbed, but as the discharge season progresses, the flow extends downstream. When hydrologic conditions permit, the flow from the 23rd Avenue WWTP can continue downstream beyond the study area.

These areas receive some groundwater recharge from WWTPs, irrigation seepage, storm drains, irrigation drains, and underflow from the Gila River. The result is that the general groundwater depth beneath the Salt River ranges from 20 to 50 feet below the river channel for the majority of the study area

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. 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. In-situ groundwater is generally suitable for agricultural uses and should be adequate for the habitat restoration project.

3.1.4 Water Rights

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 Oeste Project water supply.

3.1.5 Assessment of In-situ Groundwater

In-situ groundwater can provide a reliable source of water for the open water area formed by effluent and irrigation return water. In this area, seepage from the open water area forms a local perched water table near the surface. Currently, wetland plant species are growing along this reach of the river and extend along the water body. 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 vicinity of open water areas.

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. Therefore in-situ groundwater is considered to be an unacceptable source of water for areas of the Oeste Project where the depth to groundwater is more than 30 feet.

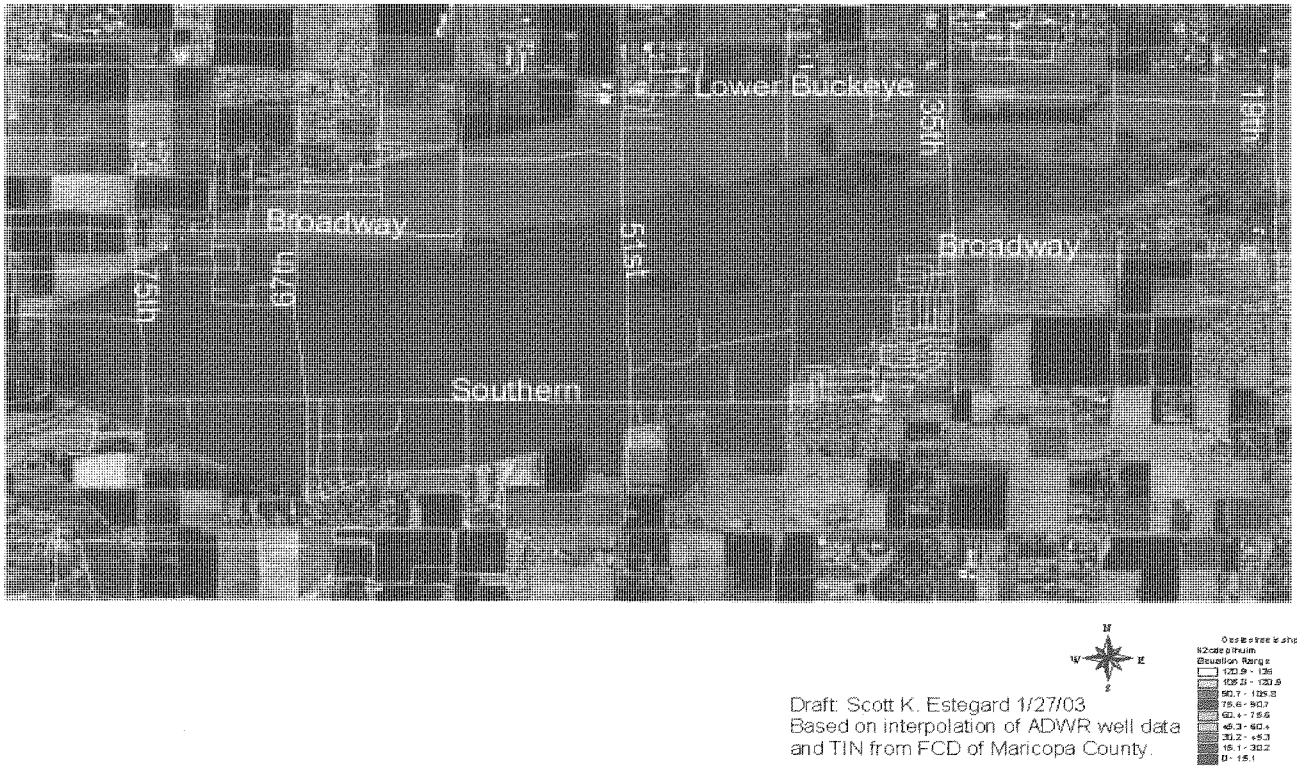


Figure 3-1. Depth to Groundwater

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. There are several legal and institutional implications that pumped groundwater could have on the project.

3.2.2 Quantity Analyses

Groundwater in sufficient quantity to supply water wells is present throughout the majority of the Oeste Project area. This is demonstrated by the location and number of existing wells. Some of these wells are shown on Figure 4 of the Groundwater Quality and Hydrogeology Report (URS, 2002).

Pumped groundwater has been a reliable source of water for many years throughout the Salt River Valley including the Oeste Project 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 6,000 gpm.

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.

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 problem associated with using pumped groundwater is the impact that this pumping may have on other nearby groundwater wells.

3.2.3 Quality Analyses

General groundwater quality data were obtained from databases including the Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) database, Arizona Department of Environmental Quality (ADEQ) water quality database, and USGS National Water Information System (NWIS) water quality database. Other data were obtained from SRP, RID, the Phase 2 Report, and COP. The locations of wells with groundwater quality data that was useful for this report. For this evaluation, the most recent data available used ranged from 2001 to as far back as 1983.

The above sources provided limited data for nitrates, volatile organic compounds (VOCs), metals, and pesticides. The majorities of these data were below detection levels or detected at concentrations below groundwater quality standards.

The ADWR Well Registry database and Imaged Records database were queried to determine the location, owner, and purpose of monitor wells within the study area. This information was used to identify sites having possible groundwater quality concerns. Further information about sites of particular concern (e.g. landfills, Leaking Underground Storage Tank (LUST) sites, etc.) was obtained from the well owners and ADEQ.

Groundwater conductivity within the study area ranges from about 1,000 to 3,500 micromhos per centimeter (μmhos/cm), which corresponds with an estimated range in TDS of 600 to 2,500 parts per million (ppm). Based on data from wells screened in the Upper Alluvial Unit (UAU) and part of the Middle Fine-Grained Unit (MFU), there is a general trend of increasing conductivity from roughly 1,200 μmhos/cm in the northeast to over 3,000 μmhos/cm in the southwest part of the study area.

Nitrate concentrations are generally less than 10 milligrams per liter (mg/L), with the exception of wells located in the southwestern part of the study area where concentrations are as high as 13.8 mg/L. There is no apparent difference in the concentration of nitrate in the shallow wells versus the deeper wells. Quarterly data from the 23rd Avenue WWTP and the 27th Avenue Landfill monitor wells show that the nitrate concentrations can vary by as much as 4 ppm from quarter to quarter. The changes in nitrate concentration do not appear to be seasonal.

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 use of groundwater needs to 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 applicable to the Oeste Project.

COP 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 COP, 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 COP'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 to be drilled, 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

The water supply and distribution system is critical to the success and sustainability of the Oeste Environmental Restoration Project. A sufficient quantity and adequate quality of water must be available to maintain the viability of the various habitat types that are being considered for Oeste. The primary water supply for the Oeste project is effluent obtained directly from the 23rd Avenue Water Reclamation Plant. Supplemental water could come from a variety of underground sources including: 1) effluent credits "recovered" (pumped) from within the area of hydrologic impact of the RID Groundwater Savings Facility; 2) incidental recharge credits associated with increased recharge from project implementation; 3) groundwater (based on the City's Assured Water Supply allowance); and 4) recovered credits for Central Arizona Project water (stored by the City). Therefore, it did consider groundwater as a makeup source for the seasonal changes of reclaimed water from the 23rd Ave. Water Reclaimed Plant.

The use of pumped water (rather than direct effluent) has several limitations. One of these relates to the City's ability to comply with state mandated water conservation requirements. 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 Oeste Project. However, institutional commitments by COP, 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 Oeste Project 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 with 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, low-head dam, into the Arizona Canal and Southern Canal. The riverbed downstream is typically dry.

The river, however, is still subject to uncontrolled 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 exceeds the diversion capacity at Granite Reef, the excess will overflow the spillway to the downstream reaches of the Salt River to flood.

3.3.2 Quantity Analyses

The Salt River is dry the majority of the time due to the upstream dams that were constructed for water supply and hydropower to agriculture and the Phoenix valley. 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 (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.

Discharge-frequency values are provided in Table 3-2 and more detailed information on flood flows can be found in Appendix A-Hydrology and Hydraulics of Rio Salado Oeste Interim Feasibility Report 2002. While not necessarily a likely preferred source for delivery of water and implementation of restoration measures flood flows need to be considered in plan formulation. On a natural system they provide the necessary dynamics to maintain the ecosystem and are an important factor in seed dispersal. Measures considered in the formulation of plans should account for possible damages resulting from flooding as well as taking advantage of the benefits they may provide to sustaining the project.

Table 3-1. Summary of Historic Salt River Flood Flows
(floods with daily flows greater than 10,000 cfs)

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

Source: Greeley and Hansen, Tres Rios, Arizona Feasibility Study, April 1998

Table 3-2. Discharge frequency values used in the existing conditions model

Location	Return Period					
	5-yr	10-yr	20-yr	50-yr	100-yr	500-yr
Peak Discharges (ft^3/s) in the Salt River at:						
Central Avenue	20,200	53,000	87,000	135,000	166,000	240,000
67th Avenue	20,000	51,000	84,000	132,000	164,000	237,000

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. 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. The flood flows 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 Oeste study area to downstream areas. There is very little information, however, on the chemical constituents in flood flows. There are no known water quality issues that would prevent flood flows from being used as a water source for the Oeste Project.

3.3.4 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.

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 Oeste Project 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 cfs, which did extensive damage to the Salt River Valley (Va Shly'ay Akimel Salt River Restoration Project, Water Budget Report, Knight Piesold, 2002). Flows of this magnitude are neither predictable nor preventable.

3.4 Stormwater Discharges

3.4.1 Description of Source

Stormwater discharges represent runoff to the Salt River 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 from areas immediately adjacent to the river.

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 down gradient 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.

Several smaller storm drains exist along the bank of the Salt River. Unfortunately, there are limited flow records for these drains. There are also several areas adjacent to the river where overland flow 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

Stormwater flows occur in direct response to precipitation. Most stormwater runoff in the study area is not measured or gaged. The runoff is sheet flow across the land, roadside curb and gutter systems, or ditches that drain to the river channels.

U.S. Army Corps of Engineers (USACE) conducted a site investigation to verify the location of storm drains into the Salt River. It was also observed that wetland plant species were growing in the riverbed near outfalls of the north side of 51st Avenue (SR01) and 67th Avenue (SR49). There are limited flow records for those drains, and the exact drainage area that contributes runoff to the drain is not known. However, the presence of wetland plant species indicates that this runoff is sufficient to maintain this vegetation.

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 (USACE, 2003). Table 3-3 provides the monthly and annual runoff amounts estimated for these drains.

3.4.3 Quality Analyses

It is important to note that stormwater quality is a function of land use, not the size of the watershed (Greeley and Hansen, 2001). In other words, how a specific section of land is used will impact stormwater quality more so than tract size. Table 3-4 provides the summary statistics for selected event-mean constituent concentrations measured in stormwater and stream by the land use. Stormwater 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 National Pollutant Discharge Elimination System (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. The quality of the "first flush" water is generally poor.

In some locations where the farm fields are near river channels, stormwater 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 (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.

As the runoff continues, the water quality improves. The numeric surface water quality standards established by ADEQ for each designated use were compared against the available surface water quality sample data obtained from the various databases. Where an established surface water quality numeric criterion was exceeded, this information was used to compile Table 3-5, Storm Water Quality Summary. In general, based on analysis of available data versus the numeric water quality standards, stormwater is a vehicle by which surface water quality appears to degrade within the Salt River.

3.4.4 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 habitat restoration project. However, the 67th Avenue Drain (SR49) has produced sufficient flow to support a small area of wetland plant species; unfortunately, there are no records to further evaluate this flow. 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. These drains, however, do not flow consistently, and releases into these drains may not be reliable.

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.

3.4.5 Future Drainage Master Plan

The purpose of the Durango Area Drainage Master Plan and Laveen Area Drainage Master Plan (ADMP) are to identify flood control problems and plan for the construction of facilities that will eliminate or minimize flooding problems. There are two major objectives of these studies. The first is to develop a plan to control stormwater runoff to prevent flood damage within the watershed. The second is to mitigate future potential runoff and subsequent ponding and to provide protection to properties from future 100-year flooding damages. Because the existing stormdrain system is not enough to carry the 100-year, 24-hour storm event. The detention basins, channels, and pipes are sized based on the revised 100-year discharges. Detention basins are sized to maximize flow attenuation with the land area available using both off-line and flow-through concepts. The off-line concept uses a perimeter channel to allow low flow to bypass the detention basin. The flow-through concept allows the entire flow to be intercepted by the detention basin. The Drainage Master plans are not going to reduce the volumes of stormwater discharge in terms of low flow discharge but it is going to reduce the peak flow and provide the longer low flow to the Oeste project area after the flooding season instead.

Table 3-3. Storm Drain Average Annual Runoff Volumes

OUTFALL No.	SITE LOCATION	PIPE SIZE (inch)	Drainage Area (acre)	Drainage Area (mi^2)	JAN (AF)	FEB (AF)	MAR (AF)	APR (AF)	MAY (AF)	JUN (AF)	JUL (AF)	AUG (AF)	SEP (AF)	OCT (AF)	NOV (AF)	DEC (AF)	ANNUAL (AF)
SR01[1,2]	51st Avenue and Salt River - North Side	96	2290	3.6	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR02[1,2]	43rd Avenue and Salt River - North Side	90	2290	3.6	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR03[1,2]	35th Avenue and Salt River- North Side	75	1856	2.9	19.5	20.2	25.7	6.5	3.6	3.8	24.2	28.0	25.1	19.0	19.3	29.1	224
SR04[1,2]	27th Avenue and Salt River- North Side	72	2862	4.5	29.6	30.7	39.2	9.9	5.4	5.8	36.8	42.6	38.1	29.0	29.3	44.3	341
SR05[1,2]	25th Avenue and Salt River- North Side	102	1017	1.6	10.9	11.3	14.4	3.6	2.0	2.1	13.5	15.6	14.0	10.6	10.8	16.3	125
SR06[1,2]	22nd Avenue and Salt River- North Side	78	4790	7.5	48.8	50.5	64.5	16.3	9.0	9.5	60.6	70.1	62.8	47.7	48.2	72.9	561
SR07[1,2]	19th Avenue and Salt River- North Side	54	632.77	1.0	6.9	7.1	9.1	2.3	1.3	1.3	8.5	9.9	8.8	6.7	6.8	10.3	79
SR30[1,2]	27th Avenue and Salt River- South Side	108	1620	2.5	17.1	17.7	22.6	5.7	3.1	3.3	21.2	24.5	22.0	16.7	16.9	25.5	196
SR31[1,2]	19th Ave, South Bank	60	1918	3.0	20.1	20.8	26.6	6.7	3.7	3.9	25.0	28.9	25.9	19.6	19.9	30.0	231
SR47[1,2]	51st Avenue and Salt River- North Side 50 feet north of SR01	48	unknown	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
SR48[1,2]	45th Avenue and Salt River- South Side	48	unknown	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
SR48a[1,2]	43rd Avenue and Salt River- South Side	N/A	14502	22.66	142.7	147.6	188.6	47.6	26.2	27.9	177.1	205.0	183.7	139.4	141.0	213.2	1640
SR49[1,2]	67th Avenue and Salt River- North Side	96	4762	7.4	48.5	50.2	64.1	16.2	8.9	9.5	60.2	69.7	62.5	47.4	48.0	72.5	558
SR58[1,2]	35th Avenue and Salt River- N/E Side	60	unknown	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
SR59[1,2]	2333 W. Durango (23rd Ave. WWTP east side of 35th Ave. and Salt River) - North Side	48	unknown	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
	Total																4503

1. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
2. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study.

Table 3-4. Summary statistics for selected event-mean constituent concentrations measured in stormwater and streamflow, Maricopa County, Arizona.

Constituent	Units	# of Samples	# < Detection Limit	Maximum	Minimum	Mean	Std. Dev.	Detection Limit USGS	Detection Limit Phoenix
				RESIDENTIAL					
COD	mg/L	13	1	200	< 10	100	50	10	1
Suspended Solids	mg/L	14	1	910	< 1	180	230	1	10
Total Cadmium	µg/L	14	5	3	< 0.2	0.8	0.7	1	0.2
Total Copper	µg/L	11	0	45	5	23	5	1	1
Total Lead	µg/L	14	0	99	5	32	28	1	1
				COMMERCIAL					
COD	mg/L	8	0	330	60	150	90	10	1
Suspended Solids	mg/L	8	0	337	20	120	120	1	10
Total Cadmium	µg/L	9	6	0.9	0.6	0.7	0.2	1	0.2
Total Copper	µg/L	9	0	64	8	20	17	1	1
Total Lead	µg/L	9	0	27	3	12	7.7	1	1
				HEAVY INDUSTRY					
COD	mg/L	9	0	4300	110	720	90	10	1
Suspended Solids	mg/L	9	0	1480	84	790	530	1	10
Total Cadmium	µg/L	10	1	6	0.9	2.5	1.7	1	0.2
Total Copper	µg/L	8	0	320	50	140	90	1	1
Total Lead	µg/L	10	0	620	31	250	180	1	1
				LIGHT INDUSTRY					
COD	mg/L	6	0	300	53	120	1360	10	1
Suspended Solids	mg/L	7	0	680	10	250	260	1	10
Total Cadmium	µg/L	7	4	2	< 1	0.8	0.8	1	0.2
Total Copper	µg/L	5	0	72	10	43	24	1	1
Total Lead	µg/L	7	0	130	11	38	43	1	1
				SOUTH MOUNTAIN AND SALT RIVER					
COD	mg/L	8	0	21000	12	2650	7420	10	1
Suspended Solids	mg/L	8	0	3390	3	620	1140	1	10
Total Cadmium	µg/L	8	7	2	< 1	--------	--------	1	0.2
Total Copper	µg/L	8	0	300	2	70	120	1	1
Total Lead	µg/L	8	2	150	< 1	28	50	1	1

(Data for South Mountain and Salt River were combined to represent nonurban sources and include event-mean and instantaneous concentrations. Data from drainage basins with mixed land use were not grouped into any land-use category. <, less than. Dashes indicate that statistics could not be computed.)
Source: USGS

Table 3-5. Rio Salado Oeste Project Storm Water Quality Summary

Site Name	Sample Date	Constituent	Result	Units	Regulatory Limit	Limiting Criteria
19th Ave. Bridge	3/28/1991	TURBIDITY	275	NTU	50	R18-11-109
19th Ave. Bridge	3/28/1991	LEAD, TOTAL	28	UG/L	9.3	A&Wedw*
19th Ave. Bridge	3/28/1991	FECAL STREPTOCOCCI	6400	CFU/100	800	R18-11-109
19th Ave. Bridge	3/28/1991	BERYLLIUM, TOTAL	0.6	UG/L	0.21	FC
19th Ave. Bridge	3/28/1991	COPPER, TOTAL	38	UG/L	24	A&Wedw*
Salt River at 27th Ave.	12/10/1991	FECAL STREPTOCOCCI	22000	CFU/100	800	R18-11-109
Salt River at 27th Ave.	12/10/1991	FECAL COLIFORM	3100	CFU/100	800	R18-11-109
Salt River at 27th Ave.	12/10/1991	FECAL STREPTOCOCCI	22000	CFU/100	4000	PBC
Salt River at 27th Ave.	12/10/1991	FECAL COLIFORM	3100	CFU/100	800	R18-11-109
Salt River at 27th Ave.	12/10/1991	FECAL STREPTOCOCCI	26000	CFU/100	4000	PBC
Salt River at 27th Ave.	12/10/1991	FECAL COLIFORM	11000	CFU/100	4000	PBC
Salt River at 27th Ave.	12/10/1991	DDE	0.14	UG/L	0.0006	FC
Salt River at 27th Ave.	12/10/1991	DDE	0.14	UG/L	0.0006	FC
Salt River at 27th Ave.	12/10/1991	FECAL STREPTOCOCCI	25500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/2/1992	FECAL STREPTOCOCCI	6500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/2/1992	DDT	0.1	UG/L	0.0005	FC
Salt River at 27th Ave.	3/2/1992	DDE	0.67	UG/L	0.0006	FC
Salt River at 27th Ave.	3/2/1992	DDT	0.1	UG/L	0.0006	FC
Salt River at 27th Ave.	3/2/1992	FECAL COLIFORM	5500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/2/1992	PCB SERIES	0.3	UG/L	0.00009	FC
Salt River at 27th Ave.	3/2/1992	PH (STANDARD UNITS)	9.05		9	R18-11-109
Salt River at 27th Ave.	3/2/1992	FECAL COLIFORM	5500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/2/1992	DDE	0.67	UG/L	0.0006	FC
Salt River at 27th Ave.	3/2/1992	FECAL STREPTOCOCCI	6500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/8/1992	FECAL STREPTOCOCCI	6600	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/8/1992	FECAL COLIFORM	5800	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/8/1992	DDE	1.1	UG/L	0.0006	FC
Salt River at 27th Ave.	3/8/1992	PCB SERIES	0.3	UG/L	0.00009	FC
Salt River at 27th Ave.	3/8/1992	DDE	1.1	UG/L	0.0006	FC
Salt River at 27th Ave.	3/8/1992	FECAL STREPTOCOCCI	6600	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/8/1992	FECAL COLIFORM	5800	CFU/100	800	R18-11-109
Salt River at 27th Ave.	3/27/1992	FECAL COLIFORM	9500	CFU/100	4000	PBC
Salt River at 27th Ave.	3/27/1992	FECAL STREPTOCOCCI	8500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	7/11/1992	FECAL COLIFORM	4500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	7/11/1992	FECAL STREPTOCOCCI	9800	CFU/100	800	R18-11-109
Salt River at 27th Ave.	7/11/1992	FECAL STREPTOCOCCI	9800	CFU/100	800	R18-11-109
Salt River at 27th Ave.	7/11/1992	FECAL COLIFORM	4500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	7/11/1992	DDE	0.35	UG/L	0.0006	FC
Salt River at 27th Ave.	7/11/1992	DDE	0.35	UG/L	0.0006	FC
Salt River at 27th Ave.	8/22/1992	FECAL STREPTOCOCCI	4170	CFU/100	800	R18-11-109
Salt River at 27th Ave.	8/22/1992	FECAL COLIFORM	5800	CFU/100	800	R18-11-109
Salt River at 27th Ave.	8/22/1992	FECAL STREPTOCOCCI	4200	CFU/100	800	R18-11-109
Salt River at 27th Ave.	8/22/1992	FECAL COLIFORM	5800	CFU/100	800	R18-11-109

Site Name	Sample Date	Constituent	Result	Units	Regulatory Limit	Limiting Criteria
Salt River at 27th Ave.	12/8/1992	FECAL STREPTOCOCCI	15000	CFU/100	4000	PBC
Salt River at 27th Ave.	12/8/1992	DDT	0.1	UG/L	0.0005	FC
Salt River at 27th Ave.	12/8/1992	FECAL COLIFORM	4500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	12/8/1992	DDE	0.4	UG/L	0.0006	FC
Salt River at 27th Ave.	12/8/1992	DDT	0.1	UG/L	0.0006	FC
Salt River at 27th Ave.	12/8/1992	FECAL STREPTOCOCCI	14700	CFU/100	800	R18-11-109
Salt River at 27th Ave.	12/8/1992	DDE	0.4	UG/L	0.0006	FC
Salt River at 27th Ave.	12/8/1992	FECAL COLIFORM	4500	CFU/100	800	R18-11-109
Salt River at 27th Ave.	1/4/1995	CYANIDE, TOTAL	0.01	MG/L	9.7	A&Wedw
Salt River at 27th Ave.	1/4/1995	CYANIDE, TOTAL	0.01	MG/L	9.7	A&Wedw
Salt River at 27th Ave.	11/1/1995	CYANIDE, TOTAL	0.01	MG/L	9.7	A&Wedw
Salt River at 27th Ave.	11/1/1995	PH (STANDARD UNITS)	9.3		9	R18-11-109
Salt River at 27th Ave.	11/1/1995	CYANIDE, TOTAL	0.01	MG/L	9.7	A&Wedw
Salt River at 27th Ave.	11/1/1995	CYANIDE, TOTAL	0.019	MG/L	9.7	A&Wedw
35th Ave. Bridge	3/29/1991	FECAL STREPTOCOCCI	670	CFU/100	800	R18-11-109
35th Ave. Bridge	3/29/1991	LEAD, TOTAL	18	UG/L	6.3	A&Wedw*
35th Ave. Bridge	3/29/1991	TURBIDITY	108	NTU	50	R18-11-109
35th Ave. Bridge	8/22/1992	FECAL COLIFORM	16000	CFU/100	800	R18-11-109
35th Ave. Bridge	12/5/1994	FECAL STREPTOCOCCI	950	CFU/100	800	R18-11-109
35th Ave. Bridge	12/5/1994	FECAL COLIFORM	1100	CFU/100	800	R18-11-109
35th Ave. Bridge	8/19/1995	FECAL STREPTOCOCCI	1300	CFU/100	800	R18-11-109
35th Ave. Bridge	9/7/1995	FECAL STREPTOCOCCI	1000	CFU/100	800	R18-11-109
35th Ave. Bridge	9/28/1995	FECAL COLIFORM	900	CFU/100	800	R18-11-109
35th Ave. Bridge	3/13/1996	FECAL STREPTOCOCCI	1600	CFU/100	800	R18-11-109
35th Ave. Bridge	7/25/1996	FECAL COLIFORM	9000	CFU/100	800	R18-11-109
35th Ave. Bridge	7/25/1996	FECAL STREPTOCOCCI	16000	CFU/100	800	R18-11-109
35th Ave. Bridge	2/22/1997	CYANIDE, TOTAL	0.03	MG/L	9.7	A&Wedw
35th Ave. Bridge	2/22/1997	FECAL COLIFORM	1600	CFU/100	800	R18-11-109
35th Ave. Bridge	12/22/1997	FECAL STREPTOCOCCI	9000	CFU/100	800	R18-11-109
35th Ave. Bridge	2/4/1998	MERCURY, TOTAL	0.6	UG/L	0.6	FC
35th Ave. Bridge	2/4/1998	FECAL STREPTOCOCCI	90000	CFU/100	800	R18-11-109
51st Ave. Bridge-REW	3/29/1991	FECAL STREPTOCOCCI	1500	CFU/100	800	R18-11-109
51st Ave. Bridge-REW	3/29/1991	TURBIDITY	103	NTU	50	R18-11-109
Salt River at 51st Ave.	4/22/1975	FECAL COLIFORM	360000	CFU/100	800	R18-11-109
Salt River at 51st Ave.	4/28/1975	FECAL COLIFORM	23000	CFU/100	800	R18-11-109
Salt River at 51st Ave.	5/1/1975	FECAL COLIFORM	26000	CFU/100	800	R18-11-109
51st Ave. Bridge	6/1/1982	1,1-DICHLOROETHYLENE	0.0277	MG/L	950	A&Wedw
51st Ave. Bridge	6/1/1982	1,1-DICHLOROETHYLENE	0.0445	MG/L	950	A&Wedw
51st Ave. Bridge	6/1/1982	CARBON TETRACHLORIDE	0.0698	MG/L	5.5	FC
51st Ave. Bridge	6/1/1982	CARBON TETRACHLORIDE	0.1039	MG/L	5.5	FC
51st Ave. Bridge	6/1/1982	TETRACHLOROETHYLENE	0.0622	MG/L	11	FC
51st Ave. Bridge	6/1/1982	TETRACHLOROETHYLENE	0.0274	MG/L	11	FC
51st Ave. Bridge	6/13/1983	LEAD, TOTAL	9.1	UG/L	6	A&Wedw*

A&Wedw*: Calculated value from available hardness data

DDE: p,p'-Dichlorodiphenyldichloroethylene

DDT: p,p'-Dichlorodiphenyltrichloroethane
FC= Fish Consumption
A&Wedw= Aquatic and wildlife (effluent dependent water)
PBC= Partial Body Contact
R18-11-109= Refer to section in Article 1, which is the Numeric Water Quality Standards.
Source: URS, Groundwater Quality and Hydrogeology Report Rio Salado Oeste Project Phoenix, Arizona, 2002

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.

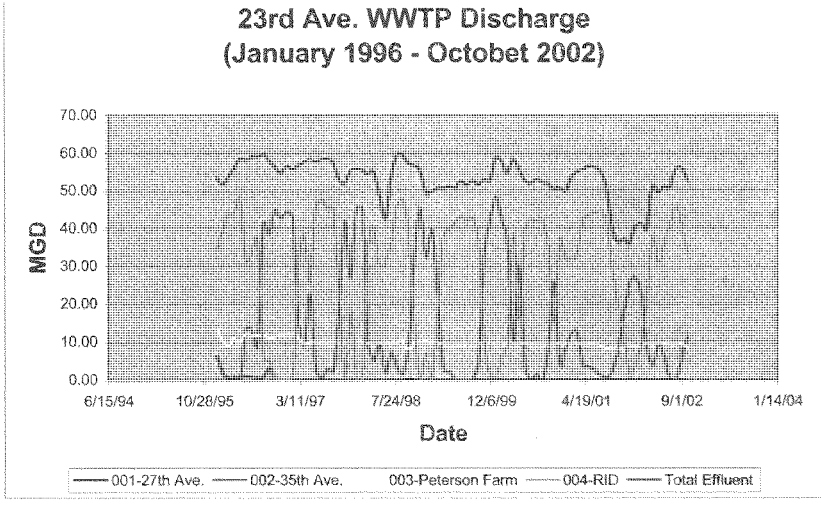
3.5.2 Quantity Analyses

The City of Phoenix operates the 23rd Avenue WWTP. Effluent produced by this plant is reused by the Roosevelt Irrigation District (RID) for irrigation water. When RID is taking the effluent, there is no flow discharged to the Salt River. RID diversions are seasonal, following the demand for irrigation water. During winter, the effluent from the WWTP is discharged into the Salt River. The discharge percolates into the riverbed, but as the discharge season progresses, the flow extends downstream. When hydrologic conditions permit, the flow from the 23rd Avenue WWTP can continue downstream beyond the study area. This occurs during periods when large storm flows or flood flows have saturated the riverbed. Table 3-6 presents the average discharges by month from the 23rd Avenue WWTP. Figure 3-2 also demonstrates the trend of daily discharges (from January 1996 to October 2002) from the 23rd Avenue WWTP.

Table 3-6. 23rd Avenue WWTP Discharge (January 1996 – October 2002)

Source: City of Phoenix

	001 South Gate of discharge structure at 27th Avenue (27th Ave.) Average Flows		002 Pipeline discharge to Salt River at 35th Avenue (35th Ave.) Average Flows		003 West gate of discharge structure at 27th Avenue (Peterson Farm-Irrigation) Average Flows		004 Junction structure on RID pipeline to RID Canal (RID) Average Flows		Total Plant Effluent Average Flows	
	MGD	AC-FT	MGD	AC-FT	MGD	AC-FT	MGD	AC-FT	MGD	AC-FT
January	0.90	85.94	29.39	2,796.23	10.48	997.23	11.20	1,065.91	51.96	4,942.91
February	0.26	22.57	29.23	2,511.40	10.08	866.29	12.54	1,077.51	52.11	4,477.76
March	0.10	9.07	15.19	1,445.07	9.76	928.90	26.97	2,565.79	52.02	4,948.83
April	0.10	9.25	4.89	450.21	9.72	894.93	40.17	3,698.03	54.87	5,052.07
May	0.10	9.51	10.98	1,044.40	9.65	917.97	33.32	3,169.47	54.03	5,140.13
June	0.15	14.06	4.19	385.85	9.97	917.77	38.38	3,533.85	52.69	4,851.03
July	0.10	9.51	3.26	309.69	9.86	938.38	41.16	3,915.91	54.38	5,173.49
August	0.10	9.51	2.57	244.60	9.72	924.91	43.10	4,100.60	55.46	5,276.42
September	0.10	9.21	7.62	701.87	9.82	903.90	36.36	3,347.79	53.90	4,962.23
October	0.50	47.34	14.21	1,351.75	9.23	878.52	27.50	2,616.47	51.44	4,893.79
November	0.00	0.00	32.39	2,981.60	9.74	896.33	8.67	798.05	50.88	4,684.26
December	0.00	0.00	30.96	2,945.02	10.08	958.91	9.68	920.88	50.76	4,828.74
Annual	0.20	225.15	15.41	17,256.45	9.84	11,025.84	27.42	30,715.91	52.87	59,227.22



Source: City of Phoenix

Figure 3-2. 23rd Avenue WWTP Discharge Rate

3.5.3 Quality Analysis

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 Mesa and Tempe Water Reclamation Plants upstream would infiltrate into the Salt River bed before reaching the Oeste study area.

23rd Avenue WWTP

The WWTP is currently active, and effluent water is discharged at the outfall point on the north side of the Salt River near 35th Avenue. There are currently eight monitoring wells surrounding the sludge drying beds and a monitoring well near the outfall point. Groundwater from these wells is sampled and analyzed periodically. The well near the 35th Avenue outfall point is monitored as part of the Aquifer Protection Permit (APP) for the site.

The quality of the effluent from the WWTP 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 COP discharged effluent to a receiving channel in the Salt River with the intent to transport the flow to the restoration project.

When COP 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, COP's right to this effluent is protected pursuant to groundwater recharge legislation statutes.

3.5.5 Assessment of Source

Effluent from the WWTP could be a dependable or supplemental supply for portions of the Oeste Project. The water source is drought tolerant and can meet water quality standards for restoration. However, COP, who controls the right to the effluent flow, must make an institutional decision to commit water to the project. Currently, COP owes a substantial water debt to the Roosevelt Water Conservation District (RWCD). Once the reclaimed water line to the RWCD canal line is in place, COP intends to use the majority of the effluent from the WWTP to fulfill this debt. COP 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 COP uses to comply with Assured Water Supply requirements and to meet current and future demands.

Effluent could be used directly downstream of 35th Avenue where gravity flow and the reclaimed water distribution system, the 27th Avenue discharge structure and the 43rd Avenue discharge structure of Peterson Farm, can be used to deliver the effluent. 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 Oeste Project 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, stormwater 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 stormwater runoff; if this stormwater runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks.

3.6.2 Quantity Analyses

Under the current configuration (Table 3-7), the 23rd Avenue WWTP discharges approximately 11,026 acre-feet of irrigation water to the Peterson Farm annually. Though Peterson's use is only about 1 mgd, approximately 10 mgd must now be diverted via a canal to meet Peter's demand. The excess water now infiltrates along the canal or is discharged back to the Salt River between 43rd and 51st Avenue. Thus, if a pressurized pipeline can be constructed to deliver Peterson 1 mgd, the remaining water, adjusted for losses, can be made available to the Rio Salado Oeste Project.

The amount of additional irrigation return flows, irrigation tailwater, generating from irrigation water users is not currently monitored and is difficult to quantify. The irrigation return flows intercepted from irrigation tailwater are not a potential source of water for restoration project.

3.6.3 Quality Analyses

The quality of the irrigation return flows can meet the needs of the Oeste Project 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. There are no specific concentrated animal feeding operations in the area that could contribute contaminated runoff into the drainage canal system.

Table 3-7. Irrigation Return Flows from the Peterson Farm

	Discharge from 23rd WWTP to Peterson Farm Average Flows		Peterson's Use (Approximation) Average Flows		Excess Water Average Flows	
	MGD	AC-FT	MGD	AC-FT	MGD	AC-FT
January	10.48	997.23	1.00	95.14	9.48	902.10
February	10.08	866.29	1.00	85.93	9.08	780.36
March	9.76	928.90	1.00	95.14	8.76	833.77
April	9.72	894.93	1.00	92.07	8.72	802.87
May	9.65	917.97	1.00	95.14	8.65	822.83
June	9.97	917.77	1.00	92.07	8.97	825.70
July	9.86	938.38	1.00	95.14	8.86	843.24
August	9.72	924.91	1.00	95.14	8.72	829.78
September	9.82	903.90	1.00	92.07	8.82	811.84
October	9.23	878.52	1.00	95.14	8.23	783.39
November	9.74	896.33	1.00	92.07	8.74	804.27
December	10.08	958.91	1.00	95.14	9.08	863.78
Annual	9.84	11,025.84	1.00	1,120.15	8.84	9,905.70

Source: City of Phoenix

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 Oeste Project, 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. 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 Oeste Project.

3.7 Irrigation Drains

3.7.1 Description of Source

Irrigation drains are typically constructed along the irrigation canals and laterals in the area to provide a means to discharge excess water to reduce the possibility of a water-overtopping incident. During storm events, some canals and laterals intercept stormwater runoff; if this stormwater runoff is significant, water may need to be released from the canal to prevent overflowing the canal banks. Additionally, the major canals occasionally collect irrigation tail water. In the event more water is being conveyed than can be handled safely, the drains allow the excess water to be carried to the Salt River. Two significant canal drains were identified within the study area, namely the SRP 67th Avenue Drain, and Maricopa Drain. Each of these canal drains is operated by SRP.

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.

3.7.2 Quantity Analyses

Flow records for the SRP 67th Drain were evaluated for the period from January 1993 through December 2002. These records indicate that, for the SRP 67th Drain, the average monthly volume of flow for this period ranged from 26.1 acre-feet in November to 173.4 acre-feet in September with an average annual total of 1,043.7 acre-feet. Table 3-8 summarizes the average monthly and annual volumes of flow for these drains for the period of record evaluated.

Flow records for the Maricopa Drain were evaluated for the period from January 1994 through December 2002. These records indicated that, for the Maricopa Drain, the average monthly volume of flow for this period ranged from 213.2 acre-feet in November to 574.5 acre-feet in April with an average annual total of 4,276.2 acre-feet. Table 3-9 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 irrigation 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 Oeste Project, it could be utilized to support the wetland and riparian habitat.

3.7.5 Assessment of Source

Irrigation drains could provide a supplemental source of water for the restoration project. The amount of water released through these drains has historically been relatively consistent from month to month. Although these amounts are sufficient to support some riparian vegetation, the timing of these flows is irregular. These releases are not reliable as the drains have historically been dry for long periods; for example, there were no releases to the SRP 67th Avenue Drain throughout the period from November 1996 through February 1997. The Maricopa Drain flows were historically more frequent and reliable. Future releases to this drain are expected to be less frequent than the historic trend. Most of these releases are controlled by SRP and are not expected to be reliable. Irrigation drains are typically 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.

Table 3-8. SRP 67th Avenue Drain Monthly Volume
(Units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1993	0.2	27.8	445.1	504.9	66.0	105.2	140.9	151.7	4.4	17.2	0.0	45.2	1,508.6
1994	174.0	28.1	57.2	42.6	34.7	30.0	16.6	56.3	17.1	23.6	2.5	14.2	496.9
1995	1.6	56.5	137.5	100.6	56.8	109.4	23.1	24.8	21.5	6.6	7.8	7.1	553.3
1996	7.7	89.4	5.6	31.3	36.2	20.8	24.3	42.7	0.2	16.5	0.0	0.0	274.8
1997	0.0	0.0	41.1	31.8	9.5	0.0	0.0	24.4	24.6	25.3	0.0	306.9	463.6
1998	63.5	64.0	399.4	77.1	247.6	85.5	27.1	51.3	1,344.5	1,015.0	45.1	51.3	3,471.2
1999	10.7	12.3	136.7	92.0	56.4	201.7	82.2	156.1	64.0	76.9	6.0	0.5	895.4
2000	31.7	15.8	30.5	63.1	196.4	219.1	34.2	81.8	27.7	92.0	79.4	11.7	883.5
2001	40.5	2.9	189.6	85.8	120.3	91.5	110.7	87.4	137.0	67.9	1.8	15.6	951.0
2002	37.0	5.5	24.2	47.1	80.9	90.7	90.8	168.4	93.0	119.0	118.3	64.2	939.0
Average	36.7	30.2	146.7	107.6	90.5	95.4	55.0	84.5	173.4	146.0	26.1	51.7	1,043.7

Source: SRP

Table 3-9. Maricopa Drain Monthly Volume
(Units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1994	271.5	237.5	296.5	349.7	172.9	431.8	362.2	310.9	1.1	36.2	24.4	366.0	2,860.6
1995	133.7	347.9	338.7	696.7	159.7	357.7	282.7	420.4	78.1	124.2	142.8	173.0	3,255.5
1996	177.9	271.0	482.7	311.1	73.5	287.4	587.8	587.8	191.6	109.0	171.1	271.5	3,522.4
1997	61.0	75.4	315.0	262.7	148.5	189.0	151.6	148.2	170.3	282.0	266.7	366.0	2,436.3
1998	288.7	344.3	481.0	812.2	1,012.8	700.2	1,063.6	682.5	394.8	239.5	241.6	250.5	6,511.7
1999	261.3	376.4	619.8	787.0	692.5	692.4	181.2	439.0	482.1	380.3	210.5	376.4	5,498.9
2000	284.8	341.4	373.8	736.7	711.2	727.3	684.0	574.3	472.2	411.8	296.3	266.3	5,880.1
2001	276.5	236.4	333.9	670.5	597.8	481.7	704.2	205.7	205.7	231.6	363.1	175.6	4,482.8
2002	258.2	273.7	502.6	544.2	518.2	577.0	311.1	33.2	268.6	355.7	202.8	192.4	4,037.5
Average	223.7	278.2	416.0	574.5	454.1	493.8	480.9	378.0	251.6	241.1	213.2	270.8	4,276.2

Source: SRP

3.8 Sand and Gravel Mining Operations Releases

3.8.1 Description of Source

Since the construction of upstream dams began controlling the flows in the Salt River, sand and gravel mining operations moved into the river bed and surrounding flood plain to mine this natural resource. The materials extracted from the river have been used extensively throughout the development of the Phoenix Metropolitan area and have contributed to geomorphic changes to the floodplain and adjacent overbank.

Approximately 1,200 acres within the project area are sand and gravel mining operations. The river between 19th and 35th Avenues is lined with operations and nearly 100% modified. Again South of the river between 43rd Avenue and 51st Avenue are mining operations, which cross the river just downstream of 51st and extend on the North side to near 63rd Avenue. To our knowledge, none of these operations discharge water to the Salt River.

3.8.2 Quantity Analyses

Sand and gravel mining operations use pumped groundwater to sort and wash the aggregate materials. Water is used for processing aggregates and stored in holding ponds when not in use. To our knowledge, no water is being discharged into the Salt River; however, inspection of aerial photography indicated that ponded water exists in the Salt River channel. The origin of this water is unknown.

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.

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 flood flow. Currently, there are active sand and gravel mining operations in the Salt River.

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 Oeste Project, 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 Residual Water from Rio Salado project

3.9.1 Description of Source

The source was to maximize groundwater pumping from the Rio Salado project wells and deliver by either pipe or open channels to Oeste. Rio Saldo drilled five wells into the shallow aquifer and is currently evaluating wellhead treatment for at least two wells to remove volatile organic compounds (VOC).

3.9.2 Quantity Analyses

The Rio Salado wells can yield, if pumped 24 hours a day, 7 days a week, approximately 12.5 mgd. This could provide the Oeste Project with approximately 5.7 mgd to 8mgd if piped or 4.5 mgd to 6.5 mgd if conveyed in open channels (COP). The residual water from Rio Salado project is calculated with given information and assumptions as shown on Table 3-10. The result is shown that the residual water available approximately 3.5 mgd from Rio Salado project.

3.9.3 Quality Analyses

The upper aquifer lies close to the surface and is about 300-400 feet thick. This ground water is under utilized and according to the City's Water Services Department, is not suitable for urban water supplies. It contains varying concentrations of pollutants resulting from agricultural, urban, and adjacent landfill impacts making it available for environmental restoration purposes.

3.9.4 Water Rights

Residual water from the Rio Salado project wells discharge to the river become available for use by other water users. If this water is diverted and directed in the Oeste Project, it could be utilized to support the wetland and riparian habitat.

3.9.5 Assessment of Source

There are concerns however with using the Rio Salado residual water. The main River channel or a low flow channel (LFC) could be used for conveyance reducing construction cost, but a substantial pump would be required in the River to move the water into Oeste's distribution system. Plus, if the water were to be conveyed through open channels, it is

estimated that evaporation and percolation losses would be 20%-30% of the piped amount. These losses could be reduced if the water was piped, but could double the conveyance cost of getting water from Rio Salado to Oeste compared to using an open channel delivery system. Trenching though the overbanks in the Rio Salado involves a high degree of waste removal, over excavation for structural stability, and more expensive construction methods to reduce impacts to existing landfills such as, double containment pipes to capture water that could result from a line break.

Table 3-10. Residual Water Budget from Rio Salado Project for Oeste Project

Month	Days	Precipitation		Stormwater[2]	Groundwater	Water Demand (Average)[1]			Water Demand (Peak)[1]			Residual Water w/ Peak Demand[3]		
		inches	acre-feet per acre	acre-feet	acre-feet	acre-feet	cfs	mgd	acre-feet	cfs	mgd	acre-feet	cfs	mgd
January	31	0.67	0.056	445.12	553.58	269.23	4.38	2.83	432.81	7.04	4.55	343.33	5.58	3.61
February	28	0.68	0.057	451.77	500.01	243.18	4.38	2.83	390.93	7.04	4.55	334.97	6.03	3.90
March	31	0.88	0.073	584.64	553.58	269.23	4.38	2.83	432.81	7.04	4.55	413.09	6.72	4.34
April	30	0.22	0.018	146.16	535.73	260.55	4.38	2.83	418.85	7.04	4.55	189.96	3.19	2.06
May	31	0.12	0.010	79.72	553.58	269.23	4.38	2.83	432.81	7.04	4.55	160.63	2.61	1.69
June	30	0.13	0.011	86.37	535.73	260.55	4.38	2.83	418.85	7.04	4.55	160.06	2.69	1.74
July	31	0.83	0.069	551.42	553.58	269.23	4.38	2.83	432.81	7.04	4.55	396.48	6.45	4.17
August	31	0.96	0.080	637.79	553.58	269.23	4.38	2.83	432.81	7.04	4.55	439.67	7.15	4.62
September	30	0.86	0.072	571.35	535.73	260.55	4.38	2.83	418.85	7.04	4.55	402.55	6.77	4.37
October	31	0.65	0.054	431.83	553.58	269.23	4.38	2.83	432.81	7.04	4.55	336.69	5.48	3.54
November	30	0.66	0.055	438.48	535.73	260.55	4.38	2.83	418.85	7.04	4.55	336.12	5.65	3.65
December	31	1.00	0.083	664.36	553.58	269.23	4.38	2.83	432.81	7.04	4.55	452.95	7.37	4.76
Annual	365	7.66	0.638	5089.00	6518.00	3170.00	4.38	2.83	5096.00	7.04	4.55	3966.50	5.48	3.54
Peak	31		0.083	664.36	553.58	269.23	4.38	2.83	432.81	7.04	4.55	452.95	7.37	4.76

1-Draft Final Conceptual Design Documentation Report, Rio Salado Phoenix, Environmental Restoration Project, Phoenix, Arizona, July 2002, Tables 2-4 and 2-5.

2-Rio Salado Salt River, Arizona, Feasibility Report, Technical Appendice, Appenxix A Hydrology, April 1998, Tables 3-7A and 3-7B.

3-Residual Water w/ Peak Water Demand = 0.5 X Stormwater + Groundwater - Water Demand (Peak).

4 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 Oeste Project. 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 Maricopa County, COP, 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 Oeste Project. Table 4-1 presents a summary of the analyses.

The water supply and distribution system is critical to the success and sustainability of the Oeste Environmental Restoration Project. A sufficient quantity and adequate quality of water must be available to maintain the viability of the various habitat types that are being considered for Oeste. The primary water supply for the Oeste project is effluent obtained directly from the 23rd Avenue Water Reclamation Plant. Supplemental water could come from a variety of underground sources including: 1) effluent credits "recovered" (pumped) from within the area of hydrologic impact of the RID Groundwater Savings Facility; 2) incidental recharge credits associated with increased recharge from project implementation; 3) groundwater (based on the City's Assured Water Supply allowance); 4) recovered credits for Central Arizona Project water (stored by the City); 5) stormwater discharge; and 6) residual water from Rio Salado Project.

Treated effluent from the City's 23rd Avenue Water Reclamation Plant and one ground water well have been identified as the primary water sources for Oeste. The use of pumped water (rather than direct effluent) has several limitations. One of these relates to the City's ability to comply with state mandated water conservation requirements as discussed above. Secondary influxes of dry weather flows and storm water flows from the network of storm drains that empty into the River, residual Rio Salado flows, and discharges east of 35th Avenue on the north bank from the 23rd Avenue Water Reclamation Plant and at 43rd Avenue on the north bank are also included.

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	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	River channel between 19th avenue and 83rd avenue	Not measured	Continuous	Dependable	Local supply available at the river channel for majority of the study area.
Pumped Groundwater					
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 COP'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.
Stormwater Discharges					
SR01: 51st Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 274 ac-ft per yr	During or immediately 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.
SR02: 43rd Avenue and Salt River	Storm runoft from COP, outfalls along the north bank side	~ 274 ac-ft per yr	During or immediately 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.
SR03: 35th Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 224 ac-ft per yr	During or immediately 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.
SR04: 27th Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 341 ac-ft per yr	During or immediately 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.
SR05: 25th Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 125 ac-ft per yr	During or immediately 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.
SR06: 22nd Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 561 ac-ft per yr	During or immediately 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.
SR07: 19th Avenue and Salt River	Storm runoff from COP, outfalls along tha north bank side	~ 79 ac-ft per yr	During or immediately 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.
SR30: 27th Avenue and Salt River	Storm runoff from COP, outfalls along the south bank side	~ 196 ac-ft per yr	During or immediately 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.
SR31: 19th Avenue and Salt River	Storm runoff from COP, outfalls along the south bank side	~ 231 ac-ft per yr	During or immediately 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.
SR47: 51st Avenue and Salt River - 50 feet north of SR01	Storm runoff from COP, outfalls along the north bank side	Minimal	During or immediately after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; drainage area is not available.

TABLE 4-1 (CONTINUED)

WATER BUDGET MATRIX

Water Source	Description/Location	Quantity Available	Availability	Supply Designation	Discussion/Issues
Stormwater Discharges (continued)					
SR48: 45th Avenue and Salt River	Storm runoff from COP, outfalls along the south bank side	Minimal	During or immediately after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; drainage area is not available.
SR48a: 43rd Avenue and Salt River	Storm runoff from COP, outfalls along the south bank side	~ 1,640 ac-ft per yr	During or immediately 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.
SR49: 67th Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	~ 558 ac-ft per yr	During or immediately 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.
SR58: 35th Avenue and Salt River	Storm runoff from COP, outfalls along the north bank side	Minimal	During or immediately after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; drainage area is not available.
SR59: 2333 W. Drango (23rd Ave. WWTP east side of 35th Ave. and Salt River)	Storm runoff from COP, outfall along the north bank side	Minimal	During or immediately after rainfall events	Problem	Runoff is of insufficient quantity with no dedicated collection system; drainage area is not available.
Effluent					
Direct Use	Effluent from the 23rd Avenue WWTP discharged directly into the 35th Avenue.	averages 15.41MGD (~17,256 ac-ft per yr)	Continuous	Dependable or Supplemental	The quantity and availability of effluent water is subject to an institutional commitment by COP; COP has existing commitments for this effluent.
Indirect Use	Effluent from the 23rd Avenue WWTP recharged into the groundwater	Pending	Continuous	Dependable or Supplemental	COP 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 agricultural area of the Community	Minimal	Irrigation season	Supplemental	Supply only available during irrigation season; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Surplus Irrigation Water	Excess water in Peterson Farm	averages 8.84MGD(~9,905 ac-ft per yr)	Continuous	Supplemental	Supply available during all season based on discharge record; unreliable because irrigation practices are designed to reduce the tailwater quantity.
Irrigation Drains					
SRP 67th Avenue Drain	Allows excess flow in SRP's Lateral 2-19.0 to drain to the Salt River: the north bank of the Salt River on the east side of 67th avenue	averages 1,044 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases occur irregularly and are not reliable.
SRP Maricopa Drain	Allows excess flows from the ditch known as the Maricopa Drain to flow to the Salt River: the south bank of the Salt River near 77th Avenue	averages 4,276 ac-ft per yr	In-frequent	Supplemental	Flow is due to controlled releases by SRP; releases occur irregularly and are not reliable.
Sand & Gravel Mining Releases					
	Within the Salt River; all reaches	None	Not available	Unacceptable	No known discharges from these operations.
Residual Water Flows from Upstream (Rio Salado Project)					
Ridual Water Flows	Excess water in Rio Salado Project. Resiual Water w/ Peak Water Demand=0.5XStormwater+Groundweter-Water Demand(Peak)	averages ~3,966 ac-ft per yr	Continuous	Supplemental	Supply available during all season based on the water budget of Rio Salado project; unreliable because Rio Salado practices are not fixed.

5 Water Budget for Project Alternatives

Prior to developing restoration alternatives constraints were identified that would affect the plan formulation process. Those constraints were:

- Availability of Water
- Maintenance of Floodway Capacity
- Proximity of Recreation to Restoration
- Endangered Species
- Local Acceptability
- Displacement of People
- Rapid Growth
- Real Estate
- County and City Lands

Water to support restoration was identified as one of the most limiting constraints because of its scarcity and cost. The next greatest limiting factor was land that could be dedicated to restoration. In fact, the last four of the constraints identified deal with land use or land cost issues. Although water and land to support restoration were identified as principal limiting constraints, this analysis determined to evaluate what could be accomplished if significant areas of land and substantial volumes of water were available. This approach allows decision makers to weigh the relative cost of the biologic outputs resulting from commitment of substantial volumes of water when evaluating plans for implementation. Alternatives were developed to focus on varying levels of water supply and varying amounts of available land in order to ensure consideration of the effects of these two resources on plan costs and outputs.

These alternatives include the modification of existing storm-water outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls and modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th avenue to 83rd avenue. Those alternatives also include the features described above and add a supplemental water supply in the form of effluent. At locations identified as suitable throughout the project area cottonwood/willow and mesquite cover types will be restored. These alternatives would also address the management, control and removal of invasive species within the study area. Some of alternatives add restoration of emergent wetlands at the existing gravel pits at 29th and 37th Avenues. The results screened are presented in **Table 5-1**.

Table 5-1. Ecosystem Restoration Alternative Plans

Alternative	Acres	Water Demand (A/F)	Water Demand (mgd)
1. No Action			
2. Storm water and Channel: This alternative includes the modification of existing storm-water outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th avenue to 83rd avenue. No additional water source is included in this alternative.	C/W: 66 M: 43 W: 28 + 17 Low flow channel	**1,583**	**1.41**
3. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive: This alternative includes the features described in alternative 2 and adds a supplemental water supply in the form of effluent. At locations identified as suitable throughout the project area cottonwood/willow and mesquite cover types will be restored. This alternative would also address the management, control and removal of invasive species within the study area.	C/W: 348 M: 409 W: 28 + 34 Low flow channel	**4,524**	**4.04**
4. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent: This alternative adds restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue.	C/W: 348 M: 409 W: 33 + 34 Low flow channel	**4,701**	**4.20**
5. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake: Added to this alternative is lake restoration at the existing gravel pits at 29th and 37th Avenues.	C/W: 375 M: 417 W: 76 + 34 Low flow channel O/W: 40	**7,752**	**6.92**
5A. Wetland restoration in lieu of permanent open water and lakes: In lieu of lake restoration this includes regarding of the existing gravel pits to restore them to the floodplain and restoration of emergent wetland and riparian areas.	C/W: 375 M: 417 W: 156 + 34 Low flow channel	**9,293**	**8.30**
5B. This alternative is a hybrid of 5 and 5A: including restoration of one gravel pit to a wetland/riparian complex and the other to include the lake.	C/W: 375 M: 417 W: 136 + 34 Low flow channel O/W: 20	**9,234**	**8.24**

Table 5-2. Water Budget Analysis for Alternative Plans

Functional Assessment Tool Name	PRECIP	OPEN WATER			COVER TYPES						SUB-TOTAL			TOTAL	
	Ann. Avg. Precip.[1] (in/yr)	AREA (acres)	Evapo-ration Loss (ft/yr)	Infiltration Loss (ft/yr)[2]	Mesq. (acres)	Mesq. Water Demand (ft/yr)	CWW (acres)	CWW Water Demand (ft/yr)	Emergent Marsh & Low Flow Channel (acres)	Emergent Marsh Water Demand[3] (ft/yr)	Area (acres)	Water Demand (acre-feet/yr)	Water Demand (mgd)	Water Demand (acre-feet/yr)	Water Demand (mgd)
Alt. 2	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41	1583.15	1.41
Alt. 3	7.66		6.03	27.2	366	3.00	282	8.00		36.20	648	2940.36	2.62	4523.51	4.04
Alt. 3-SW	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41		
Alt. 4	7.66		6.03	27.2	366	3.00	282	8.00	5	36.20	653	3118.17	2.78	4701.32	4.20
Alt. 4-SW	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41		
Alt. 5	7.66	40.00	6.03	27.2	374	3.00	309	8.00	48	36.20	771	6168.65	5.51	7751.79	6.92
Alt. 5-SW	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41		
Alt. 5A	7.66		6.03	27.2	374	3.00	309	8.00	128	36.20	811	7709.91	6.88	9293.06	8.30
Alt. 5A-SW	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41		
Alt. 5B	7.66	20.00	6.03	27.2	374	3.00	309	8.00	108	36.20	811	7650.51	6.83	9233.66	8.24
Alt. 5B-SW	7.66		6.03	27.2	43	3.00	66	8.00	28	36.20	137	1583.15	1.41		

[1]-Source: National Climatic Center, 1995. Phoenix Annual Summary of the Local Climatological Data

[2]-Assume "27.2" with the clay liner for the wetland and lake (Rio Salado, Salt River, Arizona, Hydrology Appendix).

[3]-Assume "36.2" with the clay liner for the wetland and lake (Infiltration Rate (27.2) + Water Demand for Emergent Marsh (9) = 36.2).

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US Army Corps
of Engineers
Los Angeles District

RIO SALADO OESTE

Salt River-Phoenix, Arizona

Interior Drainage Report
(Future Conditions)

June 2004

LOS ANGELES DISTRICT, CORPS OF ENGINEERS
HYDROLOGY AND HYDRAULICS SECTION

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1.0 Introduction and Summary

Interior drains, or side drains, that outfall into Salt River between 19th Avenue on the east and 83rd Avenue on the west may have implications on the Rio Salado Oeste Project (Oeste Project).

Two types of interior drains were identified that outfall into the Salt River within the project study limits – irrigation drains and storm drains. Figure 1-1 presents locations of irrigation drains and storm drains. Irrigation drains are designed to release water from the irrigation facilities and discharge it into the Salt River. These drains are an operational mechanism to restrict flow in the irrigation system. Storm drains are designed to collect runoff generated by rainfall events. These are typically installed in urbanizing areas to protect developments from a design storm of a certain return period.

These 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.

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. To that regard, 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.

Salt River Project (SRP) has maintained the discharge gaging stations of two irrigation drain outfalls within this study area. The irrigation drains, which flow in response to controlled releases, have received occasional flows throughout the record period from 1993 through 2002. The average annual volumes of water released to the Salt River during this period were 1,044 acre-feet (the record period from 1993 through 2002), and 4,276 acre-feet (the record period from 1994 through 2002) for the SRP 67th Avenue Drain, and Maricopa Drain, respectively. Although these amounts are sufficient to support some riparian vegetation, the timing of these flows is irregular. These releases are not reliable as the drains have historically been dry for long periods.

To evaluate the possibility of using storm water as a water sources, the approach used in the Rio Salado study (U.S. Army Corps of Engineers (USACE), 1998) was used to estimate the average annual volume of runoff because there are no gaging stations for the storm drains in this study area. The storm drains flow in response to rainfall events, so the

discharge from these drains is typically infrequent and highly variable. The storm drains provide an average annual volume of water to the Salt River ranging from 79 to 561 acre-feet.

Table 1-1 presents the average monthly and annual volumes of water released through the interior drains. The table shows the interior drains can supply 8,183 acre-feet of water annually to the project area. Although this is a reasonable amount of water supply to the project, it was calculated through regressive analysis and long-term arithmetic average values. As mentioned earlier, the water supply from interior drains is ephemeral. It is not a reliable source of water supply for the habitat restoration project. However, it can be treated as a secondary water supply through a storm and irrigation water collection system.

Localized water quality problems could occur if surface runoff drainage enters the irrigation drains and transports contaminants from surrounding areas into the irrigation drain canals. The water discharged from irrigation drains is generally high quality and suitable for the habitat restoration project.

Stormwater runoff often contains a significant amount of sediment that is washed from undeveloped and developed 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 National Pollutant Discharge Elimination System (NPDES) permits require each industrial site to have a stormwater pollution prevention plan (SWPPP). The quality of the "first flush" water is generally poor. As the runoff continues, the water quality improves.

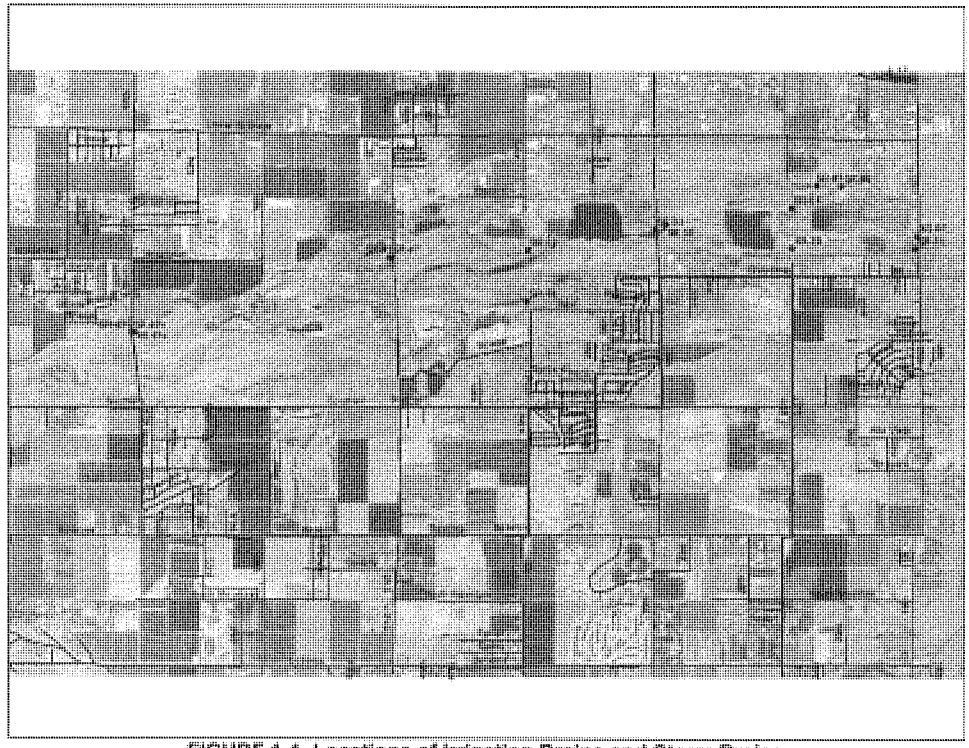

FIGURE 1-1. Locations of Irrigation Drains and Storm Drains

TABLE 1-1. Interior Drains Average Monthly Volume

OUTFALL No.	SITE LOCATION	JAN (AF)	FEB (AF)	MAR (AF)	APR (AF)	MAY (AF)	JUN (AF)	JUL (AF)	AUG (AF)	SEP (AF)	OCT (AF)	NOV (AF)	DEC (AF)	ANNUAL (AF)
	SRP Irrigation Drains													
67th Ave. Drain[1]	67th Ave. and Salt River- North Side	36.7	30.2	146.7	107.6	90.5	95.4	55.0	84.5	173.4	146.0	26.1	51.7	1,044
Maricopa Drain[2]	Near 77th Ave.and Salt River - South Side	223.7	278.2	416.0	574.5	454.1	493.8	480.9	378.0	251.6	241.1	213.2	270.8	4,276
	Storm Drains													
SR01[3,4]	51st Avenue and Salt River - North Side	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR02[3,4]	43rd Avenue and Salt River - North Side	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR03[3,4]	35th Avenue and Salt River- North Side	19.5	20.2	25.7	6.5	3.6	3.8	24.2	28.0	25.1	19.0	19.3	29.1	224
SR04[3,4]	27th Avenue and Salt River- North Side	29.6	30.7	39.2	9.9	5.4	5.8	36.8	42.6	38.1	29.0	29.3	44.3	341
SR05[3,4]	25th Avenue and Salt River- North Side	10.9	11.3	14.4	3.6	2.0	2.1	13.5	15.6	14.0	10.6	10.8	16.3	125
SR06[3,4]	22nd Avenue and Salt River- North Side	48.8	50.5	64.5	16.3	9.0	9.5	60.6	70.1	62.8	47.7	48.2	72.9	561
SR07[3,4]	19th Avenue and Salt River- North Side	6.9	7.1	9.1	2.3	1.3	1.3	8.5	9.9	8.8	6.7	6.8	10.3	79
SR30[3,4]	27th Avenue and Salt River- South Side	17.1	17.7	22.6	5.7	3.1	3.3	21.2	24.5	22.0	16.7	16.9	25.5	196
SR31[3,4]	19th Ave, South Bank	20.1	20.8	26.6	6.7	3.7	3.9	25.0	28.9	25.9	19.6	19.9	30.0	231
SR48a[3,4]	43rd Avenue and Salt River - South Side	142.7	147.6	188.6	47.6	26.2	27.9	177.1	205.0	183.7	139.4	141.0	213.2	1640
SR49[3,4]	67th Avenue and Salt River- North Side	48.5	50.2	64.1	16.2	8.9	9.5	60.2	69.7	62.5	47.4	48.0	72.5	558
	Total													9,823

1. 10-yr statistical average (1993-2002).
2. 9-yr statistical average (1004-2001).
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.

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2.0 Irrigation Drains

Irrigation drains are often constructed along the irrigation canals and laterals in the area to provide a means to discharge excess water from the canal to reduce the possibility of a water-overtopping incident. The drains may be used for a variety of reasons. During storm events, some canals and laterals 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 collect irrigation tail water. In the event more water is being conveyed than can be handled safely, the drains allow the excess water to be carried to the Salt River. 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.

SRP has maintained the discharge data of two outfalls within this study area. The records indicate how many acre-feet per month were discharged at each location. The records do not, however, provide an indication of the instantaneous peak flow rate. SRP 67th Avenue Drain collects and discharges excess water including ordered but unused irrigation water, agricultural return flows, and some street runoff from as far north as Thunderbird Road. The Maricopa Drain collects and discharges excess water including ordered but unused irrigation water, agricultural return flows, and some street runoff from an area as far south as Olney Avenue and as far east as perhaps 16th Street. The average daily flow rates are indicative of the peak flow rates that occur in these canals.

2.1 SRP 67th Avenue Drain

This drain located on the north bank of the Salt River on the east side of 67th Avenue allows excess flows in SRP's Lateral 2-19.0 to drain to the River. Its origin is SRP's Grand Canal near 67th Avenue, just north of Indian School Road. However, it collects and discharges excess water including ordered but unused irrigation water, agricultural return flows, and some street runoff from as far north as Thunderbird Road. The design for the outlet works is detailed on SRP drawing number B-112-405.1. At the point of discharge to the Salt River, it is an open concrete ditch 9.0 feet wide and 3.5 feet deep designed to convey 37.5 cfs.

Flow records for the SRP 67th Avenue Drain were evaluated for the record period from January 1993 through December 2002. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 0.87 acre-feet in November to 5.77 acre-feet in September with an average of 2.86 acre-feet. The maximum daily flow rate that occurred during this period was 311.51 acre-feet during October 1998. Table 2-1a and Table 2-1b summarize the average daily and maximum daily flow rates for each month of the period of record evaluated. Although these amounts are sufficient to support some riparian vegetation, these releases are irregular and not reliable since the drains have historically been dry for approximately four months as showed in **Appendix A**. The

average monthly volume of flow for this period ranged from 26.1 acre-feet in November to 173.4 acre-feet in September with an average annual total of 1,043.7 acre-feet. Table 2-2 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

TABLE 2-1a. SRP – 67th Avenue Drain Average Daily Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1993	0.01	0.99	14.36	16.83	2.13	3.51	4.54	4.89	0.15	0.56	0.00	1.46	4.13
1994	5.61	1.00	1.84	1.42	1.12	1.00	0.54	1.82	0.57	0.76	0.08	0.46	1.36
1995	0.05	2.02	4.44	3.35	1.83	3.65	0.74	0.80	0.72	0.21	0.26	0.23	1.52
1996	0.25	3.08	0.18	1.04	1.17	0.69	0.78	1.38	0.01	0.53	0.00	0.00	0.74
1997	0.00	0.00	1.33	1.06	0.31	0.00	0.00	0.79	0.82	0.82	0.00	9.90	1.27
1998	2.05	2.28	12.88	2.57	7.99	2.85	0.88	1.65	44.82	32.74	1.50	1.66	9.51
1999	0.35	0.44	4.41	3.07	1.82	6.72	2.65	5.04	2.07	2.48	0.20	0.01	2.45
2000	1.02	0.54	0.98	2.10	6.34	7.30	1.10	2.64	0.92	2.97	2.65	0.38	2.42
2001	1.31	0.10	6.12	2.86	3.88	3.05	3.57	2.82	4.57	2.19	0.06	0.50	2.61
2002	1.19	0.20	0.78	1.57	2.61	3.02	2.93	5.43	3.10	3.84	3.94	2.07	2.57
Average	1.18	1.07	4.73	3.59	2.92	3.18	1.77	2.73	5.77	4.71	0.87	1.67	2.86

Source: SRP

TABLE 2-1b. SRP – 67th Avenue Drain Maximum Daily Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1993	0.20	6.33	46.73	48.85	9.14	7.91	14.08	25.75	1.15	5.24	0.00	8.65	48.85
1994	9.14	9.56	12.16	11.17	6.51	5.95	3.69	9.58	3.53	3.23	1.11	3.37	12.16
1995	0.65	16.62	13.92	10.95	6.59	27.79	5.81	5.45	2.78	3.13	3.21	3.53	27.79
1996	2.98	10.95	2.46	4.78	4.22	3.67	6.47	7.12	0.12	5.18	0.00	0.00	10.95
1997	0.00	0.00	5.47	8.57	2.34	0.00	0.00	4.40	8.07	6.94	0.00	30.70	30.70
1998	9.64	11.94	31.34	11.17	32.55	19.00	11.88	17.45	305.94	311.51	19.80	18.70	311.51
1999	3.81	4.09	22.49	14.94	8.35	23.35	11.46	18.45	18.51	10.37	3.47	0.26	23.35
2000	9.32	9.88	10.18	11.03	14.66	14.96	6.98	9.32	5.87	12.89	9.34	2.78	14.96
2001	10.23	2.08	123.45	8.39	11.58	11.11	9.28	10.79	10.87	7.72	0.65	4.72	123.45
2002	2.34	0.69	5.79	7.14	13.59	12.38	16.62	9.26	10.45	18.82	18.88	2.24	18.88
Maximum	10.23	16.62	123.45	48.85	32.55	27.79	16.62	25.75	305.94	311.51	19.80	30.70	311.51

Source: SRP

TABLE 2-2. SRP – 67th Avenue Drain Monthly Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1993	0.2	27.8	445.1	504.9	66.0	105.2	140.9	151.7	4.4	17.2	0.0	45.2	1,508.6
1994	174.0	28.1	57.2	42.6	34.7	30.0	16.6	56.3	17.1	23.6	2.5	14.2	496.9
1995	1.6	56.5	137.5	100.6	56.8	109.4	23.1	24.8	21.5	6.6	7.8	7.1	553.3
1996	7.7	89.4	5.6	31.3	36.2	20.8	24.3	42.7	0.2	16.5	0.0	0.0	274.8
1997	0.0	0.0	41.1	31.8	9.5	0.0	0.0	24.4	24.6	25.3	0.0	306.9	463.6
1998	63.5	64.0	399.4	77.1	247.6	85.5	27.1	51.3	1,344.5	1,015.0	45.1	51.3	3,471.2
1999	10.7	12.3	136.7	92.0	56.4	201.7	82.2	156.1	64.0	76.9	6.0	0.5	895.4
2000	31.7	15.8	30.5	63.1	196.4	219.1	34.2	81.8	27.7	92.0	79.4	11.7	883.5
2001	40.5	2.9	189.6	85.8	120.3	91.5	110.7	87.4	137.0	67.9	1.8	15.6	951.0
2002	37.0	5.5	24.2	47.1	80.9	90.7	90.8	168.4	93.0	119.0	118.3	64.2	939.0
Average	36.7	30.2	146.7	107.6	90.5	95.4	55.0	84.5	173.4	146.0	26.1	51.7	1,043.7

Source: SRP

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2.2 SRP Maricopa Drain

This drain, located on the south bank of the Salt River near 77th Avenue allows excess flows from the ditch known as the Maricopa Drain to flow to the River. Its origin is near 23rd Avenue and Roeser Road. However, it collects and discharges excess water including ordered but unused irrigation water, agricultural return flows, and some street runoff from an area as far south as Olney Avenue and as far east as perhaps 16th Street. It also includes excess flows from the Peninsula and Horowitz (P&H) Irrigation service area roughly north of Baseline Road and west of 43rd Avenue. It was historically known as many names including the "Drainage Ditch of the Maricopa County Drainage District No. 5", circa 1930. In addition to carrying excess flows to the Salt River, SRP also uses the facility to transport up to 10 cfs of contracted irrigation water to the Gila River Indian Community, which is diverted from the ditch near 75th Avenue and Baseline. The Flood Control District of Maricopa County plans to convert the western half of the Maricopa Drain to the Laveen Area Conveyance Channel (LACC) sometime in the near future. The capacity of the existing Maricopa Drain northeast of 75th Avenue is approximately 75 cfs and when it's converted to the LACC the updated capacity will be about 2880 cfs. The LACC will carry the normal flows of the existing Maricopa Drain within the LACC's low flow channel.

Flow records for the Maricopa Drain were evaluated for the period from January 1994 through December 2002. These records indicate that the average daily flow rates, on a monthly basis, for this period ranged from 7.11 acre-feet in November to 19.15 acre-feet in April with an average of 11.62 acre-feet. The maximum daily flow rate that occurred during this period was 78.80 acre-feet during May 1995. Table 2-3a and Table 2-3b summarize the average daily and maximum daily flow rates for each month of the period of record evaluated. Although these amounts are sufficient to support some riparian vegetation, these releases are irregular and not reliable since the drains have historically been dry for approximately a month as showed in **Appendix B**.

The average monthly volume of flow for this period ranged from 213.2 acre-feet in November to 574.5 acre-feet in April with an average annual total of 4,276.2 acre-feet. Table 2-4 summarizes the average monthly and annual volumes of flow for the period of record evaluated.

TABLE 2-3a. Maricopa Drain Average Daily Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1994	8.76	8.48	9.56	11.66	5.58	14.39	11.68	10.03	0.04	1.17	0.81	3.08	7.10
1995	4.31	12.42	10.93	23.22	5.15	11.92	9.12	13.56	2.60	4.01	4.76	5.58	8.92
1996	5.74	9.35	15.57	10.37	2.37	9.58	18.96	18.96	6.39	3.52	5.70	8.76	9.62
1997	1.97	2.69	10.16	8.76	4.79	6.30	4.89	4.78	5.68	9.10	8.89	11.80	6.67
1998	9.31	12.30	15.52	27.07	32.67	23.34	34.31	22.02	13.16	7.73	8.05	8.08	17.84
1999	8.43	13.44	19.99	26.23	22.34	23.08	5.84	14.16	15.55	12.27	7.02	12.14	15.02
2000	9.19	11.77	12.06	24.56	22.94	24.24	22.06	18.53	15.74	13.28	9.88	8.59	16.08
2001	8.92	8.44	10.77	22.35	19.28	16.06	22.72	6.64	6.86	7.47	12.10	5.67	12.28
2002	8.33	9.77	16.21	18.14	16.72	19.23	10.04	1.07	8.95	11.47	6.76	6.21	11.06
Average	7.22	9.85	13.42	19.15	14.65	16.46	15.51	12.19	8.33	7.78	7.11	7.77	11.62

Source: SRP

TABLE 2-3b. Maricopa Drain Maximum Daily Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1994	15.81	19.22	33.68	22.08	18.82	24.54	31.34	18.55	1.09	5.59	6.51	9.94	33.68
1995	12.97	19.36	28.90	32.01	78.80	25.73	26.44	78.76	15.59	11.90	31.54	11.94	78.80
1996	22.71	18.29	26.50	24.42	12.89	23.29	31.87	31.87	16.32	17.79	12.00	15.99	31.87
1997	13.23	13.07	23.72	26.26	27.17	20.73	16.64	27.21	12.48	14.06	12.85	22.67	27.21
1998	17.47	26.48	41.89	36.18	57.28	49.75	60.79	38.08	25.83	20.75	17.14	15.03	60.79
1999	14.00	20.89	35.90	52.78	28.44	34.49	27.77	18.98	18.51	27.09	13.73	24.22	52.78
2000	16.68	20.37	33.72	32.41	30.76	34.26	30.59	28.88	24.12	32.05	20.11	24.62	34.26
2001	20.39	17.12	20.01	39.81	29.00	57.36	39.04	19.08	19.08	22.47	21.22	19.80	57.36
2002	12.95	16.72	26.96	27.93	27.07	37.27	20.03	2.18	16.26	37.29	13.69	20.43	37.29
Maximum	22.71	26.48	41.89	52.78	78.80	57.36	60.79	78.76	25.83	37.29	31.54	24.62	78.80

Source: SRP

TABLE 2-4. Maricopa Drain Monthly Volume

(units are in acre-feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
1994	271.5	237.5	296.5	349.7	172.9	431.8	362.2	310.9	1.1	36.2	24.4	366.0	2,860.6
1995	133.7	347.9	338.7	696.7	159.7	357.7	282.7	420.4	78.1	124.2	142.8	173.0	3,255.5
1996	177.9	271.0	482.7	311.1	73.5	287.4	587.8	587.8	191.6	109.0	171.1	271.5	3,522.4
1997	61.0	75.4	315.0	262.7	148.5	189.0	151.6	148.2	170.3	282.0	266.7	366.0	2,436.3
1998	288.7	344.3	481.0	812.2	1,012.8	700.2	1,063.6	682.5	394.8	239.5	241.6	250.5	6,511.7
1999	261.3	376.4	619.8	787.0	692.5	692.4	181.2	439.0	482.1	380.3	210.5	376.4	5,498.9
2000	284.8	341.4	373.8	736.7	711.2	727.3	684.0	574.3	472.2	411.8	296.3	266.3	5,880.1
2001	276.5	236.4	333.9	670.5	597.8	481.7	704.2	205.7	205.7	231.6	363.1	175.6	4,482.8
2002	258.2	273.7	502.6	544.2	518.2	577.0	311.1	33.2	268.6	355.7	202.8	192.4	4,037.5
Average	223.7	278.2	416.0	574.5	454.1	493.8	480.9	378.0	251.6	241.1	213.2	270.8	4,276.2

Source: SRP

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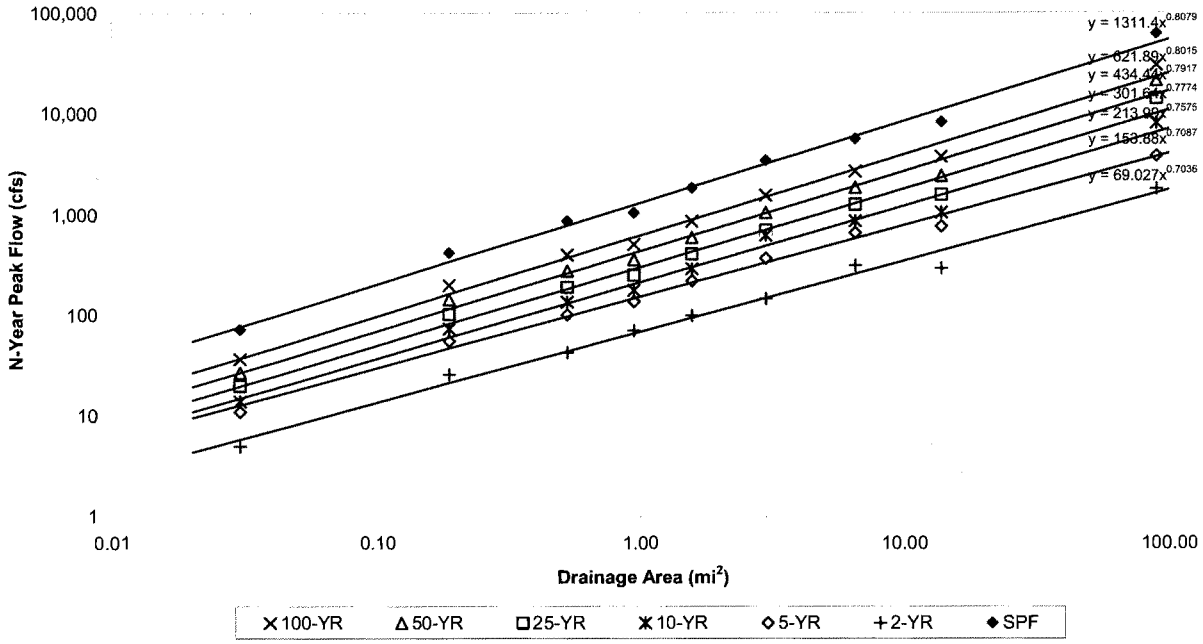
3.0 Storm Drains

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 developed for the Rio Salado project (USACE, 1998). The Rio Salado project is a similar habitat restoration project within the Salt River. The drainage areas within the Rio Salado study area are similar to those within the Oeste 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. In the Va Shly'ay Akimel Project, a set of N-year peak discharge/drainage area curves was generated by the linear regression analysis to estimate peak flows with only 8-sample drain data without Indian Band Wash (IBW) values. That is a main reason that peak flow rates of Va Shly'ay Akimel project are smaller than peak flow rates of Rio Salado Project. Originally Rio Salado project also included IBW values to aid in providing a consistent set of relationships and to enhance the range established. To keep the consistency for all outfalls to the Salt River, the 8-sample drain sample data and IBW values were then used to generate a series of linear regression curves representing the relationship between peak flow rate and drainage area for this Oeste project. Curves were devcloped 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. 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, some of longitudinal pipe slopes were surveyed or found in As-Built drawing by the City of Phoenix (COP) but if the existing slope is unable to figure, a longitudinal slope of 0.0015 was assumed as average value of known value.

To evaluate the possibility of using storm water as a water source, the approach used in the Rio Salado study (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 drainage area. These curves are shown in 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 Table 3-1.



SPF: Standard Project Flood
Data Source: USACE Rio Salado Project

FIGURE 3-1. Peak Flow Relationships for Various Return Periods

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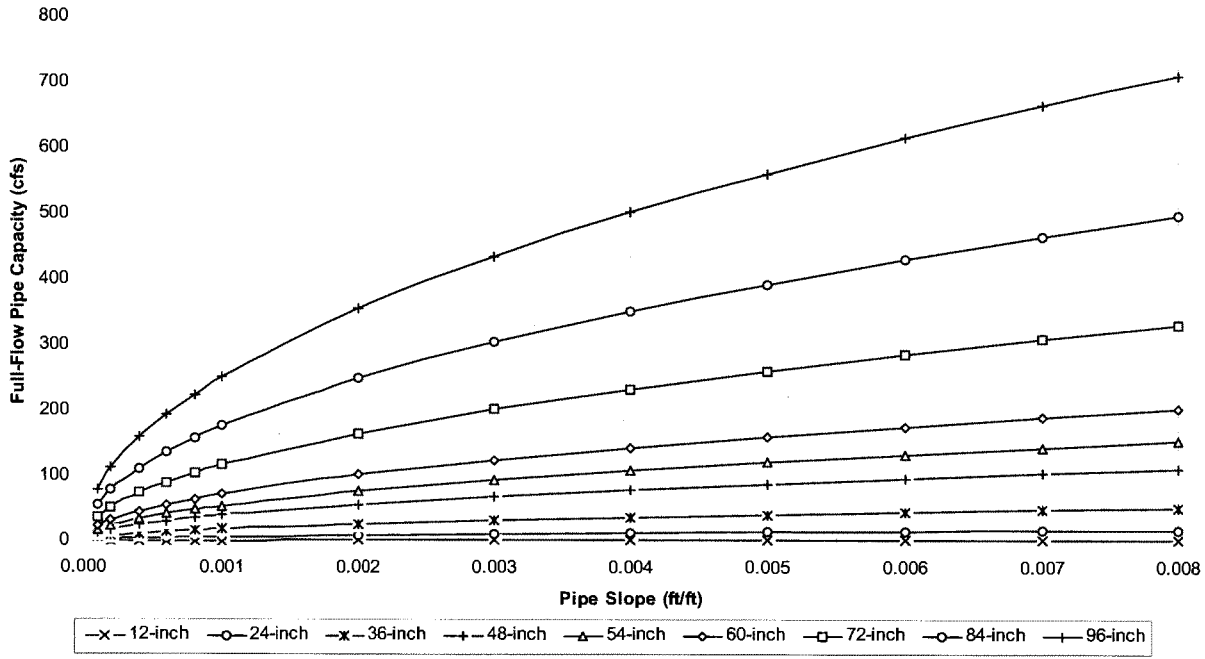
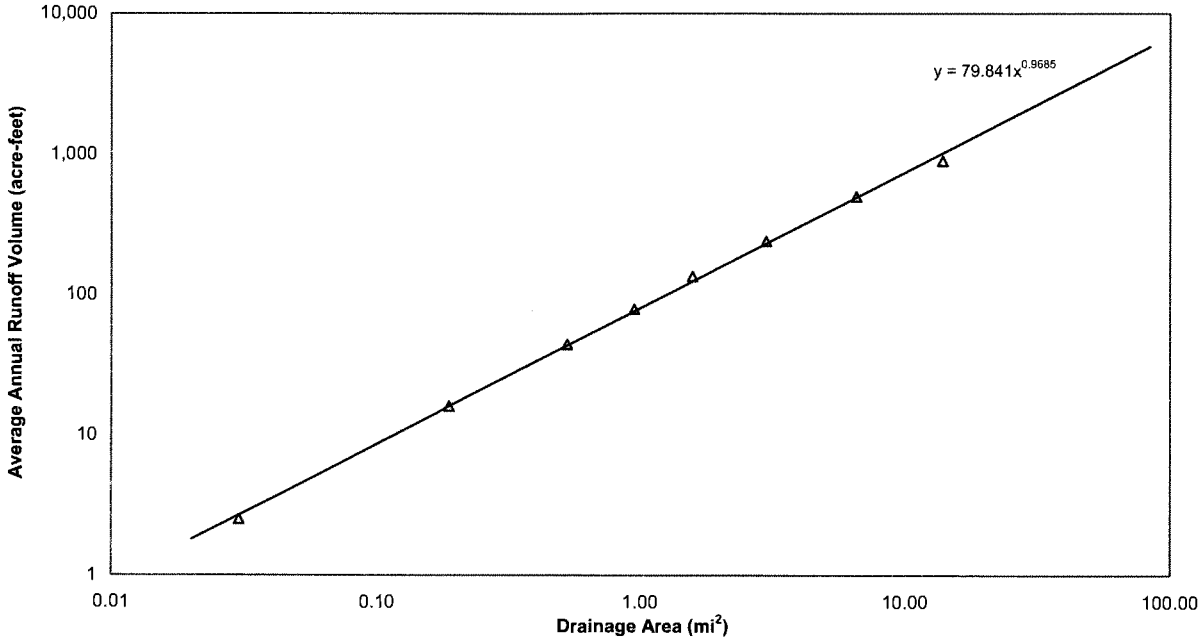


FIGURE 3-2. Typical Full-Flow Storm Drain Pipe Capacity



Source: USACE Rio Salado Project

FIGURE 3-3. Average Annual Storm Drain Runoff for the Phoenix Metro Area

TABLE 3-1. 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

Source: Schmidli, 1996

3.1 SR01: 51st Avenue and Salt River – North Side

The SR01 Storm Drain is located at 51st Avenue of north side bank. A 96-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 3.6 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 1,728 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 96-inch pipe is approximately 177 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 177 cfs would produce a maximum velocity of approximately 3.5 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 274 acre-feet.

3.2 SR02: 43rd Avenue and Salt River – North Side

The SR02 Storm Drain is located at 43rd Avenue of north side bank. A 90-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 3.6 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 1,728 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 90-inch pipe is approximately 221 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 221 cfs would produce a maximum velocity of approximately 5.0 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 274 acre-feet.

3.3 SR03: 35th Avenue and Salt River – North Side

The SR03 Storm Drain is located at 35th Avenue of north side bank. A 75-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 2.9 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 1,460 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 75-inch pipe is approximately 123 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 123 cfs would produce a maximum velocity of approximately 4.0 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 224 acre-feet.

3.4 SR04: 27th Avenue and Salt River – North Side

The SR04 Storm Drain is located at 27th Avenue of north side bank. A 72-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 4.5 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 2,066 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 235 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 235 cfs would produce a maximum velocity of approximately 8.3 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 341 acre-feet.

3.5 SR05: 25th Avenue and Salt River – North Side

The SR05 Storm Drain is located at 25th Avenue of north side bank. A 102-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 1.6 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 901 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 102-inch pipe is approximately 342 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 342 cfs would produce a maximum velocity of approximately 6.0 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 125 acre-feet.

3.6 SR06: 22nd Avenue and Salt River – North Side

The SR06 Storm Drain is located at 22nd Avenue of north side bank. A 78-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 7.5 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 3,121 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 78-inch pipe is approximately 112 cfs. Thus, the peak flow that can

realistically discharge from this drain is governed by the pipe size. A peak flow rate of 112 cfs would produce a maximum velocity of approximately 3.4 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 561 acre-feet.

3.7 SR07: 19th Avenue and Salt River – North Side

The SR07 Storm Drain is located at 19th Avenue of north side bank. A 54-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 1.0 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 622 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 54-inch pipe is approximately 66 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 66 cfs would produce a maximum velocity of approximately 4.1 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 79 acre-feet.

3.8 SR30: 27th Avenue and Salt River – South Side

The SR30 Storm Drain is located at 27th Avenue of south side bank. A 108-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 2.5 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 1,309 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 108-inch pipe is approximately 447 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 447 cfs would produce a maximum velocity of approximately 7.0 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 196 acre-feet.

3.9 SR31: 19th Avenue and Salt River – South Side

The SR31 Storm Drain is located at 19th Avenue of south side bank. A 60-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 3.0 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 1,499 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 60-inch pipe is approximately 88 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 88 cfs would produce a maximum velocity of approximately 4.5 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 231 acre-feet.

3.10 SR48a: 43rd Avenue and Salt River – South Side

The SR48a Storm Drain is located at 43rd Avenue of south side bank. A 96-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 22.66 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 3,107 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 96-inch pipe is approximately 336 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 336 cfs would produce a maximum velocity of approximately 6.7 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 1640 acre-feet.

3.11 SR49: 67th Avenue and Salt River – North Side

The SR49 Storm Drain is located at 67th Avenue of north side bank. A 96-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a drainage area of approximately 7.4 mi^2. There are no flow records available for this drain.

Figure 3-1 was used to estimate the peak flow rates for a series of storm events. These results are provided in Table 3-2. A peak flow rate of approximately 3,107 cfs was estimated for the 100-year storm event. However, Figure 3-2 indicates that the maximum capacity of a 96-inch pipe is approximately 336 cfs. Thus, the peak flow that can realistically discharge from this drain is governed by the pipe size. A peak flow rate of 336 cfs would produce a maximum velocity of approximately 6.7 ft/sec 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 3-3. Using this approach, the average annual volume of storm runoff was estimated to be approximately 558 acre-feet.

3.12 Supplementary

The SR47 Storm Drain is located at 51st Avenue of north side 50 feet north of SR01outfall. A 48-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a probably small drainage area. The drainage area is not well defined; however, it is not expected to generate significant amounts of storm runoff. These are not expected to have implications on the habitat restoration project.

The SR48 Storm Drain is located at 45th Avenue of south side bank. A 48-inch storm drain conveys runoff into the Salt River. This drain collects runoff from a probably small drainage area. The drainage area is not well defined; however, it is not expected to generate significant amounts of storm runoff. These are not expected to have implications on the habitat restoration project.

The SR58 Storm Drain is located at 35th Avenue of northeast side bank. A 60-inch storm drain conveys runoff into the Salt River. This drain discharges runoff from a 23rd Avenue Waste Water Treatment Plant (WWTP). The flow records of this outfall are available in the Water Budget Draft Report.

The SR59 Storm Drain is located at 2333 W. Durango (23rd Ave. WWTP east side of 35th Avenue and Salt River) of north side bank. A 48-inch storm drain conveys runoff into the Salt River. This drain is a part of SR05 conveyance system. The drainage area is not well defined; however, it is not expected to generate significant amounts of storm runoff. These are not expected to have implications on the habitat restoration project.

3.13 Natural Surface Drainage

Natural surface drainage ways, west of 67th Avenue from north bank side and west of 27th Avenue from south bank side, ultimately discharge into the Salt River. The SRP canal intercepts a part of runoff from the areas south of the canal. Because runoff from these areas in not confined to a well-defined drainage ways, storm events will not generate significant flow rates at any location. These areas are not expected to have implications on the habitat restoration project.

TABLE 3-2. Storm Drain N-Year Peak Flow

OUTFALL No.	SITE LOCATION	PIPE SIZE (inch)	Drainage Area[1] (AF)	Pipe Slope (ft/ft)	Drainage Area (mi^2)	N-Year Peak Flow[2] (AF)						CAPACITY[3] (CFS)
						2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
SR01	51st Avenue and Salt River - North Side	96	2290	0.0005	3.58	169	380	562	813	1192	1728	177
SR02	43rd Avenue and Salt River - North Side	90	2290	0.0011	3.58	169	380	562	813	1192	1728	221
SR03	35th Avenue and Salt River- North Side	75	1856	0.0009	2.90	146	327	479	690	1009	1460	123
SR04	27th Avenue and Salt River- North Side	72	2862	0.00409	4.47	198	445	665	966	1422	2066	235
SR05	25th Avenue and Salt River- North Side	102	1017	0.00135	1.59	96	214	304	432	627	901	342
SR06	22nd Avenue and Salt River- North Side	78	4790	0.0006	7.48	284	641	983	1442	2138	3121	112
SR07	19th Avenue and Salt River- North Side	54		0.0015[4]	1.00	69	154	214	302	434	622	66
SR30	27th Avenue and Salt River- South Side	108	1620	0.0017	2.53	133	297	432	621	906	1309	447
SR31	19th Ave, South Bank	60	1918	0.0015[4]	3.00	149	335	491	708	1036	1499	88
SR47	51st Avenue and Salt River- North Side 50 feet north of SR01	48	unknown	0.0015[4]	unknown	N/A	N/A	N/A	N/A	N/A	N/A	48
SR48	45th Avenue and Salt River- South Side	48	unknown	0.0015[4]	unknown	N/A	N/A	N/A	N/A	N/A	N/A	48
SR49	67th Avenue and Salt River- North Side	96	4762	0.0018	7.44	283	638	979	1436	2128	3107	336
SR58	35th Avenue and Salt River- N/E Side	60	unknown	0.0015[4]	unknown	N/A	N/A	N/A	N/A	N/A	N/A	88
SR59	2333 W. Durango (23rd Ave. WWTP east side of 35th Ave. and Salt River) - North Side	48	unknown	0.0015[4]	unknown	N/A	N/A	N/A	N/A	N/A	N/A	48

1. Drainage areas were provided by COP.

2. N-Year peak flow rates were computed from the drainage area vs. peak flow relationships developed for the Rio Salado Study.

3. A Manning's N-values of 0.015 pipe was assumed for the storm drain capacity estimates.

4. A longitudinal slope of 0.0015 was assumed as average value of known value for the storm drain capacity estimates if the existing slope is unknown.

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TABLE 3-3. Storm Drain Average Annual Runoff Volumes

OUTFALL No.	SITE LOCATION	PIPE SIZE (inch)	Drainage Area (acre)	Drainage Area (mi^2)	JAN (AF)	FEB (AF)	MAR (AF)	APR (AF)	MAY (AF)	JUN (AF)	JUL (AF)	AUG (AF)	SEP (AF)	OCT (AF)	NOV (AF)	DEC (AF)	ANNUAL (AF)
SR01[1,2]	51st Avenue and Salt River - North Side	96	2290	3.6	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR02[1,2]	43rd Avenue and Salt River - North Side	90	2290	3.6	23.9	24.7	31.6	8.0	4.4	4.7	29.6	34.3	30.7	23.3	23.6	35.7	274
SR03[1,2]	35th Avenue and Salt River- North Side	75	1856	2.9	19.5	20.2	25.7	6.5	3.6	3.8	24.2	28.0	25.1	19.0	19.3	29.1	224
SR04[1,2]	27th Avenue and Salt River- North Side	72	2862	4.5	29.6	30.7	39.2	9.9	5.4	5.8	36.8	42.6	38.1	29.0	29.3	44.3	341
SR05[1,2]	25th Avenue and Salt River- North Side	102	1017	1.6	10.9	11.3	14.4	3.6	2.0	2.1	13.5	15.6	14.0	10.6	10.8	16.3	125
SR06[1,2]	22nd Avenue and Salt River- North Side	78	4790	7.5	48.8	50.5	64.5	16.3	9.0	9.5	60.6	70.1	62.8	47.7	48.2	72.9	561
SR07[1,2]	19th Avenue and Salt River- North Side	54	632.77	1.0	6.9	7.1	9.1	2.3	1.3	1.3	8.5	9.9	8.8	6.7	6.8	10.3	79
SR30[1,2]	27th Avenue and Salt River- South Side	108	1620	2.5	17.1	17.7	22.6	5.7	3.1	3.3	21.2	24.5	22.0	16.7	16.9	25.5	196
SR31[1,2]	19th Ave, South Bank	60	1918	3.0	20.1	20.8	26.6	6.7	3.7	3.9	25.0	28.9	25.9	19.6	19.9	30.0	231
SR47[1,2]	51st Avenue and Salt River- North Side 50 feet north of SR01	48	unknown	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
SR48[1,2]	45th Avenue and Salt River- South Side	48	unknown	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
SR48a[1,2]	43rd Avenue and Salt River- South Side	N/A	14502	22.66	142.7	147.6	188.6	47.6	26.2	27.9	177.1	205.0	183.7	139.4	141.0	213.2	1640
SR49[1,2]	67th Avenue and Salt River- North Side	96	4762	7.4	48.5	50.2	64.1	16.2	8.9	9.5	60.2	69.7	62.5	47.4	48.0	72.5	558
SR58[1,2]	35th Avenue and Salt River- N/E Side	60	unknown	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
SR59[1,2]	2333 W. Durango (23rd Ave. WWTP east side of 35th Ave. and Salt River) - North Side	48	unknown	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
	Total																4503

1. Monthly storm water runoff distributions were assumed to follow the monthly pattern of rainfall.
2. Annual runoff volumes were computed from the drainage area vs. average annual runoff relationships developed for the Rio Salado Study.

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4.0 Water Quality Analyses

The water quality of the irrigation drains can meet the needs of the Oeste Project in most cases. Localized water quality problems could occur if surface runoff enters the irrigation drains and transports contaminants from surrounding areas into the drain canals. There are no concentrated animal feeding operations in the area that could contribute contaminated runoff into the irrigation drains system.

It is important to note that storm water quality is a function of land use, not the size of the watershed (Greeley and Hansen, 2001). 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. The quality of the "first flush" water is generally poor. As the runoff continues, the water quality improves. In general, based on analysis of available data versus the numeric water quality standards, stormwater is a vehicle by which surface water quality appears to degrade within the Salt River.

5.0 Evaluation of Interior Drainage System

Two types of interior drains were evaluated that outfall into the Salt River within the Oeste project study limits – irrigation drains and storm drains. The interior drains were evaluated to assess the potential damage that their flows may have on the habitat restoration project. 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
Report.

5.1 Damage to Restored Habitat

The irrigation drains flow in response to controlled releases by 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 311.51 acre-feet, and 78.80 acre-feet for the SRP 67th Avenue Drain, and Maricopa Drain, respectively.

The storm drains flow in response to rainfall events. The two major storm drains identified are the SR06 and SR49. For this study, the peak flow rate associated with the 100-year storm was assumed to represent the upper bound possible condition. The peak 100-year flow rates for these drains were estimated to be approximately 3,121 cfs and 3,107 cfs. However, the maximum capacity of the SR06 is considerably less. The peak flow rates that could realistically discharge from these drains are 112 cfs and 336 cfs, which would generate discharge velocities of 3.4 ft/sec and 6.7 ft/sec, respectively.

The remaining storm drains within the project area could discharge peak flow rates as high as 447 cfs with velocities as high as of 7.0 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 3-2.

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 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 (USACE, 1998). To that regard, there is little advantage to providing protection from the interior drainage discharge.

5.2 Water Source

The irrigation drains, which flow in response to controlled releases, have received occasional flows throughout the record period from 1993 through 2002. The average annual volumes of water released to the Salt River during this period were 1,044 acre-feet (the record period from 1993 through 2002), and 4,276 acre-feet (the record period from 1994 through 2002) for the SRP 67th Avenue Drain, and Maricopa Drain, respectively. Although these amounts are sufficient to support some riparian vegetation, the timing of these flows is irregular. These releases are not reliable as the drains have historically been

dry for long periods; for example, there were no releases to the SRP 67th Avenue Drain throughout the period from November 1996 through February 1997. The Maricopa Drain flows were historically more frequent and reliable. Future releases to this drain are expected to be less frequent than the historic trend. Table 2-2, and Table 2-4 summarize the average monthly and annual volumes of water released through the irrigation drains for the period of record evaluation. The water discharged from irrigation drains is generally high quality and suitable for the habitat restoration project.

The storm drains flow in response to rainfall events, so the discharge from these drains is typically infrequent and highly variable. The storm drains provide an average annual volume of water to the Salt River ranging from 79 to 1640 acre-feet. Table 3-3 summarizes the average monthly and annual volumes of water released through the storm drains. 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. The quality or the "first flush" water is generally poor. As the runoff continues, the water quality improves.

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 two irrigation 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 SR06, SR48a, and SR49 Drain have supplied a relatively enough flow to the river based on estimated flow rates. However, long-term records are not available to ascertain this supply. The SR01, SR02, SR03, SR04, SR05, SR06, SR07, SR30, SR31, and SR49 should all be included in the water budget analyses.

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APPENDIX A

SRP 67th Avenue Drain Daily Flow Records

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1993
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	0.08	40.78	2.64	3.71	0.56	0.77	1.15	0	0	0
2	0	0	0.73	33.96	1.35	2.84	2.72	1.63	0.32	0	0	0
3	0	0	0	30.7	4.24	2.72	6.64	2.04	0.32	0	0	0
4	0.2	0	0	33.08	5.97	2.46	8.65	6.19	0.32	0	0	0
5	0	0	0	37.83	4.34	2.34	3.09	1.19	0.32	0	0	0
6	0	0	0	48.85	5.75	2.52	1.88	0.93	0.32	0	0	2.06
7	0	0	1.13	47.98	6.61	3.37	3.51	1.63	0.32	1.53	0	2.56
8	0	0	5.08	39.75	9.14	3.73	4.05	4.5	0.32	5.18	0	0.02
9	0	0	9.32	21.24	6.33	1.88	3.51	3.63	0.2	5.24	0	0
10	0	0	8.73	8.03	0	0.24	2.96	7.68	0	4.22	0	0.02
11	0	0	5.99	15.51	0	0.44	1.75	6.31	0	0	0	0.52
12	0	0	1.11	10.97	0	1.07	3.21	7.8	0	0	0	3.57
13	0	0	0	8.75	0	3.91	5.69	0.61	0	0	0	0
14	0	0	0.42	10.79	1.31	6.37	5.65	0.58	0	0	0	0
15	0	0	9.4	15.65	2.4	7.91	14.08	0.32	0	0	0	0
16	0	0	15.09	12.38	2.96	4.34	9.08	0.32	0	0	0	0
17	0	0	17.42	10.55	2.34	3.45	9.01	0.32	0	0	0	1.33
18	0	0	10.51	8.75	2.34	2.32	4.88	0.32	0	0	0	0.26
19	0	0	10.31	10.55	2.36	2.48	1.9	0.32	0	0	0	0.06
20	0	0	14.96	6.29	2.4	4.92	1.79	0.32	0	0	0	2.62
21	0	0	17.32	0.52	0.18	6.59	4.07	1.79	0	0	0	4.46
22	0	0	15.57	4.88	0	7.54	3.73	4.34	0	0	0	0
23	0	2.22	8.37	13.73	0	7.56	5.18	5.57	0	0	0	0
24	0	4.4	16.03	9.22	0	7.1	5.83	5.08	0	0	0	0
25	0	4.62	40.84	5.45	0	6.33	10.99	19.46	0.83	0	0	0
26	0	6.33	46.1	7.46	0.26	5.02	7.99	25.75	0	0	0	4.88
27	0	4.01	31.28	4.92	1.33	1.37	1.25	13.31	0	0.02	0	5.3
28	0	6.19	27.85	0.71	0.63	0.24	0.32	4.32	0	0.42	0	8.65
29	0		46.73	0.87	0.3	0.24	1.05	12.42	0	0.28	0	5.26
30	0		41.55	4.7	0.3	0.22	2.42	9.62	0	0.3	0	0.89
31	0		43.22		0.52		3.41	2.66		0.04		2.76
Total	0.20	27.77	445.14	504.85	66.00	105.23	140.85	151.73	4.42	17.23	0.00	45.22
Count	1	6	26	30	23	30	31	31	10	9	0	17
Average	0.01	0.99	14.36	16.83	2.13	3.51	4.54	4.89	0.15	0.56	0.00	1.46
Maximum	0.20	6.33	46.73	48.85	9.14	7.91	14.08	25.75	1.15	5.24	0.00	8.65

Minimum	0.00	0.00	0.00	0.52	0.00	0.22	0.32	0.32	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	4.28	0	3.05	2.62	0	0	3.69	0	1.11	0	0	0.48
2	4.58	1.37	4.56	3.11	0	0.06	1.47	0	0	0	0	0.79
3	4.26	3	1.8	3.05	0.5	0	0.75	0	0	0	0	1.11
4	7.91	0	0	0	1.27	3.09	0.06	0	0	0	0	1.23
5	7.99	0	0.16	0	1.43	3	0	3.47	0	0	0	0.12
6	5.06	0	0	0	6.51	0.97	0	9.4	0	0	0.65	0
7	5.1	2.44	5.55	0.16	2.76	0	1.31	5.3	1.79	0.02	0	0
8	5.65	9.56	8.45	5.1	0.3	0	1.79	0	0	0	0	0
9	7.56	2.7	0	11.17	0	0	2.46	0	0	0	0	0.08
10	7.81	8.99	0	3.73	1.55	0	2.22	0	0	0	0	0.26
11	7.28	0.02	0	6.57	2.96	0.63	0.02	0	2.74	0.28	0	0
12	6.17	0	0.02	2.46	1.82	1.13	0	0	2.98	2.64	0	0
13	6.94	0	1.37	2.18	0	1.61	0	0.1	0.5	2.14	0	0
14	7.83	0	0.2	0.4	0.52	0.38	0	0	0	2.2	0	0
15	8.93	0	0	0	0.34	0.4	0	0	0	0.02	0	0
16	7.78	0	0.26	0	0.16	0.14	0	0	0	0	0	0
17	7.32	0	3.09	0	4.74	2.06	0.91	0	0	0	0	0
18	7.44	0	0	0	3.01	5.95	1.96	0	0	0.71	0	0.58
19	4.56	0	0	0	0.89	3.57	0	0	0	2.42	0	0
20	1.09	0	0	0.32	1.79	0.1	0	0	0	3.07	0	0.75
21	5.49	0	0	0.04	0	0	0	0.87	0	3.23	0	1.11
22	9.14	0	0	1.67	0	0	0	9.18	0	1.73	0	0
23	6.39	0	1.41	0	0	0	0	3.91	0.06	0.26	0	3.37
24	4.44	0	8.61	0	0.44	0	0	5.26	3.53	0	0	1.49
25	4.21	0	12.16	0	1.92	0	0	7.85	2.9	0	0	1.33
26	5.87	0	6.37	0	0	0	0	9.58	1.49	0	0	1.47
27	8.35	0.02	0	0	0.02	0	0	0	0	2.76	1.11	0
28	4.56	0	0	0	0	0	0	0	0	2.12	0.04	0
29	0		0	0	0	1.35	0	0	0	0	0.12	0
30	0		0	0	1.8	5.51	0	0	0	0	0.58	0
31	0		0.1		0		0	1.41		0		0
Total	173.99	28.10	57.16	42.58	34.73	29.95	16.64	56.33	17.10	23.60	2.50	14.17
Count	28	8	16	14	20	16	11	11	9	14	5	14

Average	5.61	1.00	1.84	1.42	1.12	1.00	0.54	1.82	0.57	0.76	0.08	0.46
Maximum	9.14	9.56	12.16	11.17	6.51	5.95	3.69	9.58	3.53	3.23	1.11	3.37
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

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	0	0	1.59	0.04	0	1.11	0	0	0	3.53
2	0	3.27	3.11	1.47	4.05	0.14	0	0.38	0	0	0.2	1.51
3	0	8.57	0.12	4.4	0.04	4.62	0	0.02	0	0	0	0.2
4	0	0.52	0.58	7.56	0	9.18	0	0.52	0	0	0	0
5	0.65	0	3.73	6.57	0.02	10.71	0	1.96	0	0	0	0
6	0	0	7.66	6.49	1.07	4.72	0	5.45	0.93	0	0	0
7	0	0.02	11.33	9.46	4.62	0.77	0	3.39	2.78	0	0	0
8	0	4.84	4.64	10.95	4.44	0.85	0	1.47	1.79	0	0	0
9	0.04	1.31	9.58	5.41	4.07	4.64	0	0	0	0	0	0
10	0.08	3.01	13.45	0	1.13	2.28	0	0.04	0	0	0	0
11	0.16	4.11	9.48	0.28	0	5	0	0	0.71	0	0	0
12	0.58	0.18	1.88	6.61	1.88	27.79	0.02	0.16	0	0	0	0
13	0.12	0	0.06	5.97	6.59	11.9	2.32	0	0.18	0	0	0
14	0	0	1.65	8.57	5.91	2.12	0.65	0	0.16	0	0	0
15	0	11.66	0	2.3	2.34	1.01	2.46	0	0.65	0	0	0
16	0	16.62	0	0.73	0.04	0.2	0	0	1.07	0	0	0
17	0	0	0	3.49	2.02	1.79	0	0	0	0	0	0
18	0	0	0.02	5.36	1.41	4.82	0	0	0	0	0	0
19	0	0	0.42	2.76	0	2.76	0	0.77	0.02	0	0	0
20	0	0	0	0.54	0.22	3.77	0	3.23	0.08	2.14	0	0
21	0	0	0.26	0	0.38	7.52	0	0.69	2.6	3.13	0	0
22	0	0	6.78	0	0.02	2.78	0	0.63	2.5	1.29	0	0
23	0	0.48	12.67	0	0.02	0	0	0	2.42	0	0	0.34
24	0	1.07	5.79	0	0.22	0	0	0	2.2	0	0	0.46
25	0	0.54	13.92	0	0	0	0	0	1.53	0	0	0
26	0	0	7.5	0	0	0	5.81	0	0	0	0	0
27	0	0.28	8.09	0.26	1.63	0	2.62	0.87	0	0	0.02	0.95
28	0	0	3.87	1.84	5.57	0	1.92	1.67	1.67	0	1.92	0.08
29	0		5.43	6.61	5.95	0	2.3	1.63	0.18	0	2.46	0
30	0		5.16	2.98	1.59	0	1.73	0.83	0	0	3.21	0
31	0		0.32		0		3.25	0		0		0

Total	1.63	56.48	137.50	100.61	56.82	109.41	23.08	24.82	21.47	6.56	7.81	7.07
Count	6	15	26	22	25	22	10	18	17	3	5	7
Average	0.05	2.02	4.44	3.35	1.83	3.65	0.74	0.80	0.72	0.21	0.26	0.23
Maximum	0.65	16.62	13.92	10.95	6.59	27.79	5.81	5.45	2.78	3.13	3.21	3.53
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

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	4.34	0.77	0	2.52	0.42	0	0	0.12	0	0	0
2	0	7.46	0	0.36	2.76	0.83	0	0	0	0	0	0
3	0	0	0	0	2.8	0.26	0	0.91	0	0	0	0
4	0	0	0	0.18	1.96	0.26	0	2.62	0	0	0	0
5	0	0	0	1.8	4.22	0.26	0	1.03	0	0	0	0
6	0	0	0	2.1	4.22	0.28	0	0.61	0	0	0	0
7	0	0	0.58	0.75	2.82	0.36	0.36	0	0	0	0	0
8	0	0	0.22	0	0.32	1.15	2.86	0	0	0	0	0
9	0	0	0	0	0	2.16	2.8	0	0	0	0	0
10	0	0	0	0.54	0	0.46	0.79	0	0	0.38	0	0
11	0	0	0	0	0.42	0.26	0.28	0	0.12	0.44	0	0
12	0	0	0	0	1.61	0.4	0	0	0	0.46	0	0
13	0.67	0	0.5	0.28	3.49	3.11	0	0	0	3.29	0	0
14	2.98	0	2.46	1.31	0.5	3.67	0	0	0	3	0	0
15	1.86	0	1.05	3.61	0.5	0.26	0	0.65	0	5.18	0	0
16	0	0	0	4.19	0.24	0.26	0.08	1.05	0	0.54	0	0
17	0	0	0	0	0	0.3	0	0.75	0	0.4	0	0
18	0.81	0	0	0	0	0.26	0	1.65	0	1.57	0	0
19	0.4	0	0	0.22	0	0.44	0	2.58	0	1.11	0	0
20	0.1	0	0	0.16	0	1.33	0.04	1.82	0	0	0	0
21	0	2.82	0	0.32	0	0.08	0.97	1.11	0	0	0	0
22	0	7.32	0	0.1	0	0.1	2.78	3.19	0	0	0	0
23	0	9.34	0	0.89	0.18	0	0.83	7.12	0	0	0	0
24	0	10.75	0	2.46	0.46	0	1.57	6.45	0	0	0	0
25	0	10.37	0	0.93	0.85	0	4.48	3.77	0	0	0	0
26	0	10.31	0	0	1.27	0	6.47	1.41	0	0.12	0	0
27	0	10.25	0	0.22	1.35	0	0	1.39	0	0.04	0	0
28	0.12	10.95	0	1.55	1.35	0.38	0	2.4	0	0	0	0
29	0	5.53	0	4.78	1.21	1.57	0	2.18	0	0	0	0
30	0.04		0	4.58	0.77	1.92	0	0.02	0	0	0	0

31	0.73		0		0.34		0	0		0		0
Total	7.71	89.44	5.58	31.33	36.16	20.78	24.31	42.71	0.24	16.53	0.00	0.00
Count	9	11	6	21	23	25	13	20	2	12	0	0
Average	0.25	3.08	0.18	1.04	1.17	0.69	0.78	1.38	0.01	0.53	0.00	0.00
Maximum	2.98	10.95	2.46	4.78	4.22	3.67	6.47	7.12	0.12	5.18	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

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	0	0	0	0	0	0	0.73	1.79	0	1.29
2	0	0	0	0	0	0	0	0	0.3	4.09	0	14.72
3	0	0	0	0	0	0	0	0	0	2.62	0	2
4	0	0	0.87	0	0	0	0	0	0	4.98	0	3.63
5	0	0	0.97	0	0	0	0	0	0	0.18	0	13.45
6	0	0	1.37	0	0	0	0	0	0	0	0	14.44
7	0	0	2.02	0	0	0	0	0	0	0	0	14.44
8	0	0	0.44	0	0	0	0	0	0	0	0	14.44
9	0	0	0	0	0	0	0	0	0	0	0	3.03
10	0	0	0	0	0	0	0	0	0.2	0	0	0
11	0	0	0	0.12	0	0	0	0	4.24	0	0	12.46
12	0	0	0	1.67	0	0	0	0	8.07	0	0	19.46
13	0	0	0	2.08	0	0	0	0	0.06	0	0	18.51
14	0	0	1.84	0	0	0	0	0	0	0	0	13.31
15	0	0	4.74	1.57	0	0	0	0	0	0	0	12.12
16	0	0	5.47	1.37	0	0	0	0	0	0	0	11.8
17	0	0	5.38	1.33	0	0	0	0.3	0	0	0	16.44
18	0	0	2.56	1.19	0	0	0	1.49	0	0	0	17.55
19	0	0	0.04	0.06	0	0	0	2.78	0	0	0	19.56
20	0	0	4.09	1.57	0	0	0	4.38	0.67	0	0	30.7
21	0	0	5.18	8.57	0	0	0	4.4	3.47	0	0	7.66
22	0	0	3.19	2.26	0.1	0	0	4.11	4.01	1.45	0	5.16
23	0	0	2.64	2.42	1.96	0	0	3.95	2.22	3.05	0	2.44
24	0	0	0.14	0.95	1.03	0	0	1.41	0.52	6.94	0	0
25	0	0	0	1.75	2.28	0	0	0.52	0	0.24	0	0
26	0	0	0	2.64	2.34	0	0	0	0	0	0	0
27	0	0	0	2.12	1.63	0	0	0	0	0	0	1.53
28	0	0	0.16	0.12	0	0	0	0	0	0	0	0.63

29	0		0	0	0.16	0	0	0	0	0	0	3.61
30	0		0	0	0	0	0	0.52	0.08	0	0	14.08
31	0		0		0		0	0.58		0		18.41
Total	0.00	0.00	41.10	31.79	9.50	0.00	0.00	24.44	24.57	25.34	0.00	306.87
Count	0	0	17	17	7	0	0	11	12	9	0	27
Average	0.00	0.00	1.33	1.06	0.31	0.00	0.00	0.79	0.82	0.82	0.00	9.90
Maximum	0.00	0.00	5.47	8.57	2.34	0.00	0.00	4.40	8.07	6.94	0.00	30.70
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

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3.45	0	0.34	2.34	1.98	0	0.08	0	21.86	0	2.88	0
2	0.1	0	0	1.23	10.85	0	0.08	0.12	0.08	0	0	0.04
3	0.85	0	4.13	1.17	11.23	0	0.1	0.1	0.14	0	0	0
4	0.02	4.4	3	1.03	10.73	0	0.22	0	0.95	0	0	0
5	1.96	1.92	3.23	0.91	5.91	19	0.08	0.12	0.08	31.12	0	0.44
6	2	0	3.45	1.03	8.53	17.81	0.08	0.18	0.14	51.49	0	3.17
7	6.03	0	13.67	11.17	1.45	0.52	0.14	0.1	0.08	3.47	0	0
8	5.38	1.27	7.26	4.7	1.55	0.71	0.12	0	0.08	0	0.56	0.04
9	1.13	7.93	19.08	6.8	15.87	1.86	0.12	0	0.08	0	19.8	10.37
10	2.14	5.28	22.93	4.58	27.41	6.19	0.08	0	0.08	0	1.19	18.7
11	0.24	3.85	21.58	2.8	10.35	4.78	0.08	1.19	0.08	0	4.76	0
12	0	0	23.8	8.85	20.49	4.98	0.08	4.07	0.08	0	2.32	0
13	0	0	28.98	0.22	32.55	5.55	0.08	5.32	0.08	0	0	0
14	0	0	24.46	0	12.3	1.96	1.23	2.74	0.08	0	0	0
15	0	6.68	23.86	0	8.05	2.72	1.05	0	87.33	0	0	0
16	0.6	0	21.34	0.52	7.54	0.1	1.23	0	32.19	0	0.06	0
17	0.04	11.94	29.77	5.93	0.67	0.12	2.04	2.72	72.16	0	0	0
18	0	10.29	27.89	5.77	0.12	0.12	11.88	0	18.37	0	0	0
19	0	0.79	1.69	1.9	0	0.12	2.1	0	0.08	0	0	0.06
20	0	1.21	0.42	0.73	0	0.34	0.3	0	87.29	0	0	0.87
21	0.26	0.4	3.93	0	0.54	0	0.34	0	189.74	0	0.08	2.62
22	0.22	0	6.68	0.5	2.84	0	0.89	0	269.44	294.15	3	2.4
23	0.48	0	7.46	1.23	0.16	4.94	0.08	0	305.94	311.51	7.24	8.27
24	2.6	4.05	5.16	5.28	5.61	6.49	0.08	0.16	257.56	284.93	1.29	2.6
25	9.64	1.37	2.02	2	10.27	7.12	0.3	0.65	0.08	26.38	1.88	0
26	5.04	0.16	12.44	4.24	10.29	0	0.75	3.53	0.08	5.91	0.02	0

27	6.84	0.97	1.21	0.1	7.74	0	0.91	1.98	0.08	0.12	0	0
28	5.41	1.45	9.86	0.85	10.06	0.04	1.21	3.09	0.08	0	0	0
29	4.5		24.4	0	9.96	0	0.08	6.8	0.08	0.73	0	0.2
30	2.74		31.34	1.17	1.63	0	0.08	17.45	0.08	4.17	0	1.21
31	1.82		13.98		0.87		1.25	0.97		1.03		0.32
Total	63.49	63.96	399.36	77.05	247.55	85.47	27.14	51.29	1,344.47	1,015.01	45.08	51.31
Count	24	17	30	26	29	20	31	18	30	12	13	15
Average	2.05	2.28	12.88	2.57	7.99	2.85	0.88	1.65	44.82	32.74	1.50	1.66
Maximum	9.64	11.94	31.34	11.17	32.55	19.00	11.88	17.45	305.94	311.51	19.80	18.70
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.00	0.00	0.00

Source: SRP Daily Flow Records

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.55	0	0	0.08	0	0	0.54	2.48	3.37	5.81	0	0.04
2	0	0	0.38	14.94	0	0	0.04	1.69	3.99	7.62	0	0
3	0	0	0.5	0	0	0	0.61	0	2.3	6.21	0	0
4	0	0	2.22	0	0.06	5.69	0.73	4.05	0	5.89	0	0
5	0	0	5.83	0.44	0	11.11	2.56	2.48	0	6.49	0	0
6	0	0	15.21	0	0	8.23	0.32	8.85	0	3.53	0	0
7	0	0	3.23	0	0	0.91	10.65	10.31	0	4.24	0	0
8	0	0	0	0	0.56	0	11.46	9.42	0	0	0	0
9	0	0	0	0.06	1.29	0	6.53	3.13	1.9	0	0	0
10	0	0	0	0.08	0	0	7.8	0.91	2.82	0	0	0
11	0	0	0.02	0	4.74	2.48	1.47	0	3.01	0	0	0
12	0	0	3.27	0	1.8	5.67	0.95	0.06	0.95	0	0.08	0
13	0	0	3.37	2.5	0.08	23.35	0.3	5.12	1.79	0.44	0	0
14	0	0	22.49	5.89	0	17.12	5.95	2.68	3.79	2.9	0	0
15	0	0	11.52	5.18	2.28	0	5.1	2.26	2.62	0	0.34	0
16	0	0.63	9.82	8.43	1.03	0	0.99	1.67	2.42	0	0.73	0
17	0	0	10.25	10.47	2.08	13.9	0	2.74	3.35	3.01	1.05	0
18	0	0	10.87	10.71	4.54	15.95	0	3.07	1.09	6.92	3.47	0
19	0	0	6.76	9.3	1.59	21.46	0	5.53	2.56	5.69	0	0.16
20	0.79	0.02	0.12	3.75	1.71	21.03	0	18.21	2.04	7.74	0	0
21	3.81	0	0	3.05	8.35	4.7	0	3.19	0	10.37	0	0
22	3.77	1.07	0	0.56	3.57	7.76	0.18	1.49	0	0	0	0
23	0.61	1.61	2.58	0.61	0.22	9.38	1.23	3.95	0	0	0	0
24	0.18	1.98	3.03	4.26	6.31	7.42	4.01	2.18	0	0	0	0

25	0	2.86	0	7.6	4.62	10.91	2.06	5.22	0	0	0	0
26	0	4.09	2.16	0.36	4.6	3.29	2.62	18.45	0	0	0	0
27	0	0.04	7.16	0	0	11.33	5.59	11.7	0	0	0	0
28	0	0	5.65	0	0	0	9.96	10.31	0	0	0	0
29	0		4.92	0.42	6.39	0	0.18	4.38	3.73	0	0	0
30	0		3.65	3.31	0	0	0	6.33	3.79	0	0.34	0
31	0		1.67		0.54		0.32	4.28	18.51	0		0.26
Total	10.71	12.30	136.68	92.00	56.36	201.69	82.15	156.14	64.03	76.86	6.01	0.46
Count	6	8	24	21	20	19	25	29	18	14	6	3
Average	0.35	0.44	4.41	3.07	1.82	6.72	2.65	5.04	2.07	2.48	0.20	0.01
Maximum	3.81	4.09	22.49	14.94	8.35	23.35	11.46	18.45	18.51	10.37	3.47	0.26
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

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	2.72	0	0.02	4.24	6.07	0.93	0.67	2.92	0.69	4.82	2.78
2	0	0	0	0.48	4.4	9.52	2.06	0	0	1.33	4.94	2.5
3	0	0	0	0	5.1	7.66	0.3	0	0	4.05	5.04	0.16
4	0	0	1.61	0	5.3	9.88	0	0	0.04	1.65	5.99	0.2
5	0	0	4.82	0	2.94	4.8	1.19	0.14	0	0	9.34	0.04
6	0	0	10.18	0	5.02	7.7	0.58	1.37	0	0	4.52	0.87
7	0	0	4.46	0	5.02	12.24	0.67	2.16	0	0	1.79	0
8	0	3.11	0.83	0	4.42	12.48	0.99	9.32	0.26	0	4.07	0.2
9	0	9.88	1.05	0	5.97	9.6	2.04	4.96	0.04	0	3.71	0
10	0	0	1.51	0.4	5.97	6.47	0	2.26	0	12.89	3.61	0
11	9.32	0	2.28	2.14	10.95	5.97	2.16	4.68	0.08	4.28	1.69	0
12	5.71	0	1.29	2.92	10.43	6.09	6.98	8.31	0.14	0	2.4	0
13	5.08	0	1.27	3.53	7.34	14.08	1.71	5.47	0	0.12	7.48	0
14	3.73	0	0	4.48	5.18	8.77	2.6	7.85	0.22	0	0	0
15	0	0	0	7.38	1.73	0.18	2.2	3.81	0	0	0	0
16	0	0	0	3.05	1.45	6.92	0	1.57	1.25	0	0	0
17	0	0	0	1.41	2.7	8.73	0	0.32	5.87	0.06	0	0
18	0	0	0	0	5.3	10.45	0	0	1.15	0	0.06	0
19	0	0	0	0	14.66	14.96	0	0	0.58	0	0.4	1.31
20	0	0	0	0	9.38	6.88	0	0.46	0.81	0	0.32	0.24
21	0	0.04	0	0.4	1.61	3.15	0	1.09	0.08	1.07	2.78	0.04
22	0	0	0.12	0.67	3.89	3.13	0	0	4.56	8.31	5.4	0

23	0	0	0	0	11.01	4.26	0.61	0	2.26	4.76	0	0
24	0	0	0	1.25	5.4	2.84	0.1	1.39	3.65	8.99	2.1	0
25	0	0	0	2.56	6.61	2.62	0	0	2.46	6.39	1.71	0
26	0	0	0	0.61	11.72	11.09	0	1.69	0.97	5.95	1.57	0
27	4.32	0	0	6.96	13.63	9.92	0	6.84	0	7.44	0.63	0.04
28	0	0	0	7.68	12.42	7.66	0	5.12	0	5.53	0	0.5
29	3.55	0	0	11.03	5.24	0.95	0.06	4.28	0	5.85	0	1.65
30	0		0.06	6.11	3.63	4.07	5.71	4.52	0.34	7.34	5.06	0.2
31	0		1.05		3.77		3.31	3.51		5.32		0.99
Total	31.71	15.75	30.53	63.08	196.43	219.14	34.20	81.79	27.68	92.02	79.43	11.72
Count	6	4	13	19	31	30	18	23	19	19	23	15
Average	1.02	0.54	0.98	2.10	6.34	7.30	1.10	2.64	0.92	2.97	2.65	0.38
Maximum	9.32	9.88	10.18	11.03	14.66	14.96	6.98	9.32	5.87	12.89	9.34	2.78
Minimum	0.00	0.00	0.00	0.00	1.45	0.18	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	50.46	7.99	1.49	1.77	4.28	10.79	6.53	0.58	0.36	0
2	0	0	123.45	4.68	5.22	2.22	3.67	4.98	9.52	2.32	0.26	0
3	0	0	0	0.95	4.07	2.46	1.13	0.67	8.45	2.14	0	1.8
4	0.6	0	0	1.07	7.95	2.68	2.92	0.1	2.94	0.77	0	3.27
5	0	0	0.04	3.13	7.81	2.36	2	2.7	2.34	0.12	0	4.72
6	4.09	2.08	0.26	8.21	4.8	1.57	0.52	0.81	3.21	4.84	0	4.72
7	5.45	0	1.49	8.39	1.75	2.28	0.3	0.58	3.73	4.76	0	0.04
8	3.23	0.06	0.71	6.78	3.15	5.28	6.49	2.58	5.02	1.86	0	0
9	1.25	0	0.71	0.34	7.04	0.26	4.72	2.82	10.87	0.12	0	0
10	0.04	0	0.6	4.05	6.72	0.28	3.69	3.07	6.29	7.72	0	0
11	0.1	0	0.16	1.69	5.77	0.2	3.77	6.92	4.86	6.15	0	0.24
12	2.34	0	0.52	2.96	9.36	0.12	7.68	0.5	4.01	1.35	0.32	0.1
13	0.04	0	0	3.71	8.21	2.24	2.9	0.42	0.6	0.26	0.65	0
14	0	0	0	2.6	2.12	1.53	1.57	0	2	0.71	0	0
15	0	0	0	0	1.9	1.94	1.43	1.49	1.84	1.07	0	0
16	0	0.77	0	0.22	3.07	2.1	3.99	0	4.74	3.99	0	0
17	0	0	0.06	0.4	1.07	2	9.28	0.58	6.9	4.4	0	0
18	0	0	0	0.46	0.38	3.37	4.15	1.82	3.69	1.88	0	0
19	0	0	0	1.61	0	1.63	3.35	0.75	0.81	4.01	0	0
20	0.61	0	0	2.72	0.4	4.24	3.53	2.24	3.59	3.31	0.1	0

21	0.1	0	0	8.15	0.06	1.03	2.08	3.49	2.96	1.47	0	0
22	0.04	0	0	4.92	0.3	1.13	2.28	2.92	6.96	0.14	0	0
23	0	0	0	0.65	1.59	0.81	2.14	5.16	3.49	0	0	0
24	0.44	0	0.5	0.36	1.41	8.99	3	4.96	1.86	0.46	0	0
25	5.16	0	2.44	0.83	0.95	11.11	6.31	9.8	3.53	0.61	0	0
26	6.19	0	0.63	0.46	1.03	10.31	4.68	4.42	7.3	0.6	0	0.02
27	10.23	0	1.37	0.58	2.4	8.53	6.9	3.55	1.63	0.79	0	0.32
28	0.48	0	1.11	2.3	4.21	5.67	0.44	3.07	1.9	0.65	0	0.38
29	0.1		0.36	3.41	10.95	1.86	2.12	2.34	7.22	3.67	0	0
30	0		0.22	2.14	11.58	1.55	3.75	1.75	8.17	4.66	0.1	0
31	0		4.48		3.55		5.65	2.12		2.52		0
Total	40.49	2.91	189.57	85.76	120.31	91.52	110.72	87.40	136.96	67.93	1.79	15.61
Count	18	3	19	29	30	30	31	29	30	30	6	10
Average	1.31	0.10	6.12	2.86	3.88	3.05	3.57	2.82	4.57	2.19	0.06	0.50
Maximum	10.23	2.08	123.45	8.39	11.58	11.11	9.28	10.79	10.87	7.72	0.65	4.72
Minimum	0.00	0.00	0.00	0.00	0.00	0.12	0.30	0.00	0.60	0.00	0.00	0.00

Source: SRP Daily Flow Records

SRP - 67TH AVE. DRAIN
DAILY FLOW RECORDS - 2002
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0.6	0.52	0	13.59	0	7.48	3.45	2.28	6.64	18.33	2.22
2	0	0.52	0.32	0	5.49	0	8.73	3.55	2.26	8.61	18.88	2.18
3	0.26	0.36	5.79	0	7.62	1.11	16.62	3.45	2.28	2.24	11.33	2.20
4	0.67	0.22	4.24	1.71	4.92	5.81	10.85	3.45	0	0	2.04	2.20
5	0.79	0	4.74	4.96	0.1	4.5	6.07	3.13	9.8	0	2.22	2.20
6	0.77	0	0.97	5.63	0	7.66	5	4.56	10.45	0	2.22	2.20
7	0.5	0.12	0	2.66	0.14	6.27	4.46	5.67	5.93	0	2.22	2.20
8	0.46	0.42	0.18	0.14	0.75	1.55	3.57	7.48	3.15	2.24	2.22	2.20
9	0.77	0.67	0.02	0.24	4.44	12.38	2.96	7.89	2.56	2.24	2.22	1.90
10	0.99	0.69	0	0.52	6.8	2.88	4.13	6.21	2.4	2.24	2.22	1.71
11	0.99	0.61	0.24	0.73	5.08	0.04	4.56	6.57	2.28	2.24	2.2	2.20
12	0.85	0.32	0	0.02	6.19	0	6.05	9.12	2.28	2.24	2.94	2.18
13	0.87	0	0.08	0	0.83	0.02	3.53	4.96	2.2	2.24	5.04	2.18
14	0.99	0	2.9	2.74	0	1.29	3.55	5.26	2.22	2.24	5.87	2.16
15	0.85	0	0	4.09	0.16	3.69	0	7.93	2.32	2.22	5.67	1.47
16	1.07	0	0	5.43	1.11	1.63	0	6.55	2.28	2.24	2.24	1.88
17	0.89	0	0	0.1	1.11	0	0	6.9	0	3.37	2.24	2.20
18	1.21	0	0	0	1.45	0	0	8.45	2.3	2.22	2.24	2.20

19	1.77	0	0.16	0	0	0.46	0	8.73	2.42	2.3	2.24	2.18
20	1.47	0	0.67	0	0	6.51	0	2.32	2.64	3.55	2.24	2.20
21	1.57	0	0.36	0	0	5.91	0	2.24	2.58	2.2	1.77	1.59
22	1.65	0.1	0	0	0	3.19	0	2.3	2.62	2.22	2	1.75
23	2.34	0.61	0	0.3	0	0	0	2.24	2.84	2.22	2.24	2.18
24	2	0.3	0	0	3.07	7.02	0	3.47	2.92	2.22	2.24	2.18
25	2.2	0	0.4	0	7.08	5.14	0	9.26	3.05	2.22	2.2	2.18
26	2.14	0	0.52	0.46	5.67	0.89	0	6.92	2.88	2.3	2.2	2.18
27	2.22	0	0.46	2.9	4.6	0.04	0	2.7	3.69	2.3	2.2	2.16
28	2	0	0.85	0.6	0.34	0.06	0	9.22	2.36	2.22	2.22	1.47
29	1.69		0.73	7.14	0	4.74	0	7.16	4.22	14.66	2.22	2.00
30	1.73		0	6.72	0	7.87	0.61	4.68	3.79	18.82	2.22	2.18
31	1.27		0		0.32		2.6	2.58		18.55		2.24
Total	36.98	5.54	24.15	47.09	80.86	90.66	90.77	168.40	93.00	119.00	118.33	64.21
Count	29	13	19	19	22	24	16	31	28	27	30	31
Average	1.19	0.20	0.78	1.57	2.61	3.02	2.93	5.43	3.10	3.84	3.94	2.07
Maximum	2.34	0.69	5.79	7.14	13.59	12.38	16.62	9.26	10.45	18.82	18.88	2.24
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.24	0.00	0.00	1.77	1.47

Source: SRP Daily Flow Records

APPENDIX B

SRP Maricopa Drain Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1994
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.85	8.27	0.3	22.08	0	7.3	7.28	10.91	0	0.18	6.51	0
2	8.45	6.9	4.66	18.09	0	7.3	7.28	10.91	0	0.32	4.8	0
3	6.8	6.88	12.71	15.35	0	12.65	7.28	9.82	1.09	0.52	1.82	0.81
4	7.26	6.09	2.02	16.58	0	9.5	7.28	9.82	0	0.42	0.08	5.81
5	11.74	9.98	12.58	16.03	0	7.8	7.28	7.64	0	0.36	1.33	1.61
6	12.54	8.53	15.21	12.99	3.03	11.56	7.83	17.45	0	0.28	5.12	7.04
7	11.84	15.67	33.68	10.89	13.31	11.19	10.65	16.36	0	0.04	0.61	1.19
8	9.34	19.22	21.72	16.48	14.76	10.53	11.41	13.09	0	0	0	1.03
9	8.25	9.78	14.62	20.25	7.58	9.14	12.56	6.55	0	0	0	1.51
10	6.09	12.65	8.99	13.27	2.36	6.62	17.12	10.91	0	0.63	0	0.38
11	6.78	6.88	9.06	16.03	0.04	6.7	17.53	12	0	1.31	0	0
12	9.74	7.02	8.51	16.38	0.79	6.7	19.14	12	0	0.18	0	0
13	8.35	12.93	10.23	7.36	2.44	6.03	15.09	9.82	0	0	0.48	0.02
14	11.5	10.31	3.87	1.21	1.69	7	24.06	10.91	0	0	0.04	1.55
15	9.4	8.55	2.68	4.84	4.11	10.97	20.43	15.27	0	0	0	0.26
16	8.31	2.98	2.24	11.41	12.42	10.93	21.6	18.55	0	0	0	0.3
17	9.9	8.99	4.05	10.67	14.72	13.07	30.19	9.82	0	0	0	1.07
18	9.76	5.93	8.65	18.66	18.82	15.77	31.34	10.91	0	0	0	0.91
19	11.56	8.15	11.72	17.85	12.38	13.86	19.26	14.18	0	0	0	0.54
20	6.8	2.9	6.35	19.34	14.3	14.22	12.34	9.82	0	0	0	3.09
21	9.01	3.99	7.2	18.57	15.41	14.12	13.71	9.82	0	0	0	6.92
22	6.59	7.85	6.03	8.63	15.57	22.51	7.7	15.27	0	4.3	0	5.49
23	5.69	4.86	7.95	2.48	14.92	24.54	3.91	9.82	0	4.68	0	9.94
24	8.85	7.44	0.04	14.08	3.09	24.54	4.13	7.64	0	0.79	0	6.66
25	9.8	11.03	8.55	4.8	1.11	24.54	3.81	7.64	0	3.21	0	5.47
26	15.81	9.62	13.69	4.36	0	24.54	3.67	6.55	0	0.26	0.02	9.58
27	8.95	12.95	7.99	10.97	0	24.54	3.67	6.55	0	3.09	0.81	4.17
28	4.36	1.17	8.39	0.02	0	24.54	3.67	8.73	0	5.59	2.04	3.19
29	5.14		10.08	0	0	24.54	3.67	2.18	0	2.22	0.77	7.68

30	6.94		11.56	0	0	24.54	3.67	0	0	2.96	0	6.59
31	8.05		21.16		0		3.67	0		4.86		2.6
Total	271.45	237.52	296.49	349.67	172.85	431.79	362.23	310.94	1.09	36.20	24.43	95.41
Count	31	28	31	28	20	30	31	29	1	20	13	27
Average	8.76	8.48	9.56	11.66	5.58	14.39	11.68	10.03	0.04	1.17	0.81	3.08
Maximum	15.81	19.22	33.68	22.08	18.82	24.54	31.34	18.55	1.09	5.59	6.51	9.94
Minimum	4.36	1.17	0.04	0.00	0.00	6.03	3.67	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1995
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.54	14.58	9.12	19.54	17.95	20.97	26.44	13.9	0	0	5.32	4.22
2	0	17.53	6.21	21.34	14.06	25.73	17.95	12.77	10.31	0	31.54	7.06
3	0	14.16	11.05	21.24	78.8	23.58	17.79	8.21	15.59	0	3.07	6.84
4	3.31	12.08	5.3	19.3	0	20.87	12.26	3.33	10.29	0	5.83	4.74
5	12.6	15.13	12.2	23.52	0	22	13.79	5.67	9.34	0	6.17	3.33
6	3.35	10.53	20.63	23.25	0	12.4	10.51	2.36	8.51	0	6.13	2.64
7	5.02	9.9	4.94	25.19	0	13.69	11.9	6.09	9.48	0	1.45	4.9
8	1.17	9.94	13.41	24.5	3.43	10.43	8.31	3.93	3.59	0	0.16	10.45
9	4.22	10.83	17.36	21.94	0.16	13.51	17.93	2.4	0	0	0	2.26
10	4.9	9.28	12.2	12.2	6.27	13.75	12.04	7.46	5.53	0	0	2.56
11	3.17	9.42	5.32	16.4	4.64	12.77	4.21	11.84	0	0.54	0	0
12	2.8	10.31	13.92	22.83	5.59	16.13	1.05	78.76	0	4.17	0	6.07
13	2.82	15.27	12.34	23.8	8.71	14.62	5.85	76.84	0	6.9	0	9.01
14	2.32	17.02	10.85	19.8	0	11.27	9.24	0	0	3.87	0	6.31
15	4.15	13.63	5.91	18.8	0	9.06	13.63	8.47	0	2.54	1.39	4.15
16	8.93	12.83	7.97	23.46	0	13.9	10.35	10.59	0	8.37	5.99	4.38
17	4.52	11.23	10.75	27.79	0	2.66	4.92	18.43	0	10.1	8.41	3.07
18	0.34	13.47	14.62	25.35	0	0	1.43	18.94	0	10.35	6.43	0.83
19	0.18	18.15	9.46	27.55	0	0	0	15.95	0	9.32	3.99	0
20	3.09	13.15	6.66	19.3	0	3.17	0	7.42	0	11.9	5.12	5.02

21	2	10.16	0	23.82	0	1.75	5.34	2.52	0	10.91	5.36	7.99
22	2.34	7.02	0	30.72	0	5.41	7.6	0	0	8.11	6.11	11.94
23	3.85	10.49	1.33	23.11	0	3.11	8.79	0	0	3.77	8.77	6.17
24	2.84	7.99	11.39	20.75	0	0	3.77	12.4	0	4.24	2.54	6.8
25	2.88	6.59	7.46	18.98	0	9.6	0.34	15.75	0	7.95	6.19	11.25
26	2.86	15.45	5.67	31.02	0	14.36	0	19.46	0	5.95	7.52	5.99
27	6.33	12.38	13.49	32.01	0	8.79	7.22	18.43	0	8.57	7.06	8.81
28	8.27	19.36	12.73	25.11	0	14.36	11.33	15.87	5.47	2.52	3.51	9.62
29	9.28		28.9	23.05	0	15.57	13.01	14.08	0	2.54	1.75	8.47
30	12.6		22.73	30.98	3.49	24.24	11.23	8.55	0	0.26	2.96	8.07
31	12.97		24.79		16.6		14.5	0		1.31		0
Total	133.65	347.88	338.71	696.65	159.70	357.70	282.73	420.42	78.11	124.19	142.77	172.95
Count	29	28	29	30	11	27	28	27	9	21	24	28
Average	4.31	12.42	10.93	23.22	5.15	11.92	9.12	13.56	2.60	4.01	4.76	5.58
Maximum	12.97	19.36	28.90	32.01	78.80	25.73	26.44	78.76	15.59	11.90	31.54	11.94
Minimum	0.00	6.59	0.00	12.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1996
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	6.15	8.79	8.49	0.42	11.37	0.06	14.92	14.92	10.75	0	8.59	5.28
2	6.07	9.84	10.41	0	5.16	0.1	15.09	15.09	10.29	0	9.46	9.16
3	5.61	7.83	14.76	0	0.06	4.24	11.41	11.41	9.28	0	9.36	15.99
4	5.55	13.59	8.59	0	0.34	0	17.99	17.99	12.12	0	5.81	11.82
5	5.1	10.27	9.92	9.26	10.81	0	21.78	21.78	10.69	0	7.48	4.22
6	5.02	9.16	13.19	0.06	0.52	0.42	28.58	28.58	7.93	0	5.02	5.43
7	4.13	9.01	24.18	18.27	0	3.01	29.04	29.04	13.15	0	2.2	7.16
8	4.36	9.64	13.09	20.17	0	4.84	15.35	15.35	10.65	0	9.94	10.45
9	4.42	7.4	13.19	23.37	0	9.16	23.19	23.19	5.22	0	7.87	8.81
10	4.21	11.29	21.4	8.85	2.22	13.82	25.09	25.09	0.06	0	5.34	11.62
11	3.67	13.19	19.46	9.02	9.02	15.15	23.29	23.29	8.61	0	2.72	12.91

12	3.55	6.29	17.51	16.86	12.89	17.77	25.69	25.69	12.14	2.84	1.27	13.98
13	3.23	4.92	16.01	20.17	0.06	10.85	31.87	31.87	2.58	10.25	3.97	13.9
14	3.15	8.85	23.27	24.42	0.06	6.37	24.3	24.3	6.25	13.88	3.97	7.54
15	2.82	15.27	14.44	14.38	0.06	6.82	14.78	14.78	12.87	10.69	4.48	13.23
16	2.6	14.34	12.4	10.49	0.06	0	18.59	18.59	12.14	2.56	8.03	7.32
17	3.25	4.64	5.83	12.58	0.85	0	24.54	24.54	16.32	0.06	5.47	8.53
18	4.03	5.87	7.46	14.52	0.06	0	17.79	17.79	13.55	0.06	1.45	8.93
19	5.14	11.21	7.08	6.39	0.06	0.75	13.21	13.21	12.6	0.06	1.53	11.29
20	7.8	8.99	6.88	11.15	0.06	14.22	16.9	16.9	4.36	0.06	4.98	7.66
21	4.66	4.21	13.51	10.18	1.11	17.99	20.49	20.49	0	4.42	9.68	8.09
22	7.04	0.06	18.09	2.92	5.18	16.88	20.41	20.41	0	7.74	2.58	8.81
23	4.74	11.78	20.23	7.06	6.66	18.57	13.94	13.94	0	0.06	6.37	8.31
24	4.6	10.45	22.81	3.95	4.01	15.81	8.57	8.57	0	0.06	2.92	5.61
25	10.73	12.04	26.5	18.51	2.46	12.87	16.98	16.98	0	0.06	0.71	12.65
26	22.71	18.29	24.4	21.78	0.06	17.81	25.79	25.79	0	0.06	6.17	9.8
27	10.2	10.35	22.2	7.89	0.06	22.75	23.33	23.33	0	17.79	7.78	12
28	4.92	8.61	24.4	3.47	0.06	17.12	23.5	23.5	0	9.94	8.19	5.53
29	6.41	4.86	22.61	7.3	0.06	23.29	16.03	16.03	0	10.23	12	4.01
30	5.71		15.85	7.7	0.06	16.74	5.28	5.28	0	10.14	5.71	1.43
31	6.31		4.58		0.08		0.06	0.06		8.03		0.06
Total	177.89	271.04	482.74	311.14	73.46	287.41	587.78	587.78	191.56	108.99	171.05	271.53
Count	31	29	31	27	28	25	31	31	20	20	30	31
Average	5.74	9.35	15.57	10.37	2.37	9.58	18.96	18.96	6.39	3.52	5.70	8.76
Maximum	22.71	18.29	26.50	24.42	12.89	23.29	31.87	31.87	16.32	17.79	12.00	15.99
Minimum	2.60	0.06	4.58	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.71	0.06

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1997
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0.06	12.06	10.53	8.19	0	3.23	6.43	0.06	10.63	6.23	7.08
2	4.24	3.25	12.26	15.02	18.15	0	10.97	2.62	7.08	8.09	8.33	6.25
3	2.8	1.92	8.83	21.54	4.66	0	8.09	6.23	3.71	5.91	5.43	8.87
4	0	0.06	14.56	20.53	0	1.82	11.82	10.35	0	13.55	12.69	12.69
5	0	0.06	13.69	6.09	0	1.09	11.62	1.8	0	11.92	12.85	14.5
6	0	0.06	12.83	0.06	0	0	14.24	0	0	12.62	11.74	15.43
7	0	0.08	14.48	0.06	0.22	3.59	16.64	0	0	11.84	8.87	13.9
8	0	0.36	14.98	0.06	0.06	14.48	6.59	0	0	9.9	8.43	11.98
9	0	9.6	11.44	0.06	1.71	20.73	0.28	3.65	0	7.95	5.75	10.97
10	0	0.48	5.12	0.95	15.55	18.51	0	0	0.2	10.31	4.82	15.13
11	0	3.89	3.65	1.27	9.52	15.97	0	0	12.18	7.85	12.79	12.2
12	0	13.03	3.31	2.66	3.03	13.84	0	0	11.88	8.99	10.43	10.43
13	0	0.67	0.06	11.41	0	2.68	1.9	0	12.48	6.96	9.92	8.93
14	0	0	12.58	10.08	6.88	3.21	6.92	0	11.56	9.32	8.09	10.02
15	0	0	4.26	2.58	17.87	14.34	7.78	0	11.31	6.78	11.56	4.52
16	0	6.15	23.72	6.86	27.17	9.22	3.45	2.94	10.55	7.18	9.06	8.09
17	0	0.87	9.6	10.81	17.71	14.7	0	7.32	5.65	9.14	7.89	11.05
18	0	0.52	11.7	2.5	3.87	7.83	6.27	27.21	0	9.48	10.43	9.86
19	0	0.06	8.89	0.18	4.8	0.06	0.06	12.75	0	7.6	9.88	10.29
20	0	0.06	9.32	6.31	9.14	0.06	0.06	4.8	0	6.15	5.34	12.73
21	0.44	0.06	11.21	7.76	0	0.06	5.32	6.37	1.33	9.64	4.26	12.02
22	13.23	0.06	1.59	11.42	0	10.12	5.4	12.42	8.55	7.34	8.39	12.32
23	9.38	8.29	20.11	0.06	0	11.41	5.41	10.79	10.95	12.85	10.75	10.73
24	5.61	9.8	13.47	19.38	0	15.79	2.02	12.04	8.15	14.06	11.62	7.74
25	5.1	0.12	13.03	26.26	0	5.38	0.1	8.53	8.55	12.1	7.8	10.41
26	9.52	0.06	10.51	19.3	0	0	7.12	2.86	8.89	9.9	11.66	7.58
27	3.17	2.8	5.51	25.86	0	0	11.23	0.06	10.2	6.98	7.85	17.57
28	0	13.07	0.1	19.68	0	0	3.99	4.07	10.47	8.41	5.79	22.67
29	0		3.05	3.33	0	1.98	0	3.73	6.88	6.92	5.24	19.32
30	0		18.45	0.06	0	2.08	0	0	9.62	5.97	12.81	16.15
31	7.52		10.63		0		1.11	1.23		5.67		14.52
Total	61.01	75.44	315.00	262.67	148.53	188.95	151.62	148.20	170.25	282.01	266.70	365.95
Count	10	26	31	30	16	23	25	21	21	31	30	31

Average	1.97	2.69	10.16	8.76	4.79	6.30	4.89	4.78	5.68	9.10	8.89	11.80
Maximum	13.23	13.07	23.72	26.26	27.17	20.73	16.64	27.21	12.48	14.06	12.85	22.67
Minimum	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	5.67	4.26	4.52

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1998
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	8.03	3.21	3.45	15.57	21.34	49.75	15.47	23.78	13.92	3.59	4.22	7.3
2	6.76	6.47	3.97	25.75	20.69	29.63	24.36	21.32	23.31	9.64	7.6	7.46
3	7.83	9.54	6.66	25.86	26.38	7.78	45.22	20.89	25.03	1.98	9.16	5.57
4	12.69	16.09	8.45	30.53	24.79	31.44	60.79	21.32	25.83	11.94	10.37	0.81
5	13.88	13.37	8.87	25.81	28.36	23.19	55.78	19.1	19.12	14.8	10	9.04
6	8.09	7.02	10.35	22.85	43.34	5.83	52.68	17.45	23.82	7.24	7.68	10.71
7	10.81	11.74	9.74	34.04	28.7	20.57	52.09	15.39	20.73	7.48	10.31	6.74
8	11.52	8.51	15.83	35.6	51.57	34.2	48.66	18.05	15.53	0	16.26	3.77
9	8.55	22.04	14.18	27.35	57.28	11.66	31.44	19.2	16.98	3.97	17.14	6.37
10	14.8	3.75	9.06	31.82	47.05	26.64	29.38	27.93	18.37	16.5	6.66	5.63
11	17.47	3.67	5.59	36.18	57.12	35.13	31.93	23.86	18.29	18.82	6.01	7.83
12	11.46	11.13	7.4	31.99	42.15	33.12	27.25	21.28	13.05	10.47	5.79	8.67
13	9.1	5.73	7.83	33.5	40.58	15.25	37.73	22.39	17.49	12.75	3.95	14.38
14	4.92	13.45	7.7	30.19	49.25	9.92	38.38	19.6	11.33	16.32	5.3	11.15
15	4.44	24.85	16.28	23.19	42.43	10.51	41.95	25.37	14.06	0	6.57	5.51
16	5.73	3.79	16.23	32.31	35.78	14.08	36.12	29.65	3.59	0	10.81	0.24
17	10.55	11.98	7.58	22.16	21.7	24.91	39.29	31.36	0	0	7.3	11.13
18	6.29	26.48	6.59	17.73	23.17	22.41	39.99	38.08	2.3	0	5.93	15.03
19	11.01	8.07	10.06	22.04	23.52	28.78	36.34	28.6	4.17	0.99	8.03	12.24
20	13.47	14.74	17.51	26.38	10.2	47.39	24.85	29.49	13.9	0	9.4	9.58
21	4.34	12.2	21.44	24.83	14.4	35.19	21.2	19.46	13.01	2.92	6.13	11.17
22	8.21	20.95	22.99	25.15	7.58	24.93	26.42	23.54	13.71	5.59	4.98	9.16

23	13.17	25.85	21.22	26.58	20.05	22.75	26.24	26.44	11.74	2.14	2.46	10.93
24	6.72	24.58	20.87	25.15	17.36	23.25	20.99	25.25	12.58	18.13	0.06	13.09
25	8.91	9.26	25.75	17.91	24.81	25.05	23.27	24.1	8.21	20.75	1.45	12.28
26	8.85	7.74	28.32	22.51	32.53	7.22	32.29	21.08	2.42	19.82	11.84	3.33
27	7.08	10.25	23.05	28.21	36.2	9.3	35.48	22.27	9.24	13.31	10.22	3.65
28	7.7	7.81	22.61	28.9	32.35	22.97	24.71	20.49	3.01	5.89	15.43	6.88
29	9.98		37.77	32.45	40.6	25.81	30.45	9.1	9.5	2.76	11.78	7.34
30	7.83		41.89	29.69	39.73	21.54	29.67	7.08	10.59	5.95	8.77	7.85
31	8.53		21.76		51.77		23.15	9.62		5.75		5.65
Total	288.72	344.27	481.00	812.23	1,012.78	700.20	1,063.57	682.54	394.83	239.50	241.61	250.49
Count	31	28	31	30	31	30	31	31	29	25	30	31
Average	9.31	12.30	15.52	27.07	32.67	23.34	34.31	22.02	13.16	7.73	8.05	8.08
Maximum	17.47	26.48	41.89	36.18	57.28	49.75	60.79	38.08	25.83	20.75	17.14	15.03
Minimum	4.34	3.21	3.45	15.57	7.58	5.83	15.47	7.08	0.00	0.00	0.06	0.24

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 1999
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	8.33	4.74	10.39	31.78	18.35	17.95	17.91	13.84	18.51	11.72	13.73	7.68
2	5.61	12.75	12.95	52.78	23.58	16.15	22.75	14.04	18.51	11.72	9.48	10.31
3	5.51	12.69	14.76	28.7	19.99	16.03	27.77	14.84	18.51	10.91	6.62	12.28
4	4.34	11.86	12.79	24.4	18.07	18.64	26.88	16.13	18.51	9.04	5.91	17
5	4.84	19.7	19.18	18.07	19.24	21.38	21.01	13.37	18.51	10.04	5.57	16.62
6	4.56	19.2	35.9	18.94	21.98	28.21	18.86	12.95	18.51	8.89	5.38	8.57
7	8.41	14.02	28.58	20.63	22.43	29.28	16.74	12.42	18.51	12.26	6.43	4.28
8	10.47	13.23	27.15	23.6	23.84	25.03	23.17	11.39	18.51	15.53	5.24	9.64
9	14	12.18	25.73	25.57	20.69	30.55	6.07	10.37	18.51	14.56	7.3	11.15
10	6.47	7.54	21.96	32.43	17.55	16.01	0	11.05	18.51	13.23	8.55	10.1

11	7.08	13.35	19.04	32.63	15.05	15.27	0	12.42	16.13	11.68	8.93	10.37
12	8.15	18.35	11.56	31.78	21.3	14.38	0	13.61	16.13	10.93	9.01	10.1
13	8.77	13.75	14.3	38.02	20.53	25.67	0	13.84	16.13	10.08	6.92	9.56
14	11.9	10.97	17.77	35.9	25.17	23.23	0	13.84	16.13	6.9	5.55	8.55
15	5.77	11.07	19.14	29.85	23.07	25.59	0	15.55	16.13	9.62	5.71	7.81
16	5.89	7.95	19.16	28.46	24.16	27.79	0	16.13	16.13	12.08	4.52	10.93
17	12.95	6.59	20.63	30.37	25.39	28.9	0	16.13	16.13	14.06	6.88	9.08
18	8.39	8.93	15.49	28.62	22.95	22.04	0	16.13	16.13	13.13	6.19	11.07
19	9.26	10.2	11.7	24.3	28.44	25.49	0	16.13	16.13	9.22	7.95	13.33
20	11.66	15.17	11.7	30.09	27.51	28.34	0	14.84	16.13	8.69	9.26	15.35
21	7.85	19.08	13.53	18.35	25.47	26.36	0	11.03	11.72	12.71	6.98	17.38
22	10.73	13.75	15.27	22.06	24.71	23.92	0	11.03	11.72	13.47	5.51	13.53
23	10.22	14.52	19.32	28.3	26.78	24.42	0	11.03	11.72	14.72	4.21	12.12
24	9.58	18.9	20.39	26.24	20.73	34.49	0	11.03	11.72	9.72	4.01	10.89
25	8.21	20.89	24.91	15.03	18.92	28.17	0	12.44	11.72	13.55	8.85	3.07
26	10.39	18.66	31.06	15.13	18.53	21.74	0	13.13	11.72	14.4	10.43	10.65
27	10.69	17.34	25.53	14.46	20.53	24.5	0	17.24	11.72	17.77	7.93	18.9
28	6.53	9.06	25.53	16.4	24.62	17.18	0	18.98	11.72	12.46	8.35	13.88
29	7.5		27.09	23.01	24.67	16.54	0	17.69	11.72	10.77	4.03	19.72
30	9.82		23.43	21.14	25.03	19.1	0	17.89	11.72	27.09	5.08	24.22
31	7.46		23.84		23.19		0	18.51	18.51	9.32		18.23
Total	261.34	376.44	619.78	787.04	692.47	692.35	181.16	439.02	482.11	380.27	210.51	376.37
Count	31	28	31	30	31	30	9	31	31	31	30	31
Average	8.43	13.44	19.99	26.23	22.34	23.08	5.84	14.16	15.55	12.27	7.02	12.14
Maximum	14.00	20.89	35.90	52.78	28.44	34.49	27.77	18.98	18.51	27.09	13.73	24.22
Minimum	4.34	4.74	10.39	14.46	15.05	14.38	0.00	10.37	11.72	6.90	4.01	3.07

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 2000
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.58	15.67	7.56	21.68	29.93	15.51	19.42	23.09	14.74	13.19	0.42	9.54
2	2.38	14.28	4.03	20.77	30.76	17.36	20.23	20.75	13.23	16.4	11.44	11.15
3	5.87	14.02	6.74	19.32	27.39	14.96	21.56	18.76	14.56	20.91	12.52	12.04
4	7.2	13.53	6.62	26.1	25.85	19.6	16.17	23.15	15.27	17.47	1.65	11.39
5	11.76	12.73	8.49	26.44	20.11	19.12	12.26	18.19	13.03	15.73	0.79	4.46
6	6.51	13.61	33.72	15.95	21.03	19.28	20.07	22.2	10.83	15.93	3.37	3.61
7	6.98	11.76	12.79	13.75	23.21	27.73	21.3	19.82	14.5	23.9	6.61	2.22
8	10.95	16.9	5.1	20.73	21.38	34.26	26.78	21.82	17.75	19.97	6.78	4.62
9	7.18	20.37	7.68	23.9	21.72	29.53	25.79	16.86	12.28	24.12	8.93	7.38
10	7.1	14.12	7.72	23.92	18.9	28.92	30.59	18.8	14.04	14.58	11.11	9.2
11	4.28	14.44	4.3	22.43	25.55	28.54	21.76	16.26	15.47	5.63	10.04	10.75
12	5.2	16.88	5.14	23.56	21.03	26.82	19.48	18.07	10.25	11.68	11.86	4.46
13	6.62	12.87	5.26	25.53	20.61	25.81	25.21	23.64	12.26	9.32	15.03	4.24
14	9.3	12.06	6.27	19.99	21.48	25.09	19.62	21.82	8.01	8.07	12.93	5.61
15	11.56	10.89	8.77	27.39	23.29	17.95	14.8	17.73	21.72	8.63	14.82	4.19
16	8.45	12.85	10.87	27.23	20.19	16.05	19.95	28.88	21.62	10.93	17	6.05
17	6.72	11.66	17.65	26.62	24.2	20.19	22.43	28.8	21.18	10.22	16.6	4.92
18	10.97	13.75	15.69	32.41	21.94	27.41	21.52	20.93	18.41	14.52	14.66	5.02
19	10	9.52	13.94	30.33	23.21	23.86	22.41	19.82	17.93	13.49	9.48	8.05
20	3.23	6.27	16.11	29.91	27.87	27.05	27.55	14.94	15.09	19.89	16.58	6.43
21	3	4.11	16.48	32.35	28.94	31.84	29.36	18.07	14.62	32.05	20.11	2.8
22	12.18	3.11	13.15	27	23.98	27.69	28.68	13.15	16.23	10.81	14.54	4.74
23	9.64	5.77	13.98	24.18	29.81	22.81	26.92	13.49	13.07	11.54	9.08	5.36
24	8.83	7.48	19.8	25.59	21.42	18.8	17.47	14.66	24.12	11.29	10.18	7.97
25	12.3	7.24	10.69	25.86	22.93	27.73	21.2	14.72	16.76	10.73	7.46	8.59
26	15.47	14.68	12.69	28.8	19.7	28.46	19.89	17.38	17.22	21.18	7.93	3.53
27	15.51	15.15	16.21	22.41	21.36	29.57	22.35	15.15	19.89	9.12	3.69	12.5
28	16.68	9.02	18.09	21.12	20.99	24.48	27.55	14.98	19.28	2	5.79	21.28
29	13.9	6.68	13.84	23.72	15.33	24.02	21.68	16.62	14.9	3.95	9.38	24.62
30	14.54		14.96	27.71	20.07	26.86	18.86	12.81	13.96	3.79	5.53	22.87
31	12.93		19.42		17.06		21.12	8.93		0.79		16.68
Total	284.82	341.42	373.76	736.70	711.24	727.30	683.98	574.29	472.22	411.83	296.31	266.27

Count	31	29	31	30	31	30	31	31	30	31	30	31
Average	9.19	11.77	12.06	24.56	22.94	24.24	22.06	18.53	15.74	13.28	9.88	8.59
Maximum	16.68	20.37	33.72	32.41	30.76	34.26	30.59	28.88	24.12	32.05	20.11	24.62
Minimum	2.38	3.11	4.03	13.75	15.33	14.96	12.26	8.93	8.01	0.79	0.42	2.22

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 2001
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	19.7	3.83	5.38	21.66	12.83	24.18	17.04	19.08	19.08	13.05	17.87	6.37
2	12.62	3.93	5.97	26.4	14.64	27.37	22.65	16.64	16.64	2.96	21.22	5.34
3	12.4	4.38	5.45	24.56	17.24	32.03	30.09	17.08	17.08	0	18.96	6.01
4	13.82	8.33	8.61	34.93	20.89	21.54	32.17	9.94	9.94	0	14.3	1.61
5	9.74	10.45	12.06	39.81	23.01	27.19	37.15	0.08	0.08	0	15.05	2.88
6	7.26	7.76	9.26	30.92	23.7	20.63	39.04	15.65	15.65	3.69	8.79	5.02
7	8.69	10.51	16.09	27.71	20.29	2.9	20.71	10.2	10.2	12.83	11.72	1.19
8	8.73	12.2	7.7	21.08	23.29	4.46	16.96	0.3	0.3	6.37	10.71	0.12
9	9.94	11.58	8.31	16.86	15.09	10.16	27.35	13.88	13.88	0	9.5	2.68
10	14.3	4.7	4.94	19.97	21.24	12.75	25.88	8.51	8.51	0.95	11.09	4.28
11	11.33	4.42	6.37	14.34	24.56	9.24	25.81	8.67	8.67	7.78	9.64	2.1
12	7.99	3.27	2.58	17.02	17.71	5.4	25.96	17.08	17.08	2.56	11.62	1.98
13	3.39	11.68	4.54	12.69	15.33	4.01	27.21	6.64	6.64	13.67	5.67	0.44
14	9.36	10.06	5.12	14.24	18.23	0.69	19.36	5.26	5.26	9.86	8.23	1.94
15	8.75	10.73	5.4	18.45	15.23	11.13	16.7	12.67	12.67	2.14	11.07	0
16	4.86	7.95	6.47	19	9.72	6.66	23.01	8.79	8.79	0.6	12.99	0
17	9.64	10.2	10.2	25.59	16.52	6.78	14.3	4.46	4.46	0	15.73	0
18	2.46	11.84	5.85	21.5	18.63	3.41	18.61	2.54	2.54	0	20.35	0
19	10.02	12.2	11.31	23.84	15.67	3.55	16.62	0	0	6.82	10.77	4.24
20	12.71	13.27	15.63	24.1	17.93	8.77	22.51	0	0	4.34	15.05	5.1
21	9.04	17.12	13.01	21.08	19.42	20.55	21.32	0	0	6.53	15.95	4.9
22	6.72	11.41	12.48	21.86	17.38	23.44	24.52	6.31	6.31	13.59	11.13	4.6
23	9.66	7.28	14.5	31.44	13.98	17.77	18.94	9.3	9.3	16.54	11.72	11.35
24	7.4	5.18	15.53	27.81	25.81	19.42	20.05	8.71	8.71	20.47	7.42	8.21
25	6.45	6.39	18.64	20.59	17.85	24.91	20.03	0	0	22.47	7.72	7.64

26	6.98	4.82	14.88	21.72	22.12	24.38	17.43	0	0	9.06	7.28	8.77
27	20.39	5.65	15.77	15.19	29	16.68	12.34	0	0	6.41	10.06	12.18
28	3.51	5.28	19.26	20.97	27.69	17.71	13.81	0	0	9.1	11.78	14.14
29	2.2		17.93	21.8	25.65	16.62	30.86	2.3	2.3	12.42	10.79	13.47
30	2.74		14.6	13.41	17.77	57.36	24.5	1.65	1.65	15.77	8.91	19.8
31	3.73		20.01		19.34		21.26	0		11.58		19.28
Total	276.53	236.42	333.85	670.54	597.76	481.69	704.19	205.74	205.74	231.56	363.09	175.64
Count	31	28	31	30	31	30	31	23	23	25	30	27
Average	8.92	8.44	10.77	22.35	19.28	16.06	22.72	6.64	6.86	7.47	12.10	5.67
Maximum	20.39	17.12	20.01	39.81	29.00	57.36	39.04	19.08	19.08	22.47	21.22	19.80
Minimum	2.20	3.27	2.58	12.69	9.72	0.69	12.34	0.00	0.00	0.00	5.67	0.00

Source: SRP Daily Flow Records

MARICOPA DRAIN
DAILY FLOW RECORDS - 2002
(units are in acre-feet)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.46	4.9	12.69	14.36	14.96	14.98	15.09	0.4	3.97	8.13	7.74	1.39
2	2.54	6.7	16.36	11.21	16.24	16.24	12.08	0.6	7.34	12.1	2.98	14.88
3	5.73	9.7	18.8	14.12	12.91	16.7	17.18	1.19	11.9	12.3	3.77	20.43
4	7.8	9.32	17.12	19.04	12.87	14.8	17.22	0.99	8.13	10.12	5.36	16.66
5	7.08	9.68	14.34	23.05	13.17	11.68	17.42	1.19	16.26	6.55	5.95	10.91
6	7.78	10.63	14.7	23.15	12.95	16.46	15.11	1.39	10.12	7.54	10.91	10.91
7	6.11	7.26	9.9	25.94	12.4	15.71	14.66	1.59	10.51	4.36	8.33	12.1
8	2.9	10.67	7.89	27	14.4	15.33	9.9	1.79	15.07	5.16	6.55	8.93
9	8.07	7.72	6.53	27.93	12.77	12.93	10.63	2.18	9.92	9.12	3.17	3.17
10	11.35	9.16	13.31	24.75	11.13	13.01	13.57	1.79	5.75	2.18	1.79	0.2
11	12.81	13.25	18.57	17.36	14	16.38	16.96	1.98	2.58	14.28	0.99	0
12	11.15	13.84	13.88	9.84	21.24	12.75	14.1	1.79	1.79	8.73	6.15	0.2
13	7.64	12.67	16.84	15.69	12.73	18.41	17.42	1.59	4.36	9.92	2.38	2.18
14	8.83	13.07	15.43	22.83	11.64	19.38	20.03	1.19	1.59	10.91	6.15	1.19
15	12.95	11.17	17.55	22.79	15.41	16.92	9.74	0.6	8.13	14.68	3.17	4.96
16	11.6	15.05	12.08	15.03	16.4	18.96	4.07	0.79	10.91	10.71	0.6	5.75
17	8.75	6.05	16.86	18.59	20.79	17.75	2	0.4	7.34	5.16	2.98	0.6
18	3.67	3.91	15.17	18.84	22.39	18.01	7.99	1.19	9.92	2.58	2.38	3.77
19	5.41	8.03	14.08	15.79	20.87	20.25	9.78	1.39	10.71	2.78	3.37	3.37
20	5.3	10.02	14.66	12.97	19.72	24.85	9.4	1.19	10.12	9.52	4.17	7.54
21	5.91	10.81	16.42	20.95	27.07	17.49	8.19	1.39	10.12	17.26	7.14	10.12
22	9.01	9.84	13.81	23.29	25.13	15.13	8.75	0.99	11.7	18.25	8.73	12.89
23	11.11	6.66	22.67	19.04	24.44	31.42	6.88	0.99	3.57	16.66	11.9	7.14
24	11.5	5.22	26.96	8.87	16.07	37.27	5.04	0.6	8.53	17.45	13.69	6.74
25	11.62	13.84	18.8	14.66	17.42	28.88	4.76	0.6	14.88	24.99	13.69	2.98
26	11.8	16.72	17.53	21.48	16.8	16.44	0	0.99	10.12	37.29	6.94	3.57
27	12.65	11.07	23.11	13.86	17.75	20.65	0	0.6	7.54	12.1	13.49	3.97
28	8.13	6.7	20.89	10.83	16.66	28.38	0	0.6	14.68	12.3	13.49	3.97
29	5.28		18.7	12.71	18.61	25.53	0	0.4	8.13	11.11	12.89	4.76
30	7.4		16.86	18.23	14.5	24.26	7.74	0.4	12.89	11.11	11.9	2.38
31	8.87		20.05		14.76		15.43	0.4		10.31		4.76
Total	258.21	273.66	502.56	544.20	518.20	576.95	311.14	33.18	268.58	355.66	202.75	192.42
Count	31	28	31	30	31	30	27	31	30	31	30	30
Average	8.33	9.77	16.21	18.14	16.72	19.23	10.04	1.07	8.95	11.47	6.76	6.21
Maximum	12.95	16.72	26.96	27.93	27.07	37.27	20.03	2.18	16.26	37.29	13.69	20.43
Minimum	2.54	3.91	6.53	8.87	11.13	11.68	0.00	0.40	1.59	2.18	0.60	0.00

Source: SRP Daily Flow Records

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX C

GROUNDWATER MODELING

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

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I. INTRODUCTION

1.1 STUDY AREA AND GROUNDWATER MODELING AREA

The U.S. Army Corps of Engineers (USACE) and the City of Phoenix (COP) have initiated a feasibility study for the Rio Salado Oeste Project to evaluate the design and completion of riparian habitat restoration along the Salt River in Phoenix area. The study area is located along the Salt River, in Phoenix, Arizona, between 19th Avenue and 83rd Avenue. The study area is located in between the authorized Rio Salado Project area and the authorized Tres Rios Project area. The Oeste study area is approximately eight river miles in length. In comparison, the authorized Phoenix reach of the Rio Salado project is five miles long and the Tres Rios study area is about seven miles long. Figure 1 shows the modeling area of the groundwater flow model study. The modeling area is bounded by 40th Street on the East, one mile from 115th Avenue on the West, one mile from Highway I-10 on the North, and Estrella Street on the South. As shown in the figure, the study area is in the central portion of the modeling area and is bounded by 19th Avenue, 83rd Avenue, Buckeye Road, and Baseline Road. The selection of a larger area for groundwater modeling is to avoid the effect from the boundary conditions to the study area.

1.2 PURPOSE OF THE GROUNDWATER MODELING TASK

The groundwater modeling task for this study includes a review of previous studies for the Salt River watershed, development of a site-specific groundwater flow model, and evaluation of project alternatives using the groundwater flow model. The regional groundwater flow model for the Salt River Valley developed by Arizona Department of Water Resources (ADWR) is reviewed and is adapted for the model development. Groundwater model is constructed and will be calibrated for baseline conditions. The developed model will be used to evaluate the impact to the local groundwater due to the selected alternatives.

II. HYDROGEOLOGICAL SETTING

The Rio Salado study area is located in the Phoenix Active Management Area (AMA) and is comprised of portions of two distinct but interconnected alluvial groundwater basins. These basins, West Salt River Valley (WSRV) and East Salt River Valley (ESRV), are shown on Figure 2.

The subsurface geologic conditions in the Salt River Valley (SRV) are described by the USBR (1976), the USGS (Laney and Hahn, 1986; Brown and Pool, 1989), and by ADWR (Corkhill, 1993). All three investigations divide the basin-fill sediments into three hydrogeologic units. However, the units have sometimes been defined differently. This report uses the most recent division of hydrogeologic units, as described by ADWR.

There are three hydrogeologic units: the lower alluvial unit (LAU), the Middle Alluvial Unit (MAU), and the Upper Alluvial Unit (UAU). There is also a Red Unit which forms the base of the aquifer beneath parts of the area. The LAU overlies the Red Unit and consists mainly of conglomerate and gravel. The LAU is tapped by many city wells and it is estimated that

approximately 25 percent of the pumpage in the SRV originates from this unit (ADWR, 1993). The LAU may be less than 100 feet thick near the basin margins and several thousands of feet thick in the central areas of the basins. The MAU overlies the LAU and consists mainly of clay, silt, mudstone and some sand and gravel. The unit ranges in thickness from 100 feet to over 1600 feet in the deeper parts of the basin. The MAU is now the primary source of groundwater in the valley. ADWR estimated that about one half of the total pumpage in the valley is from the MAU. The UAU overlies the MAU and consist primarily of gravel, sand and silt. The amount of coarse-grained deposits in this unit is highest near the Salt and Gila Rivers. The thickness of the UAU is relatively uniform and ranges from 200 to 300 feet thick in ESRV and between 300 and 400 feet thick in the WSRV. In the past, the UAU was the primary source of groundwater in the valley, but because of lower water levels (decreased groundwater elevations) and large areas of poor quality water, only about one fourth of groundwater pumped in the valley is from the UAU. Important sources of recharges to groundwater in the valley include infiltration of Salt River flows, mountain recharge along the McDowell and Superstition Mountains, percolation of excess irrigation water, and canal seepage. Figure 3 shows the Salt River Valley generalized geologic cross-section. The location of the cross-section is shown in Figure 2.

The UAU is divided into four subunits within the study area (URS, 2002). These subunits are designated from youngest to oldest as S, A, B, and C. These subunits appear to be essentially horizontal within the study area and no significant geologic structures have been identified.

- **Subunit S** is exposed at the surface near the river and consists of silty sand with clay and gravel. This unit is typically unsaturated in the vicinity of the Salt River.

- **Subunit A** is further subdivided into Subunits A_1 and A_2, and is generally comprised of sandy gravel and cobbles. Subunit A_1 extends to a depth of 90 to 110 feet below ground surface (bgs) and consists of unconsolidated, poorly sorted, coarse sand and gravel. The primary difference between A_1 and A_2 is that Subunit A_2 contains 30 to 40 percent fine to coarse sand versus 5 to 20 percent in Subunit A_1. In addition, Subunit A_2 is typically better sorted than A_1. The contact between these subunits is gradational and is identified by a transition from coarse to medium-sized gravel, increased roundness, and greater amounts of fine sand and silt (Dames & Moore, 1991). In the vicinity of the 19th Avenue Landfill Subunit A_1 was observed to be about 100 feet thick, and Subunit A_2 was observed to be about 90 feet thick.

- **Subunit B** underlies Subunit A_2 and is dominated by coarse to fine sand, silt, clay, and minor gravels. Subunit B is distinguished by its reddish-brown color and finer-grained nature. In the vicinity of the 19th Avenue Landfill Subunit B was observed to be about 40 feet thick.

- **Subunit C** underlies Subunit B and primarily consists of fine to medium sand, angular to subrounded fine gravel, minor silt, and clay. The transition from Subunit B to Subunit C is identified by an increase in grain size and a color change to brown. In the vicinity of the 19th Avenue Landfill Subunit C was observed to be about 150 feet thick.

III. HYDROLOGIC SYSTEM

3.1 PREDEVELOPMENT HYDROLOGIC SYSTEM

The predevelopment hydrologic system of the Salt River Valley is described by the ADWR. Prior to the arrival of non-Indian settlers in the 1860's and 1870's, the hydrologic system in the SRV was in a state of equilibirum. Flows into and out of the SRV were in approximate balance and water levels generally remained constant. The main components of the predevelopment groundwater budget were underflow, stream channel infiltration, mountain front recharge, and evapotranspiration. An approximate predevelopment groundwater budget is presented in Table 1 and the components are described below.

3.2 GROUNDWATER FLOW

In general, groundwater moved east to west through the SRV. Most of the Salt River Valley groundwater moved in a direction towards the lower topographic areas. Substantial groundwater flow underflow moved northwestward along the Gila River and passed through the gap between the South Mountain and the Sierra Estrella.

3.3 STREAM RECHARGE

Prior to development of the valley and construction of upstream reservoirs, the Salt and Gila Rivers were perennial throughout the SRV. The rivers were significant sources of groundwater recharge in some areas and recipients of groundwater discharge in other areas. The reaches of the river can be classified as losing or gaining. The rivers 'lose' water where the groundwater table elevation is lower than the water level in the river channel. Similiarly, the river 'gains' when groundwater is discharged into the river, where the water table is higher than the water level in the channel. ADWR estimated the total recharge from the Agua Fria River, Cave Creek, New River, Skunk Creek, and Queen Creek to be about 20,000 acre-feet per year.

3.4 MOUNTAIN FRONT DISCHARGE

Mountain-front recharge is water that infiltrates into the alluvial material along the interface between mountains and the alluvial groundwater basin. The amount of mountain-front recharge depends on average precipitation. The ADWR estimated that mountain-front recharge in the SRV is only significant along the McDowell and Superstition Mountains.

3.5 EVAPOTRANSPIRATION

Under predevelopment conditions, ADWR identified evapotranspiration as the major source of discharge from the groundwater system in the SRV. Evapotranspiration is the process of evaporation from water surfaces and moist soil and transpiration from vegetation. During the predevelopment period, there were approximately 48,000 acres of phreatophytes along the Salt and Gila Rivers. ADWR used an evapotranspiration rate of 1.6 acre-feet per acre per year to estimate a loss of 76,000 acre-feet per year.

3.6 MODERN HYDROLOGIC SYSTEM

Irrigation was originally developed by diversion of streamflow into canals. By the turn of the century, much of the valley was waterlogged, due to recharge from canal seepage and deep percolation, combined with a lack of groundwater pumping. Beginning in the 1920's and 1930's, substantial groundwater pumpage began for irrigation and to control shallow groundwater levels. Following World War II, extensive pumpage began, primarily for irrigation. This resulted in extensive groundwater overdraft. With the advent of the State Groundwater Management Act, the extent of overdraft has been curtailed through management procedures such as decreased irrigation pumpage, water conservation pratices, and irrigational recharge projects. By the late 1980's, water levels within the Salt River Project had essentially stabilized. Continuing overdraft was present, however, in some off-project areas.

3.7 REGIONAL STATIC GROUNDWATER-LEVEL CONDITIONS

ADWR published "Maps Showing Groundwater Conditions in the Phoenix Active Management Area" in July 1995. The detailed groundwater survey of fall and winter 1991-92 was the first one in which water levels in wells were measured in all seven sub-basins of the Phoenix Active Management Area at about the same time. The vast majority of the more than 2,000 measurements were made during November 1991. Field work continued intermittently in the area through January 1992 in order to obtain additional data to provide acceptable coverage.

On the regional scale groundwater is generally moving laterally toward extensive and deep depressions in some of the main aquifer systems. In the East Salt River sub-basin, major groundwater depressions are centered in the Scottsdale-Paradise Valley area, in east Mesa, and north of the Santan Mountains. A depression in the vicinity of the community of Maricopa in the Pinal Active Management Area is apparently diverting groundwater from the southern part of the East Salt River sub-basin near the Gila River.

Significant water-level or head differences exist in proximate wells within some of the main aquifer systems. During the 1991-92 measurement period, differences exceed 25 ft in several places, and exceeded 400 ft in a small area north of the Santan Mountains in the East Salt River sub-basin. The major areas of these differences are located in the East Salt River sub-basin, and extend from north Scottsdale to south Chandler to the southeast part of the sub-basin. They are separated by the Salt River. Presumably, the higher water levels are mostly the result of fine-grained deposits in the upper basin fill which inhibit downward movement of water. Much of these areas corresponds to areas described as having perched groundwater in the upper unit by Laney and Hahn (1986), and to a regional perched zone described by Schmidt based on work done by the U.S. Bureau of Reclamation and the U.S. Geological Survey in 1972 (1981).

3.8 REGIONAL GROUNDWATER-LEVEL CHANGES

For the time periods extending from the detailed water-level surveys of fall and winter 1981-82 and 1982-83 to that of fall and winter 1991-92, data indicate there were general rises in water levels in the study area. During the respective periods, pumpage was reduced compared to the recent past, and abundant surface water was available in many areas, with much of this surface water becoming incidental recharge. Measurements in 1991-92 were made in approximately

1,150 wells that had also been measured in the earlier survey. Of these, only about 100 wells exhibited declines in water levels during the respective periods.

In the main aquifer system, water level rises of 50 feet or more occurred in many wells in all of the major groundwater depressions mentioned in the previous section except in the south portion of the Hassayampa sub-basin, where maximum rises of about 20 feet occurred over the respective time period. The rises in all of these groundwater depressions were probably due primarily to the combined effect of reduced pumping and migration of groundwater from adjacent areas.

In general, water levels declined during the period in much of the areas near the Salt, Gila, and Agua Fria Rivers in the West Salt River sub-basin. The declines were generally less than 25 feet. An explanation for at least part of these declines could be that when the survey was conducted in 1982-83, water levels near these rivers were still elevated due to the especially large flood flows that began in late 1978 and continued off and on through 1981. Part of the rises in areas adjacent to areas of decline might be explained by lateral groundwater movement away from the rivers, where the groundwater had been introduced as recharge during the flood flows. Similarly, this type of process may explain part of the declines and rises in the vicinity of the Town of Queen Creek, near the course of Queen Creek itself, in the East Salt River sub-basin.

III. CURRENT GROUNDWATER CONDITION IN THE STUDY AREA

URS (April 2002) conducted a groundwater quality and hydrogeology study for the Rio Salado Oeste Project. The current groundwater condition in the study area was presented in the URS study report. According to the URS report, groundwater generally occurs under unconfined conditions within the UAU. Groundwater flow in the eastern third of the study area (east of 39th Avenue) is generally from the south to north-northwest toward the RID well field located along or north of Lower Buckeye Road between 19th and 35th Avenue. The groundwater gradient is steepest to the north with values as high as 0.008 ft/ft in the vicinity of 35th Avenue and Lower Buckeye Road. The groundwater flow direction in the western two thirds of the study area (west of 39th Avenue) ranges from northwest to west. The groundwater gradient flattens to the west with values as low as 0.002 ft/ft. Static water level is relatively shallow, ranging from 20 to 50 feet below ground surface within the Salt River channel to 60 to 80 feet below ground surface north and south of the river.

Fluctuations in static water level can be as much as 20 to 30 feet on an annual basis due to agriculture pumping demands, and have declined as much as 25 feet in the last five years (Dames & Moore, 1991; Parsons Engineering Science, 2001). Hydrographs of selected wells show this decline is most pronounced in the eastern portion of the site near the RID wellfield. The selected wells provided static water levels from both ends of the study area that have the most complete water level records. Contributing factors that may cause the fluctuations are water discharge from the 35th Avenue water treatment plant outfall during winter months that produces groundwater mounding, and related radial flow during periods of discharge and basin-wide groundwater pumping and storm water runoff into the Salt River.

A groundwater contour map of the study area was prepared using ADWR well data from 1997 because it represented the most complete data set available (Figure 4). ADWR collected many water levels from both production and monitoring wells in the month of October, at the end of the pumping season. Water levels represent static values prior to significant precipitation. Some data outside of the Study Area were incorporated while contouring to fill data gaps. The hydrographs were prepared and reviewed to validate whether the contour map is representative of current conditions. In general the selected wells show a consistent water level decline without radical changes in gradient direction. Therefore, while the groundwater elevation has declined approximately 10 to 20 feet since 1997, the current contours are likely to be similar to the 1997 contours (URS, 2002).

IV. DEVELOPMENT OF A GROUNDWATER FLOW MODEL

The Arizona Department of Water Resources (ADWR) has developed a regional groundwater flow model of the Salt River Valley. The goal of the SRV groundwater modeling effort is to provide an analytical tool capable of quantifying the effects of various groundwater management and conservation scenarios on the groundwater supplies within the study area. The SRV groundwater model uses 3D-MODFLOW and has been calibrated under steady state and transient conditions. Based on the SRV groundwater model, a site-specific model along the Rio Salado Oeste study area was developed to assist in the wetland restoration, groundwater infiltration, and drawdown analysis. General model characteristics are presented in this section below.

5.1 MODEL GRID

The site specific model grid is 100 rows by 190 columns, with 3 layers and is aligned with the local baseline and meridian. The north and south boundaries of the model are one mile north of Mc Dowell Road and Estrella Road respectively, while the east and west boundaries are 40th Street and one mile west of 115th Avenue. Model cells are one-tenth mile in length and width. Each model layer corresponds to a single hydrogeologic unit. The active model domain encompasses 190 square miles. Figure 5 presents the model grid.

5.2 MODEL LAYER AND AQUIFER CONDITIONS

Three model layers were used to represent the hydrogeologic system. The uppermost layer, Layer 1, corresponds to the Upper Alluvial Unit (UAU). The UAU is modeled as an unconfined aquifer. The middle layer, Layer 2, corresponds to the Middle Alluvial Unit (MAU). The MAU is modeled as a confined/unconfined aquifer, confined when the overlying UAU is saturated and unconfined when the UAU is dewatered. The bottom layer, Layer 3, corresponds to the Lower Alluvial Unit (LAU). The LAU is also modeled as a confined/unconfined aquifer, confined when the overlying MAU is saturated and unconfined when the MAU is dewatered. The thickness of each model layer is defined by the elevation of each hydrogeologic unit contact.

5.3 BOUNDARY CONDITIONS

The selection of proper model boundary cell types is essential to the accuracy of the model. Boundary cells define the hydrologic conditions along the model borders. General-Head boundaries were applied in this model. The function of the General-Head Boundary Package is mathematically similar to that of the River, Drain, or ET Packages of the MODFLOW model. In the General-Head boundaries, flow into or out of a cell i,j,k, from an external source is provided in proportion to the difference between the head in the cell, $h_{i,j,k}$, and the head assigned to the external source, $H_{i,j,k}$.

5.4 VERTICAL LEAKANCE

The vertical leakance between Layers 1 and 2, and between Layers 2 and 3 was modeled using the VCONT option. MODFLOW requires VCONT to be calculated independently, and input as an array in the Block Centered File (BCF) package. VCONT was calculated by the following equation:

$$VCONT_{1\text{-}2} = 1 / (V_1/2K_{v1} + V_2/2K_{v2})$$

Where:

$VCONT_{1\text{-}2}$: Vertical leakance between Layers 1 and 2
V_1 : Saturated thickness of Layer 1 (feet)
V_2 : Saturated thickness of Layer 2 (feet)
K_{v1} : Vertical hydraulic conductivity of Layer 1 (feet/day)
K_{v2} : Vertical hydraulic conductivity of Layer 2 (feet/day)
Units : 1/day

The final calibrated ratios of horizontal hydraulic conductivity for Layers 1, 2, and 3 are given below.

Layer 1 Horizontal:Vertical K ratio = 20:1
Layer 2 Horizontal:Vertical K ratio = 100:1
Layer 3 Horizontal:Vertical K ratio = 50:1

5.5 INITIAL WATER LEVEL

The water-level data for the steady-state model simulation was adapted mainly from the depth to water map constructed by Lee (1905), and predevelopment water level maps constructed by Anderson (1968), and by Thomsen and Baldys (1985). The selected water level contours were then digitized and introduced into the model. After introduced into the model, the water levels were further adjusted to the current water levels based on a few measured water levels.

5.6 AQUIFER PARAMETERS

Initial hydraulic conductivity (K) estimates were developed using aquifer test data from groundwater contamination site studies, specific capacity data from GWSI and other sources, and recovery test data from the Salt River Project (SRP). Hydraulic conductivity values of all model layers were adjusted during the calibration of the steady-state model.

5.7 INITIAL MODEL SIMULATION

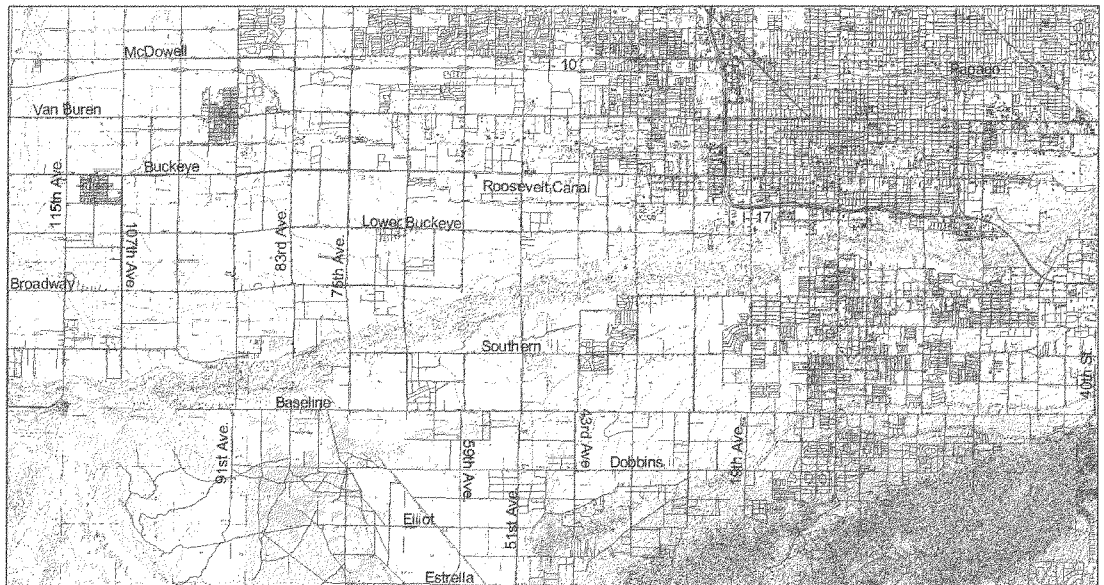
Model simulation runs were conducted for initial simulations with the COE's Groundwater Modeling System (GMS). Model runs were converged successfully. Figure 6 shows a test run result. Simulated groundwater contours for the modeling area are shown in the figure. The red line enclosed the modeling area is the general-head boundary. The model grids outside the boundary are inactive grids. Further model runs will be conducted to simulate the known static groundwater condition to complete the model calibration.

IV. SUMMARY

The Phoenix Rio Salado Project Report prepared by COE (April, 1998), ADWR Modeling Report No. 6 and No. 8 (A Regional Groundwater Flow Model of the Salt River Valley Phase I and Phase II), and Groundwater Quality and Hydrogeology Report by URS (April, 2002) were reviewed and applied for this study. A site-specific groundwater flow model was developed based on the regional groundwater flow model developed by ADWR. The project site groundwater condition and hydrogeologic data presented by URS were used for the model development. Initial model simulation runs were conducted for the without project condition.

TABLE 1, ESTIMATED PREDEVELOPMENT GROUNDWATER BUDGET FOR SRV

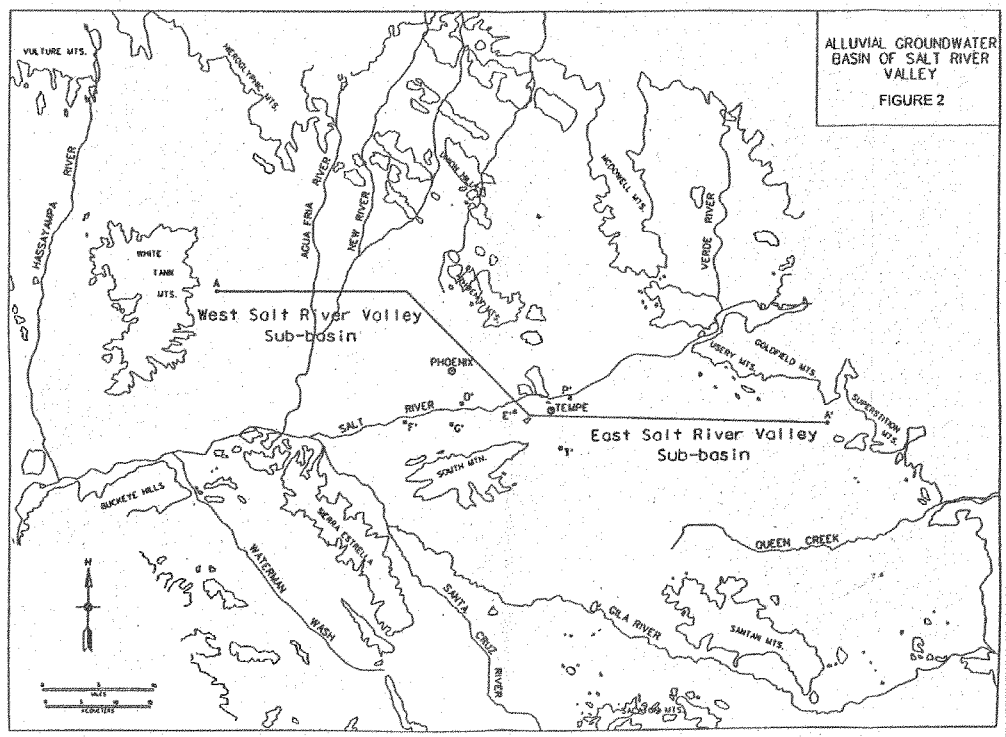
Source of Inflow to SRV	Volume (ac-ft/yr)
Stream Channel Recharge	100,000
Groundwater Inflow	30,000
Mountain Front Recharge	10,000
Total Inflow	140,000
Groundwater Discharge to Stream Channel	60,000
Evapotranspiration	76,000
Total Outflow	140,000



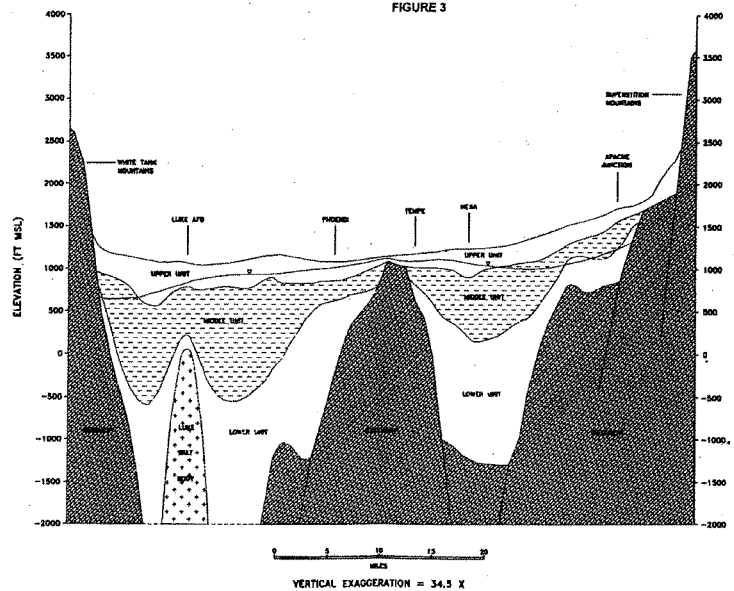
0 1 2 Miles N

FIGURE 1 GROUNDWATER FLOW MODEL - MODELING AREA

RIO SALADO OESTE STUDY
SALT RIVER
PHOENIX, ARIZONA
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


ALLUVIAL GROUNDWATER BASIN OF SALT RIVER VALLEY
FIGURE 2
VULTURE MTS.
HEROGLYPHIC MTS.
HASSAYAMPA RIVER
WHITE TANK MTS.
AGUA FRIA RIVER
NEW RIVER
MCDOWELL MTS.
VERDE RIVER
West Salt River Valley Sub-basin
PHOENIX
TEMPE
SALT RIVER
SOUTH MTN.
USERY MTS.
GOLDFIELD MTS.
SUPERSTITION MTS.
East Salt River Valley Sub-basin
BUCKEYE HILLS
WATERMAN WASH
SANTA CRUZ RIVER
GILA RIVER
QUEEN CREEK
SANTAN MTS.
N

SALT RIVER VALLEY GENERALIZED GEOLOGIC CROSS SECTION
FIGURE 3



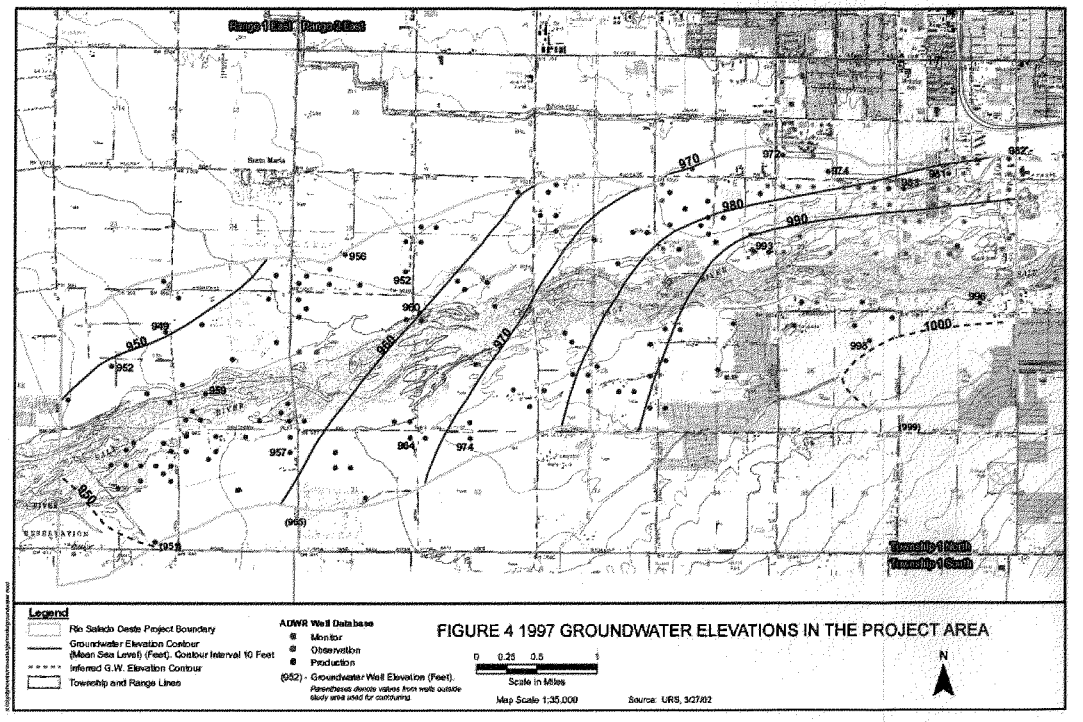
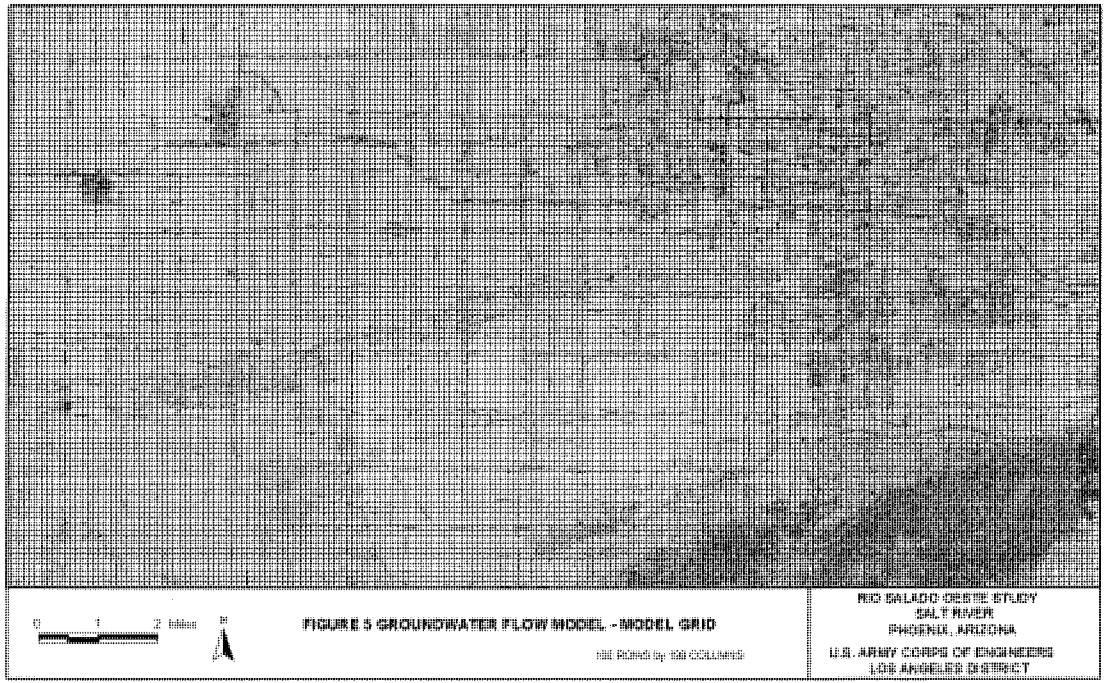


FIGURE 4 1997 GROUNDWATER ELEVATIONS IN THE PROJECT AREA


0 1 2 Miles
N
FIGURE 5 GROUNDWATER FLOW MODEL - MODEL GRID
RIO SALADO OESTE STUDY
GILA RIVER
PHOENIX, ARIZONA
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

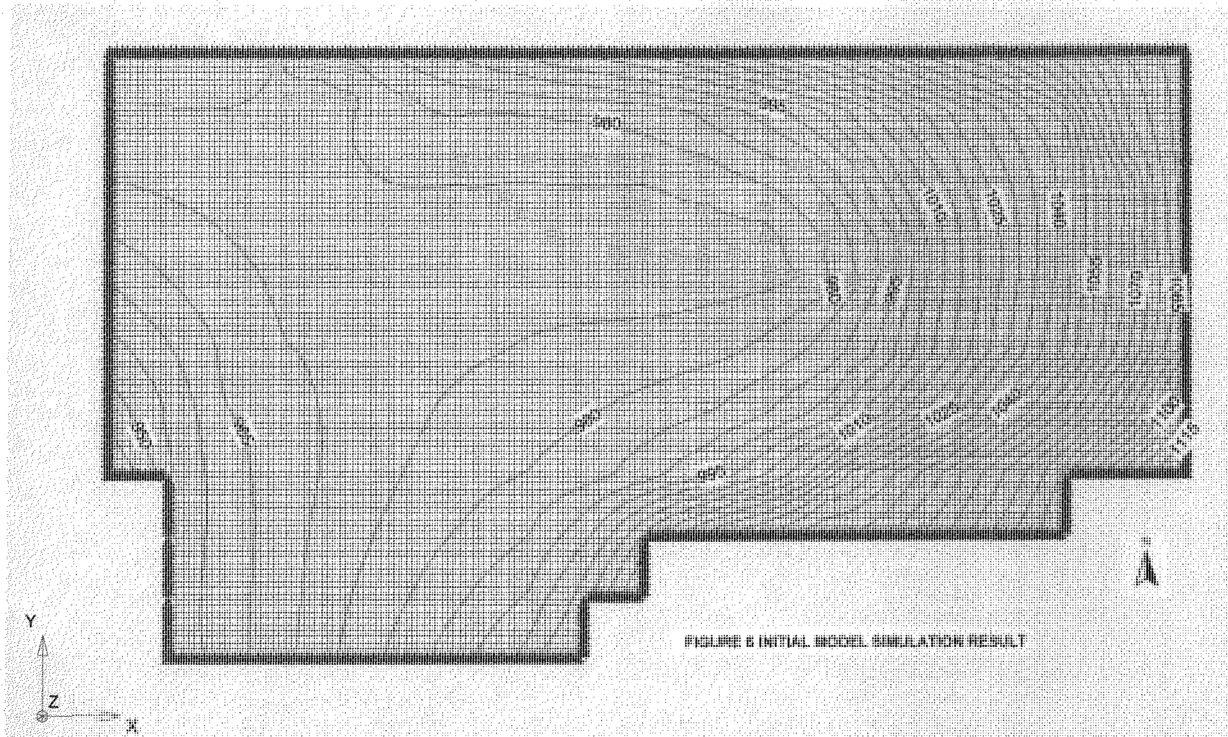


FIGURE 6 INITIAL MODEL SIMULATION RESULT

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX D

GROUNDWATER QUALITY AND HYDROGEOLOGY REPORT

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

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A Well Inventory Reports

1.0 INTRODUCTION

The U.S. Army Corp of Engineers (USACE) and the City of Phoenix (COP) have initiated a feasibility study for the Rio Salado Oeste Project (Oeste Project) to evaluate the design and completion of a riparian habitat restoration project. The Oeste Project lies within the Salt River between 19th Avenue on the east and 83rd Avenue on the west. The north and south boundaries are designated to be Durango Street and Southern Avenue, respectively, for the eastern portion; and Broadway Road and Baseline Road, respectively, for the western portion. As part of the feasibility study, the USACE and COP are assessing the various water sources and potential locations and design for the production and monitor wells for the project.

The purpose of this report is to evaluate the existing groundwater and surface water quality, describe the hydrogeology of the project area, and provide information about existing monitor and production wells in tabular format. The hydrogeologic and groundwater data will be used to facilitate the design specifications and future siting of monitor and production wells in the project area.

2.0 SCOPE OF WORK

The scope of work for this project was developed by the COP and during meetings with the USACE. To meet the objectives of this project URS's scope of work included the following tasks:

1. **Provide a Base Map of the Project Area.** URS was tasked to update and delineate the project boundary, major roads, major geographic features, streams, storm water drainages, and existing land use. Major roads and geographic features were derived from URS archives of existing data. Existing land use data were inventoried at 1:35,000 scale. The land use inventory effort resulted in polygon coverage with the following categories: residential, commercial/industrial, landfill, sand/gravel operation, agricultural, recreational, and river bottom/native.

2. **Review "Phase 2 Middle Gila Watershed Study Final Report".** Using the "Phase 2 Middle Gila Watershed Study Final Report" (Phase 2 Report) prepared by Greeley and Hanson (2001), URS provided a general description of the surface water quality in the project area. URS conducted a cursory field reconnaissance along the Salt River to identify discharges of effluent, irrigation return flows, and storm water drainage. The locations of these features were provided on the project base map. Assessing the surface water quality along the Salt River was conducted by researching databases from the COP, U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA) Storage and Retrieval system *STORET,* and Salt River Project (SRP).

3. **Review and Identify Existing Public Records.** This task was to provide a general description of the groundwater chemistry and assess whether water quality should be considered in siting production wells along the Salt River. To accomplish this task, we researched records and files at the Arizona Department of Environmental Quality (ADEQ) and the Arizona Department of Water Resources (ADWR) on existing wells and groundwater investigations. Using the modified base map prepared in Task 1, URS delineated areas of groundwater environmental contamination and identified the potential extent of groundwater contamination where it can be inferred from the available data. URS also delineated areas of high Total Dissolved Solids (TDS), based on conductivity measurements, and nitrate contamination in groundwater, on the project base map.

4. **Describe the Hydrogeology of the Oeste Project.** URS provided a general description of the regional hydrogeology of the project area. We researched available well records,

groundwater modeling reports at ADWR, and the Roosevelt Irrigation District (RID). With the available data, URS calculated and estimated aquifer hydraulic properties such as groundwater gradient, hydraulic conductivity, transmissivity, and storativity. The aquifer property data will be used to provide recommendations for the design specifications and siting for future production wells and monitor wells.

5. **Preparation of the Well Inventory Report.** This task was subdivided into several subtasks and included the following: extraction of ADWR well records, research and compilation of records, database design and form generation, database population, and generation of tabular well inventory reports. The well inventory report tables will be used to facilitate future siting of production and monitor wells for the Oeste Project.

Once this groundwater and hydrogeologic report is completed and finalized, URS will provide a letter report that will provide recommendations on the siting criteria and design specifications for the monitor and production wells that will be required for the habitat restoration project.

3.0 DATA COLLECTION AND COMPILATION METHODS

3.1 DATA SOURCES

URS queried the following databases for groundwater quality, surface water quality, and aquifer properties:

- 1999 and 2002 ADWR well registry database
- ADEQ Water Quality database as of March 2002
- 2002 ADWR Groundwater Site Inventory (GWSI) database
- ADWR Imaged Records database as of March 2002
- EPA *STORET* as of March 2002
- USGS National Water Information System (NWIS) database as of March 2002.

URS collected the following reports to summarize the land use issues, hydrogeology, groundwater quality, and surface water quality of the project area:

- Phase 2 Middle Gila Watershed Study Final Report (Greeley and Hanson, 2001a)
- Salt/Gila Groundwater Analysis Project Summary Report (Greeley and Hansen, 2001b)
- Tres Rios Hydrologic Model Development and Applications Report (Water & Environmental Systems Technology, 2000)
- Del Rio Landfill Report (Dames & Moore, 1991)
- Groundwater Quality Survey, Rio Salado Habitat Restoration Project (Dames & Moore, 1997)
- Draft Well Installation and Data Analysis of Rio Salado Production Well (RSPW-2) (URS, 2002).

URS collected data pertaining to well production capacity, groundwater quality, and surface water features from the various sources:

- SRP
- RID
- Peninsula-Horowitz Irrigation District (P&H)
- COP 23rd Avenue Waste Water Treatment Plant (23rd Avenue WWTP) and 27th Avenue Landfill
- ADEQ Leaking Underground Storage Tank (LUST) files
- Personnel communications with various landowners.

3.2 WELL DATA PROCESSING AND REPORTING

Initially, URS created a suitable reporting format for the well inventory reports, and submitted it to the COP and USACE for approval. Once the format was approved, URS contacted and obtained public files from sources such as the ADWR, ADEQ, COP, SRP, RID, and several private entities, which own wells in the project area. URS then utilized Microsoft Access 2000 to design a relational database with four tables (Sites, Well_Construction, Water_Levels, and Surface_Water_Quality). The compiled electronic as well as hard copy data were then entered into the database. With the database design and population accomplished, URS employed the four (4) tabular reports: Table 1 – Well Locations, Table 2 – Well Construction, Table 3 – Water Levels, and Table 4 – Surface Water Quality. These reports are provided in Appendix A.

4.0 STUDY RESULTS

4.1 SITE DESCRIPTION

The project site is located within the Salt River between 19th Avenue on the east and 83rd Avenue on the west in Phoenix, Maricopa County, Arizona. The north and south study boundaries are located between approximately Durango Street and Southern Avenue for the eastern portion, and Broadway Road and Baseline Road for the western portion. Specifically, the northern and southern boundaries were defined by including all areas between 19th and 83rd Avenues that are within one mile of any segment of the Salt River centerline (Figure 1).

4.2 LAND USE

Land use within the study area was classified into the following seven categories: Residential, Commercial/Industrial, Landfill, Sand/Gravel Operation, Agricultural, Recreational (i.e. public parks), and River Bottom/Native (Figure 1). The project study area was divided into four separate portions of land based on the dominant types of uses; 19th - 35th Avenues, 35th - 51st Avenues, 51st - 67th Avenues, and 67th - 83rd Avenues (Figure 1).

- **19th - 35th Avenues** Sand and gravel operations line the Salt River with no remaining native river bottom. Commercial/industrial properties dominate both north and south of the river with about equal portions of agricultural and sand and gravel operations making up most of the balance

- **35th - 51st Avenues** Major sand and gravel operations exist in and along the Salt River. Almost half the river has remained undisturbed and is designated as native. Large areas of commercial/industrial properties exist primarily north of the river, gravel operations are present along the river, and residential properties are present south of the river

- **51st - 67th Avenues** Sand and gravel operations are present in and along a large portion of the Salt River. Almost half the river has remained undisturbed and is designated as native. Although there are small pockets of residential land north and south of the river, the majority of land is utilized for agricultural purposes

- **67th - 83rd Avenues** Sand and gravel operations are present in and along some areas of the Salt River with a small portion remaining undisturbed. Few commercial/industrial properties are present. While there is a small pocket of residential land north of the river, the majority of land is utilized for agricultural purposes.

4.3 SURFACE WATER

The purpose of this task was to evaluate the data compiled during the Phase 2 Report by Greeley and Hansen (2001) and review that database to identify only those data that are applicable to the Oeste Project area. These data, as well as newly compiled data, were then used to describe the surface water quality within the Oeste Project area and delineate surface water chemical constituents that exceed the Arizona Administrative Code, Title 18, Chapter 11, § 109 A Appendix A, Numeric Water Quality Criteria, September 30, 1996 (A.A.C. R18-11-109.A Appendix A).

4.3.1 Information Sources

Compiling information to provide a general overview of the surface water quality within the Oeste Project area involved three distinct steps. The first step was to conduct cursory field reconnaissance to correlate field data and surface water sources identified within the Phase 2 Report with current project area site conditions, attributes, and narrative water quality standards. Field reconnaissance was conducted on five separate days from March 1 through March 8, 2002. This reconnaissance primarily focused on identifying surface water features, discharge points, and making observations relative to applicable surface water quality narrative standards. In addition, the field work identified commercial and industrial activities that may have the ability to impact surface water quality in the study area.

The second step involved the review of available databases from recognized sources to compile the most recent numeric surface water quality data. Data for the study area were extracted from the Phase 2 Report as well as from those sources known to collect surface water quality data. These additional sources of data include the COP, SRP, ADEQ, ADWR, EPA, and the USGS. All of these sources were able to provide surface water quality data, but not all data were applicable to the Oeste Project area.

The last step in data compilation was to describe the surface water quality within the study area by comparing available surface water quality sample data and field observations with numeric and narrative surface water quality standards, respectively.

4.3.1.1 Field Data

Field reconnaissance was conducted over a period of five days by a two-person field crew. Based on this work, it was concluded that the information presented within the Phase 2 Report was accurate and complete with regard to outfall locations, storm water sampling locations and

commercial and industrial activities. Observations relative to narrative surface water quality standards were also completed.

URS field personnel confirmed that there are a limited number of point-source outfalls impacting the Oeste Project area. These outfalls include the National Pollutant Discharge Elimination System (NPDES) permitted outfalls associated with the 23rd Avenue WWTP operated by the COP. In addition, several point-source, stormwater outfalls were identified and confirmed to be the same as those identified within the Phase 2 Report. A map of surface water features is presented in Figure 2.

It is suspected that there are additional connections to the point-source, stormwater outfalls. These connections are associated with the various canal systems. Irrigation district maps acquired from SRP show irrigation district connections to storm drains at 19th, 27th, 35th, 43rd, and 51st Avenues along the north and south sides of the Salt River. It would require a comprehensive field effort to obtain the necessary authorizations to enter private property and survey the entire project area to identify and assess the extent of these connections. Therefore, although these irrigation-impacted outfalls have been identified, the extent of those connections to the outfalls have not been identified within the scope of this project.

Second, it was confirmed that there is a variety of commercial and industrial activities having the ability to impact the project area via non-point source storm water run-off. Along the south side of the Salt River from 19th Avenue to 43rd Avenue, the land use was predominantly auto-wrecking yards and construction lay-down areas, which can be expected to contribute to the contamination of storm water run-off. The north side of the river was impacted by a larger percentage of commercial and industrial activity between 19th and 43rd Avenues, including the COP transfer station and landfill at 27th Avenue. These sources can be expected to introduce metals, grease, oils and organic contaminants via storm water run-off. Residential impact was minimal. Although a significant amount of agricultural activity was present, most of this activity was not adjacent to the river, but was located along the study area borders. At approximately 51st Avenue, the primary commercial and industrial impact activity transitioned to agricultural use. Sand and gravel mining activities have a significant presence within the Salt River channel. Dewatering from the mining activities has resulted in established riparian segments, although these water features do not meet the ADEQ definition of "surface water" in accordance with A.A.C. R18-11-109.A. Thus, given the variety of commercial and industrial impact activities described above, it is apparent that non-point source storm water run-off has the potential to impact storm water and, thus, surface water quality in the study area. The only exception to this was the COP 27th Avenue Landfill, which has on-site stormwater retention ponds.

Lastly, it was determined that data gaps exist with regard to the quality and impact of irrigation return flows. SRP, RID, and P&H were contacted for available surface water quality information, but they either did not have surface water quality data or they did not have information from within the study area boundaries. SRP did indicate that the return flow networks are complex and the discharge of water empties to multiple sites (personal communication with Gregg Elliott of SRP, March 13, 2002). SRP also indicated that during the early 1980s many former agricultural sites were developed for commercial/industrial use and, in some cases, the canal systems were not removed or disconnected. As a result, storm water from these developed areas would enter the canal system and eventually discharge into the Salt River during a storm event (personal communication with Gregg Elliott of SRP, March 13, 2002). Analysis of canal maps provided by SRP indicates that storm drain connections are present throughout the canal system along the perimeter of the entire project area.

4.3.1.2 Databases

Three databases contained water quality data applicable to the Salt River project area. These databases were part of the original Phase 2 Report and were obtained from:

- EPA STORET,
- SRP, and
- COP.

Several other sources of data were queried for surface water quality data. These sources of data included USGS, ADWR, ADEQ, RID, SRP and P&H. However, surface water quality data from these sources were either: (1) not available, (2) not within the site area boundaries, (3) never delivered from the source, or (4) reported in a format that could not be directly compared to the ADEQ surface water quality standards[1].

EPA STORET

The EPA STORET database is a repository for water quality, biological, and physical data and is used by a variety of local, state and federal agencies. The EPA maintains two data management systems containing water quality information: the Legacy Data Center (LDC) and STORET. The LDC contains historical water quality data from the early part of the 20th Century to the end of

[1] The USGS database reported values to be "less than" a certain quantity. These data could not be directly compared to the ADEQ value to determine if the USGS value exceeded the ADEQ criteria value.

1998. STORET contains data collected beginning in 1999 to the present. Both databases were queried for data applicable to the study area. STORET did contain surface water quality data, but it did not contain any Arizona data from 1997 forward.

SRP

SRP provided flow volume data for the Maricopa Drain, an irrigation drain that discharges to the Salt River in the vicinity of 77th Avenue (Figure 2). Although SRP had previously supplied some surface water quality data for the Phase 2 Report, it was not able to provide any additional surface water quality data for inclusion in this report.

COP

COP provided storm water sampling data and river sampling information as part of the Phase 2 Report. River sampling information pertained to the discharge of the 23rd Avenue WWTP to the Salt River. The data collected by the COP were in response to NPDES permit requirements for both point-source outfalls associated with the 23rd Avenue WWTP and for non-point source impacts (storm water).

4.3.2 Water Quality Standards

Surface water quality standards are comprised of designated uses, associated numeric water quality criteria, and narrative standards. The numeric water quality criteria are established to protect the designated use(s) of the specific reach of a river system, while the narrative standards are to protect all surface waters. Both the designated use and the numeric criteria are prescribed by the ADEQ in accordance with A.A.C. R18-11-109.A Appendix A, and the narrative standards are prescribed in A.A.C. R18-11-108.A and B.

It should be noted that ADEQ is in the process of updating various water quality standards and this update may impact surface water quality standards (personal communication with Samuel Rector of ADEQ, March 2002). Presently, ADEQ has adopted new standards and, although these standards have not been reviewed and approved by the EPA (and thus are not yet applicable as NPDES permit standards), they are considered to be the applicable water quality standards within Arizona. However, a current listing of the revised standards was not yet available from ADEQ. Therefore, those ADEQ numeric standards that have been in effect since 1996 were used in the surface water quality analysis presented herein.

4.3.2.1 Designated Uses

ADEQ separates rivers into specific reaches for the purpose of assigning designated uses. The study area discussed in this report includes Reaches 4 and 5 along the Salt River. Reach 4 extends from the Interstate-10 Bridge at the Salt River to the 23rd Avenue WWTP. Reach 5 extends from the 23rd Avenue WWTP past the 83rd Avenue study area boundary (at the confluence of the Salt and Gila Rivers).

The current associated designated uses for the Salt River (Reaches 4 and 5) are as follows:

- Reach 4 – designated for aquatic life and wildlife – warm water (A&W w), partial body contact – recreation (PBC), and fish consumption (FC)
- Reach 5 – designated for aquatic life and wildlife – effluent dependent water (A&W edw), partial body contact – recreation (PBC), fish consumption (FC), agricultural irrigation (AgI), and agricultural livestock watering (AgL).

4.3.2.2 Numeric Surface Water Quality Standards

For each of the above-designated uses, there are numeric surface water quality criteria established for each established criteria element (A.A.C. R18-11-109.A Appendix A and B). As the numeric standards are used to protect a designated use, a value that exceeds the numeric standard indicates that a particular criteria element is a pollutant that may cause water quality degradation within that Reach. Within this report, data were compared against numeric standards to identify these potential surface water quality pollutants and the source of the pollution.

4.3.2.3 Narrative Surface Water Quality Standards

Narrative water quality standards are established to protect all surface waters. Current standards require that surface water be free from pollutants in accordance with A.A.C. R18-11-108.A and B. In summary, surface water shall be free from pollutants that cause odor, off-taste, undesirable growth, changes in color or contribute to violation of an aquifer water quality standard. Surface water shall also be free from oil, grease, and other pollutants that float as debris, foam or scum.

4.3.3 Water Quality Summary

With respect to the databases discussed in Section 4.3.1.2, the data for the Salt River between 19th Avenue and 83rd Avenue were generally collected prior to 1997. There is a limited amount

of data available for 1999, and no data for this river segment beyond 1999. Also, there is a minor amount of surface water flow in the Salt River between 19th Avenue and 83rd Avenue. As a result, limited water quality sampling information is available for this area. The following sampling location information has been included in this report and was also provided within the Phase 2 Report. The data availability moving downstream through the study area includes the following:

- 23rd Avenue WWTP Outfall (7/92-6/93),
- 35th Avenue Bridge (7/92-6/93),
- 51st Avenue Bridge (7/92- 6/93),
- 59th Avenue and Salt River (4/94-4/95),
- 67th Avenue Bridge (7/92-6/93), and
- SRP Maricopa Drain (1996-1999).

4.3.3.1 Surface Water Sources

The sources of surface water in the study area include: point-source outfalls from the COP 23rd Avenue WWTP, SRP Maricopa Drain, storm water point-source discharges, and irrigation flows. Surface water quality data were available for:

- COP 23rd Avenue WWTP,
- SRP Maricopa Drain, and
- COP storm water outfalls at designated locations.

In 1995, the COP began discharging treated wastewater to the Salt River channel at the 35th Avenue outfall. The COP discharges approximately 45 million gallons per day (MGD) to the river during a 4-month period, generally ranging from mid/late October to mid/late February or March. During the remaining 8 months of the year, treated wastewater is distributed via canals and pipelines to the RID for agricultural use. In addition, approximately 10 MGD of treated effluent is distributed from the 23rd Avenue WWTP continuously throughout the year for other agricultural irrigation allotments (Parsons Engineering Science, 2001).

The SRP Maricopa Drain is an irrigation district discharge point that discharges intermittently dependent upon agricultural needs, system maintenance needs and storm water impacts. It is a drainage ditch that collects unused water from about 27th Avenue west to 75th Avenue.

The COP storm water outfalls provide an intermittent source of surface water to the project area. The average annual rainfall in Phoenix metropolitan area is 7.95 inches per year (Western Regional Climate Center, 2002).

4.3.3.2 Storm Water Data

It is important to note that storm water quality is a function of land use, not the size of the watershed (Greeley and Hansen, 2001). In other words, how a specific section of land is used will impact stormwater quality more so than tract size. Thus, to better manage stormwater data, the Phase 2 Report produced by Greeley and Hansen divided the storm water database into three data sets that are designated as follows:

- In-stream storm water samples from a variety of storm water drainage basins in urbanized areas, including natural runoff and background streamflow.
- Storm water samples at the point of discharge to Waters of the United States (U.S.) that represent storm water from a defined drainage basin and land use mixture.
- Storm water samples from within a municipal storm drain system that represent storm water from a defined drainage basin and land use mixture that are not representative of storm water discharges to Waters of the U.S.

Storm water data were divided into the above files so that data from within the storm drain system are not misunderstood and extrapolated to represent the storm water characteristics at the point of discharge to Waters of the U.S. or in-stream water quality. Greeley and Hansen (2001) strongly caution against the direct comparison of storm water data with water quality standards, particularly those related to acute and chronic toxicity. Storm water data were available from the following in-stream locations within the project area:

- Downstream side of 19th Avenue bridge — In-stream
- Arizona Central District Canal (ACDC) at 43rd Avenue — In-stream
- Downstream side of 51st Avenue bridge over the ACDC — In-stream
- Downstream side of 51st Avenue bridge over Salt River — In-stream

Storm water data were also available for the following point-of-discharge locations:

- Salt River at 27th Avenue – south bank of river — Point-of-Discharge
- Salt River at 35th Avenue – north bank of river — Point-of-Discharge
- 67th Avenue at Salt River — Point-of-Discharge

4.3.3.3 Numeric Surface Water Quality Criteria Summary

The numeric surface water quality standards established by ADEQ for each designated use were compared against the available surface water quality sample data obtained from the various databases. Where an established surface water quality numeric criterion was exceeded, this information was used to compile Table 4, Surface Water Quality Summary (Appendix A). Because the amount of data provided for the study area is rather limited as a whole, and especially limited between 51st Avenue and 83rd Avenue, data from two locations downstream outside of the study area were also included in the analysis. This was done to provide a set of comparison values that may be indicative of the surface water quality of the western portion of the study area and downstream of the study area.

As an overall observation, the A&W edw designated use was frequently problematic for certain metal analytes because the standard requires hardness data for evaluation. Where hardness data were available, all applicable data were evaluated and concentrations greater than the current standard were included in the table. Data from sampling events lacking hardness results were not evaluated as the numeric value for the standard could not be calculated. Additionally, all data that were qualified by the analytical laboratory (e.g. estimates, calibration failure, contamination, etc.) were excluded.

A total of 21 parameters were found to have exceeded numeric surface water quality criteria (Appendix A, Table 4). The parameters included pesticides, metals, chlorinated hydrocarbons, the water quality parameters pH and turbidity, and bacteriological parameters. Approximately 45 percent of the exceedances were elevated bacteria counts, 15 percent of the results were from pesticides, 13 percent of the results were from metals, and 9 percent of the results were chlorinated hydrocarbons. The remainder represents parameters such as pH, dissolved oxygen, and cyanide.

In general, based on analysis of available data versus the numeric water quality standards, stormwater is a vehicle by which surface water quality appears to degrade within the Salt River.

4.3.3.4 Narrative Surface Water Quality Criteria Summary

Based on field observations and the comparison of site data with the narrative water quality standards, stormwater can degrade surface water quality within the Salt River. Point-source stormwater outfalls were observed to be non-compliant with narrative standards as these points tended to accumulate debris, foam, scum and odor.

4.3.4 Data Gaps

In the process of compiling this surface water quality summary, the following data gaps were identified:

- There was a limited amount of surface water quality data for the Salt River study area from 19th to 83rd Avenues (data location gap).
- Based on inquiries, it is believed that additional surface water quality data exists, but it was not delivered timely to URS for inclusion in this summary (data source gaps).
- Older storm water data (from 1992 and 1993) were predominant in the analysis (data date gap). As land use patterns have changed, it is logical to assume that storm water quality has been impacted by these land-use changes and that the older data may no longer be truly reflective of actual site conditions.
- Sample data were not available for the comprehensive list of surface water quality criteria compiled by ADEQ (study parameter data gaps).
- Non-point source storm water run-off is likely a key contributor to the degradation of water quality in the project area, but comprehensive data sets are not available to confirm this supposition.
- Major data gaps include ungaged agricultural drains, impact of concentrated animal feeding operations (CAFO) on water quality, and storm water pollutant loads and RID canals and discharges.
- Gila River Indian Community discharges into the Salt River, just at edge of study area near 83rd Avenue, but no data on these discharges were made available to URS for inclusion in this report.

4.4 HYDROGEOLOGY

The purpose of this task was to evaluate the aquifer characteristics and groundwater use within the study area. Understanding the hydrogeology will help with design and site selection for future monitor and production wells required for habitat restoration project.

4.4.1 Geologic Setting

The Oeste Project is located in the Basin and Range Physiographic Province of Arizona, which is characterized by predominantly north to northwest-trending mountain ranges that are separated by gently sloping alluvial basins. Basin-fill deposits in this region range in thickness from less than 100 feet near the basin margins to over 10,000 feet in the central areas of some basins. Basin-fill deposits consist of intercalated sequences of alluvial sediments and evaporites, and are underlain by basement rocks that consist of Precambrian igneous and metamorphic rocks and Tertiary sedimentary and volcanic rocks (Corkhill, et al., 1993). In the Oeste Project area, unconsolidated basin-fill sediments are approximately 1,000 feet thick at the eastern portion of the study area and thicken to the west to over 3,000 feet.

The clastic sediments are interpreted as alluvial fan, lacustrine, and fluvial deposits formed during development of the Salt River Valley basin and sub-basins. The unconsolidated alluvial and lacustrine deposits have been subdivided into three stratigraphic units from oldest to youngest: the Lower Conglomerate Unit (LCU), the Middle Fine-Grained Unit (MFU), and the Upper Alluvial Unit (UAU). As previously stated, this project focuses on the water quality and water supply potential of the UAU, which is the proposed source of water for the Oeste Project.

The UAU is divided into four subunits within the study area. These subunits are designated from youngest to oldest as S, A, B, and C. These subunits appear to be essentially horizontal within the study area and no significant geologic structures have been identified.

- **Subunit S** is exposed at the surface near the river and consists of silty sand with clay and gravel. This unit is typically unsaturated in the vicinity of the Salt River

- **Subunit A** is further subdivided into Subunits A_1 and A_2, and is generally comprised of sandy gravel and cobbles. Subunit A_1 extends to a depth of 90 to 110 feet below ground surface (bgs) and consists of unconsolidated, poorly sorted, coarse sand and gravel. The primary difference between A_1 and A_2 is that Subunit A_2 contains 30 to 40 percent fine to coarse sand versus 5 to 20 percent in Subunit A_1. In addition, Subunit A_2 is typically better sorted than A_1. The contact between these subunits is gradational and is identified

by a transition from coarse to medium-sized gravel, increased roundness, and greater amounts of fine sand and silt (Dames & Moore, 1991). In the vicinity of the 19th Avenue Landfill Subunit A_1 was observed to be about 100 feet thick and Subunit A_2 was observed to be about 90 feet thick

- **Subunit B** underlies Subunit A_2 and is dominated by coarse to fine sand, silt, clay, and minor gravels. Subunit B is distinguished by its reddish-brown color and finer-grained nature. In the vicinity of the 19th Avenue Landfill Subunit B was observed to be about 40 feet thick

- **Subunit C** underlies Subunit B and primarily consists of fine to medium sand, angular to subrounded fine gravel, minor silt, and clay. The transition from Subunit B to Subunit C is identified by an increase in grain size and a color change to brown. In the vicinity of the 19th Avenue Landfill Subunit C was observed to be about 150 feet thick.

4.4.2 Hydrogeology and Aquifer Properties

Hydrogeologic data and aquifer properties for the UAU were collected from available reports and public database information as described in Section 3.1. URS contacted various owners with a history of groundwater production capacity greater than 500 gallons per minute (gpm), a casing diameter greater than 10 inches, and screen intervals placed in either subunits A, B, or C of the UAU. While many other production and monitor wells were located during the investigation, aquifer properties were based preferentially on data from wells capable of producing significant discharge (≥ 500 gpm) in order to stress the aquifer of the UAU. For wells with limited aquifer property data, but with pumping, drawdown, and well construction information available, a mathematical approximation was used to estimate aquifer characteristics (Razack & Huntley, 1991). ADWR personnel were contacted to obtain the most recent data regarding water levels, aquifer modeling, and recent publications in the study area. ADWR also queried their databases for recent aquifer testing and research done to support submitted Certificates of Assured Water Supply or Water Adequacy Statements, however none were encountered in the study area. The compiled aquifer parameters of the UAU are presented in Table 4.4.2.

TABLE 4.4.2
AQUIFER PROPERTIES OF THE UPPER ALLUVIAL UNIT
RIO SALADO OESTE PROJECT

Sources	Hydrogeologic Units	Transmissivity (ft^2/day)	Storativity (Dimensionless)	Hydraulic Conductivity (K) (ft/day)
161 ARG Site Characterization Report, LUST File Pump Test, (Dames & Moore, 1997)	UAU Unit A	18,048 - 19,519	0.4 – 0.44	27.7 – 338.6
19th Avenue Landfill Modeling, (Dames & Moore, 1997)	UAU Unit A	15,709 - 36,096	NA	NA
19th Avenue Landfill Aquifer Testing, (Dames & Moore, 1997)	UAU Unit A	25,209 (a)	0.11 (a)	30.7
Aquifer Test in Salt River Sediments, Avis Facility at Airport, (Dames & Moore, 1997)	UAU Unit A	25,936	NA	160.4
Salt River Valley Modeling Report No. 8, (Corkhill, et al., 1993)	UAU undifferentiated	NA	0.08 – 0.22	20 – 250
Renovation of Wastewater at the 23rd Avenue Rapid Infiltration Project (Bouwer and Rice, 1984)	UAU Unit A	25,401 (a)	NA	72.6
Well Installation and Data Analysis Report, Rio Salado Production Well No. 2 (RSPW-2), (URS, 2002)	UAU Unit A	21,390	NA	203
Well #55-613468, (personal communication Mr. A. King, 2002)	UAU Unit A	59,927	NA	500
Well #55-605117 (United Metro Materials), (personal communication Mr. A. Shelton, 2002)	UAU Units A, B, and C	27,629	NA	153
Well #55-528969 (Hansen Aggregate), (personal communication Mr. A. Jason, 2002)	UAU Unit C	23,815	NA	297
Well # 55-607697 (SRP 7E-1N), (SRP well database, 3/2002)	UAU Units A, B, and C	32,727	NA	76
Well # 55-607698 (SRP 4.8E-0N), (SRP well database, 3/2002)	UAU Units A, B, and C	23,258	NA	83
Well # 55-608378 (SRP 11.8E-2N), (SRP well database, 3/2002)	UAU Units A, B, and C	26,011	NA	68
Well # 55-578740 (SRP 6E-0.9N), (SRP well database, 3/2002)	UAU Units A, B, and C	19,487	NA	63
Tres Rios Hydrologic Model Development and Applications Report (Water & Environmental Systems Technology Inc., 2000)	UAU Units A, B, and C	NA	0.10-0.15	600-800
Dewatering Investigation Southern Ave. Sewer Line/ Sewage Lift Station #43 (Southwest Groundwater Consultants, Inc., 2000)	UAU Unit A	26,738	0.1	668

ARG= Air Refueling Group
LUST= Leaking Underground Storage Tank
UAU= Upper Alluvial Unit
(a)= averaged calculation
SRP= Salt River Project

Overall, the estimates of transmissivity for the UAU range from 15,000 to 60,000 ft^2/day (112,200 to 448,800 gallons per day per foot [gpd/ft]). However, the average estimate of transmissivity is approximately 27,000 ft^2/day (201,960 gpd/ft). Estimates of storativity ranged

from 0.08 up to 0.44. Hydraulic conductivity values in the study area vary from 20 ft/day to 800 ft/day (150 gpd/ft to 5,984 gpd/ft); the representative estimate of the hydraulic conductivity is 200 ft/day (1,496 gpd/ft).

The range of hydraulic conductivity values result from a combination of three factors: complexity of the fluvial system, well screen constructed across differing hydrogeologic units, and unconfined groundwater conditions in Unit A. Within each of the defined hydrogeologic units some variability in hydraulic conductivity is expected. Lateral changes in grain size or the presence of partial cementation can greatly impact the hydraulic conductivity. Because hydraulic conductivity is the resultant taken from the transmissivity value divided by the thickness of the aquifer, it is sensitive to the thickness of the aquifer. Because many wells in the study area were screened across the subunits A, B, C, of the UAU and sometimes into the MFU, aquifer thickness was estimated to be the length of the screened interval. The consequence of this assumption is that the hydraulic conductivity becomes an average over the entire screened interval for the higher conductivity A and C units as well as the lower conductivity B and MFU units. In general, the presence of low conductivity units within the screened interval decreases the estimated value of hydraulic conductivity. Lastly, inaccurately low hydraulic conductivity values may have resulted from declining water levels or local pumping that dewatered a portion of the screened interval and saturated aquifer, shortening the effective saturated thickness. Where data were available, the hydraulic conductivity estimates were corrected for dewatered screen and aquifer.

4.4.3 Depth to Water and Groundwater Gradient

Groundwater generally occurs under unconfined conditions within the UAU. Groundwater flow in the eastern third of the study area (east of 39th Avenue) is generally from the south to north-northwest toward the RID well field located along or north of Lower Buckeye Road between 19th and 35th Avenues. During winter months when the well field is inactive, the gradient shifts to the west-northwest. The groundwater gradient is steepest to the north with values as high as 0.008 ft/ft in the vicinity of 35th Avenue and Lower Buckeye Road. The groundwater flow direction in the western two thirds of the study area (west of 39th Avenue) ranges from northwest to west. The groundwater gradient flattens to the west with values as low as 0.002 ft/ft. Static water level is relatively shallow, ranging from 20 to 50 feet below ground surface (bgs) within the Salt River channel to 60 to 80 feet bgs north and south of the river (URS, 2002).

Fluctuations in static water level can be as much as 20 to 30 feet on an annual basis due to agricultural pumping demands, and have declined as much as 25 feet in the last five years (Dames & Moore, 1991; Parsons Engineering Science, 2001). Hydrographs of selected wells

(Figure 3) show this decline is most pronounced in the eastern portion of the site near the RID wellfield. The selected wells provided static water levels from both ends of the study area that have the most complete water level records. Contributing factors that may cause the fluctuations are water discharge from the 35th Avenue water treatment plant outfall during winter months that produces groundwater mounding, and related radial flow during periods of discharge and basin-wide groundwater pumping and storm water runoff into the Salt River.

A groundwater contour map of the study area was prepared using ADWR well data from 1997 because it represented the most complete data set available (Figure 4). ADWR collected many water levels from both production and monitoring wells in the month of October, at the end of the pumping season. Water levels represent static values prior to significant precipitation. Some data outside of the Study Area were incorporated while contouring to fill data gaps. Values that materially impacted contours (southern Study Area boundary) are represented as elevations without a well symbol. The hydrographs were prepared and reviewed to validate whether the contour map is representative of current conditions. In general the selected wells show a consistent water level decline without radical changes in gradient direction. Therefore, while the groundwater elevation has declined approximately 10 to 20 feet since 1997, the current contours are likely to be similar to the 1997 contours shown in Figure 4.

4.5 GROUNDWATER QUALITY

General groundwater quality data were obtained from databases including the ADWR GWSI database, ADEQ water quality database, and USGS NWIS water quality database. Other data were obtained from SRP, RID, the Phase 2 Report, and COP. The locations of wells with groundwater quality data that were useful for this report are shown on Figure 4. For this evaluation, the most recent data available used ranged from 2001 to as far back as 1983.

The above sources provided limited data for nitrates, volatile organic compounds (VOCs), metals, and pesticides. The majority of these data were below detection levels or detected at concentrations below groundwater quality standards.

The ADWR Well Registry database and Imaged Records database were queried to determine the location (Figure 4), owner, and purpose of monitor wells within the study area. This information was used to identify sites having possible groundwater quality concerns. Further information about sites of particular concern (e.g. landfills, LUST sites, etc.) was obtained from the well owners and ADEQ.

Groundwater conductivity within the study area ranges from about 1,000 to 3,500 micromhos per centimeter (μmhos/cm), which corresponds with an estimated range in TDS of 600 to 2,500 parts per million (ppm). Based on data from wells screened in the UAU and part of the MFU, there is a general trend of increasing conductivity from roughly 1,200 μmhos/cm in the northeast to over 3,000 μmhos/cm in the southwest part of the study area (Figure 5).

In the vicinity of the 23rd Avenue WWTP and the associated effluent outfalls, there are a number of monitor wells screened only in the uppermost part of Subunit A of the UAU. Groundwater from these wells has a relatively low conductivity—approximately 1,000 ±500 μmhos/cm—compared to groundwater from the deeper wells. The lower conductivity may be due to recharge of effluent water from the WWTP, or the upper UAU may have lower conductivity throughout the study area. Additional data from the upper UAU in other parts of the study area would be required to determine which is the case. There was not sufficient data available to distinguish between Subunit A and Subunit C of the UAU.

Nitrate concentrations are generally less than 10 milligrams per liter (mg/L), with the exception of wells located in the southwestern part of the study area where concentrations are as high as 13.8 mg/L (Figure 5). There is no apparent difference in the concentration of nitrate in the shallow wells versus the deeper wells. Quarterly data from the 23rd Avenue WWTP and the 27th Avenue Landfill monitor wells show that the nitrate concentrations can vary by as much as 4 ppm from quarter to quarter. The changes in nitrate concentration do not appear to be seasonal.

4.6 AREAS WITH GROUNDWATER QUALITY CONCERNS

The locations of sites where the groundwater quality may have been impacted are shown on Figure 6. These sites include landfills, wastewater treatment plants, and LUST sites. In addition, the study area is located in proximity of two Water Quality Assurance Revolving Fund (WQARF) or National Priority List (NPL) sites also known as Superfund sites. Groundwater investigations at the sites within the study area were all limited to Subunit A of the UAU. Monitor wells at these sites ranged in depth from 60 to 110 feet. The following sections give brief descriptions of each site.

4.6.1 WQARF/NPL Sites

19th Avenue Landfill

The 19th Avenue Landfill is located adjacent to the east side of the study area on 19th Avenue between Lower Buckeye Road on the north and the Salt River on the south. The landfill was used for disposal of municipal and local industrial waste. Historically very low concentrations of

VOCs, heavy metals, and beta radiation have been detected in groundwater at the site. Remediation activities at this site have been completed and the site is currently in the operations and maintenance phase (ADEQ, 2001).

In 2001, 1,1-Dichloroethylene (1,1-DCE) was the only compound detected above drinking water standards. Moderate concentrations of 1,1-DCE were detected in two wells located in the study area and associated with the 19th Avenue Landfill NPL Site. One of these wells had a concentration exceeding the ADEQ Aquifer Water Quality Standard (AWQS) of 7 micrograms per liter (µg/L). Based on these data and data from wells east of the study area, the likely extent of groundwater with high concentrations of 1,1-DCE was estimated as shown on Figure 6.

West Van Buren WQARF Site

The WVB site is located between Buckeye Road on the south and Van Buren Street on the north and between 7th Avenue on the east and 83rd Avenue on the west. Part of the Oeste Project study area falls within the one-mile buffer zone of the WVB site. This site has elevated concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) (ADEQ, 2001).

The portion of the study area north of the Salt River and east of 51st Avenue is most likely to be impacted by poor groundwater quality from these sites. However, the study area is located up-gradient, so encroachment of poor quality groundwater from these sites is not anticipated.

4.6.2 Landfills

27th Avenue Landfill

The 27th Avenue Landfill was closed in 1995. It is currently used as a waste transfer station. Monitor wells are located along the edges of the landfill to monitor groundwater quality in the vicinity of the landfill. Quarterly sampling data from these wells indicate that there has been no impact to groundwater quality from the landfill and that groundwater quality in the area is good.

SRP Landfill

This site is located on the east side of 67th Avenue, just north of the Salt River (Point 1 on Figure 5). There are five observation wells registered with ADWR (Registration Nos.: 55-517070 through 55-517074) that are located at this site. These wells were drilled in 1987, and the purpose of these wells listed on the Notices of Intent to Drill a Well (NOIs) is to monitor potential groundwater contamination, "Monitoring program to identify the extent and nature of

any groundwater contamination at SRP landfills." No groundwater quality data were available from SRP for these wells. Site closure was obtained from ADEQ in 2000.

4.6.3 Waste Water Treatment Plants

23rd Avenue WWTP

The WWTP is currently active, and effluent water is discharged at the outfall point on the north side of the Salt River near 35th Avenue. There are currently eight monitoring wells surrounding the sludge drying beds and a monitoring well near the outfall point. Groundwater from these wells is sampled and analyzed periodically. The well near the 35th Avenue outfall point is monitored as part of the Aquifer Protection Permit (APP) for the site.

91st Avenue WWTP

The WWTP is currently active and effluent water is discharged to the Salt River and used as a water source for the Tres Rios Project, a riparian habitat restoration project that is located west of 83rd Avenue. Part of the WWTP's field of sludge drying beds is located within the project boundary. Since the WWTP's effluent outfalls are west of the study area and groundwater flow is to the west in the vicinity of the WWTP, the WWTP will likely have little influence on groundwater quality within the study area.

4.6.4 Leaking Underground Storage Tank Sites

Only LUST sites where monitor wells were installed and registered with ADWR are discussed here. Many of these sites have obtained site closure from ADEQ. In general, LUST site closure requires the following criteria:

- Extent of contamination at the release location was adequately investigated both laterally and vertically;
- Depth to groundwater determined;
- Soil contamination in exceedance of ADEQ's cleanup standard(s) was remediated to concentrations below the standards;
- Soil that remains in place is below ADEQ's cleanup standard(s) per R18-7-205; and
- Groundwater concentrations of contaminants have remained at or below the AWQS for a sufficient period of time.

Contaminants that were commonly detected in the groundwater at sites within the study area include benzene, toluene, ethylbenzene, and xylenes (BTEX) as well as total petroleum hydrocarbons (TPH). The AWQS for the BTEX compounds are as follows: benzene, 5 µg/L; toluene, 1,000 µg/L; ethylbenzene, 700 µg/L; and total xylenes, 10,000 µg/L. An AWQS for TPH has not been established.

Based on the above criteria it is possible for detectable concentrations of contaminants to remain in the soil and groundwater after the site has been closed. It is assumed that concentrations of petroleum hydrocarbons will degrade over time due to natural processes.

19th Avenue Landfill (ADEQ Facility ID: 0-003859)

There are two LUST sites (Leak IDs: 2235.01 and 2728.01) associated with the landfill. The actual locations and the impacts to groundwater at these sites are unknown; the ADEQ files for these sites were not available for review at the time this report was written. Both of these sites were closed in 1993.

27th Avenue Landfill (ADEQ Facility ID: 0-003858)

There is one LUST site (Leak ID: 1787.01) associated with the 27th Avenue Landfill (Point 6 on Figure 5). One monitor well was installed to determine if there was any impact to groundwater. There were minor BTEX detections that did not exceed the ADEQ AWQS. The well was abandoned when the site was closed in 1998.

PCE was also detected at a concentration of 0.4 µg/L. It was reported that the analytical results of the groundwater samples from the monitor well were typical of the ambient groundwater quality of the WVB study area.

USF Bestway Transportation (ADEQ Facility ID: 0-005062)

This site, located at 3045 South 43rd Avenue. (Point 3 on Figure 5), had three diesel and one gasoline USTs. ADEQ was notified about leakage from these tanks in 1988 (Leak ID: 0456.01). Nine monitor wells were installed to characterize the nature and extent of the impact to groundwater. Initially 12 inches of free product was measured in one monitor well, and detectable concentrations of BTEX and TPH were present in four of these wells. Concentrations exceeded the ADEQ AWQS for benzene in three wells with a maximum concentration of 420 µg/L. Remedial activities have been performed at the site and concentrations have been lowered to levels required by ADEQ. Site closure has been requested.

Publicker Ind/Masterveiw Window (ADEQ Facility ID: 0-004800)

This site is located at 3065 South 43rd Avenue (Point 4 on Figure 5). In 1991 an incident report was filed with ADEQ documenting a release of petroleum hydrocarbons discovered during removal of the UST (Leak ID: 1864.01). Six monitor wells were installed to evaluate the degree and extent of the impact to groundwater. In one of the monitor wells, 4.4 inches of free product was measured. Detectable concentrations of BTEX were present in five of the six monitor wells. Only benzene was detected at concentrations exceeding the ADEQ AWQS of 5 µg/L with concentrations as high as 520 µg/L. Concentrations of isopropylbenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, n-butylbenzene, and naphthalene were detected in five of the monitor wells. These compounds are typical components of unleaded gasoline and are associated with the hydrocarbon release at the site. The site is currently being remediated.

Other compound detections that are not related to the petroleum release at this site include TCE, chloroform, and dichloromethane (methylene chloride). TCE was detected at concentrations as high as 5.7 µg/L. The source and extent of the TCE contamination is unknown; however, it is believed that the source is off-site (Geraghty and Miller, 1997).

Phoenix Transit System (ADEQ Facility ID: 0-003877)

This site is located at 2225 West Lower Buckeye Road (Point 12 on Figure 5). A petroleum release from leaking USTs was reported to ADEQ in 1995 (Leak ID: 3869.01). Six monitor wells were installed to evaluate the impact to groundwater. Approximately 143 gallons of free product had been removed from one of these wells as of July 2, 1996. Free product was not discovered in any of the other wells. No VOCs were detected in the groundwater in any of the wells. Remedial action was taken and the site was closed in 2000.

City of Phoenix Petroleum Stores (ADEQ Facility ID: 0-003854)

This facility located at 2239 West Lower Buckeye Road (Point 10 on Figure 5) is used for fuel and lubricant storage and distribution. Between September 1987 and March 1989 the facility had four incidents of documented product release or inventory loss (Leak ID: 0350.01). Four monitor wells were installed to evaluate the impact to groundwater. Detectable concentrations of TPH, BTEX, and 1,1-DCE were present in all four of the monitor wells. Benzene was detected in one well at concentrations exceeding ADEQ AWQS levels with concentrations up to 39 µg/L. Remedial action was taken to lower the concentration and the site was closed in 1998.

Phoenix Salt River Service Center (ADEQ Facility ID: 0-003864)

This facility located at 3045 South 22nd Avenue is used as a fueling and maintenance facility (Point 11 on Figure 5). At least eleven USTs were removed from the site. Four monitor wells were installed to evaluate the impact to groundwater due to product released from leaking tanks (Leak IDs: 1102.01 through 1102.06). Detectable concentrations of TPH and BTEX were present in all four wells and 1,1-DCE in one well. Benzene was detected in one well at concentrations exceeding the ADEQ AWQS as high as 53µg/L. Remedial action was taken and the site was closed in 1999.

Phoenix Redi-Mix Co Inc (ADEQ Facility ID: 0-004998)

This site is located at 3635 South 43rd Avenue (Point 5 on Figure 5). No groundwater information was found in the available ADEQ files. However, there are two monitor wells at this location registered with ADWR that were reportedly drilled to investigate a UST petroleum release.

Tanner-United Metro (ADEQ Facility ID: 0-004836)

This facility is located at 3640 South 19th Avenue (Point 15 on Figure 5). A diesel fuel release from a UST system was reported in 1988 (Leak ID: 0476.01). The USTs were removed and eight monitor wells were installed to evaluate the impact to groundwater due to the release. As much as 1.6 feet of free product was measured in two of the wells and TPH concentrations up to 11 mg/L were detected in the groundwater from other monitor wells. Remedial action was taken and the site was closed in 1999. Following closure, six of the monitor wells were abandoned. The ADWR records for other monitor wells installed at the site in 1997 indicate that these wells were drilled to monitor potential contamination from a petroleum hydrocarbon constituent released from a former lube pit and oil/water separator. The status of this investigation is not known at this time.

Salt River Recycling/Smithey (ADEQ Facility ID: 0-003031)

This site is located at 3640 South 35th Avenue (Point 14 on Figure 5). One monitor well was installed to determine if there was any impact to groundwater due to leaking USTs (Leak IDs: 4480.01, 4480.02, 4480.03). No detectable concentrations of BTEX or TPH were present. The site was closed in 2000.

Empire Metals Inc. (ADEQ Facility ID: 0-001930)

This site is located at 2010 West Lower Buckeye Road (Point 13 on Figure 5). Two USTs were removed in 1994. Release of hydrocarbons at this site was reported to ADEQ (Leak IDs: 3466.01 and 3466.02). Three monitor wells were installed to evaluate the impact to groundwater. Detectable BTEX concentrations were discovered in all three wells. However, the concentrations were all below the ADEQ AWQS. A request for closure of the site was submitted in 1996. Closure has not yet been granted.

Just Enterprises Inc.

This site is located at 3250 West Broadway Road (Point 7 on Figure 5). One monitor well registered with ADWR (Registration No. 55-586366) was drilled at this site as part of a UST investigation in 2001. No records for this site were found at ADEQ.

Patton Boggs L.L.P.

This site is located on the southeast corner of 43rd Avenue and Lower Buckeye Road (Point 8 on Figure 5). According to ADWR registration records, two monitor wells were installed at this site (Registration Nos. 55-564801 and 55-564802). No other information for this site was found.

5.0 CONCLUSIONS

The primary findings and conclusions of this project are summarized as follows:

- As the Salt River is ephemeral and the average annual rainfall in the area is less than 8 inches per year, it is not possible to collect surface water samples on a regular or routine basis to develop a comprehensive data set for analysis against all the identified surface water quality standards.

- There are numerous sources that impact the surface water quality in and around the Salt River. This impact comes primarily in the form of stormwater run-off, but also includes ungaged agricultural drains. Based on land use, analysis of available numeric data, and field observations compared against narrative surface water quality standards, it is clear the stormwater has the ability to negatively impact stormwater quality by introducing pollutants to the Salt River.

- Groundwater elevations in the study area have declined approximately 15 to 20 feet in the last 25 years; groundwater gradient remains to the west-northwest. The gradient in the eastern end of the site is influenced by heavy groundwater production, which alters the local gradient except during the winter months.

- Overall, the general stratigraphy of the alluvial units is consistent throughout the study area.

- The estimated value of transmissivity for the UAU (Units A_1, A_2, B and C) is 27,000 ft^2/day, and the hydraulic conductivity is estimated to be 200 ft/day.

- Groundwater in the eastern half of the study area has lower TDS relative to other portions of the study area. However, groundwater has been impacted by several petroleum hydrocarbon releases from USTs and may have elevated concentrations of 1,1-DCE.

- Available groundwater quality data indicate that groundwater in the southwestern part of the study area has elevated concentrations of TDS and nitrates.

6.0 REFERENCES

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FIGURES

Existing Land Use
Figure 1

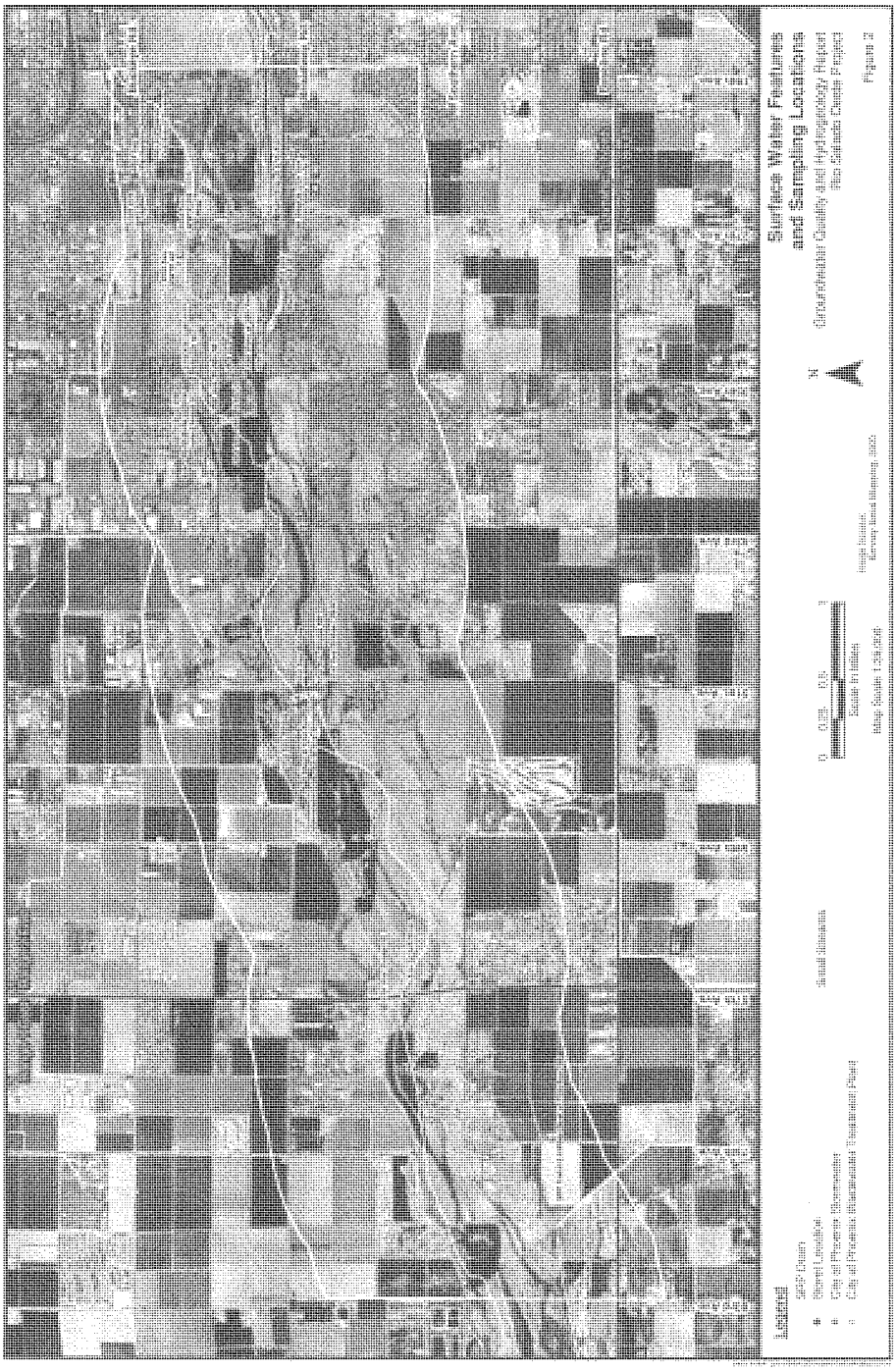
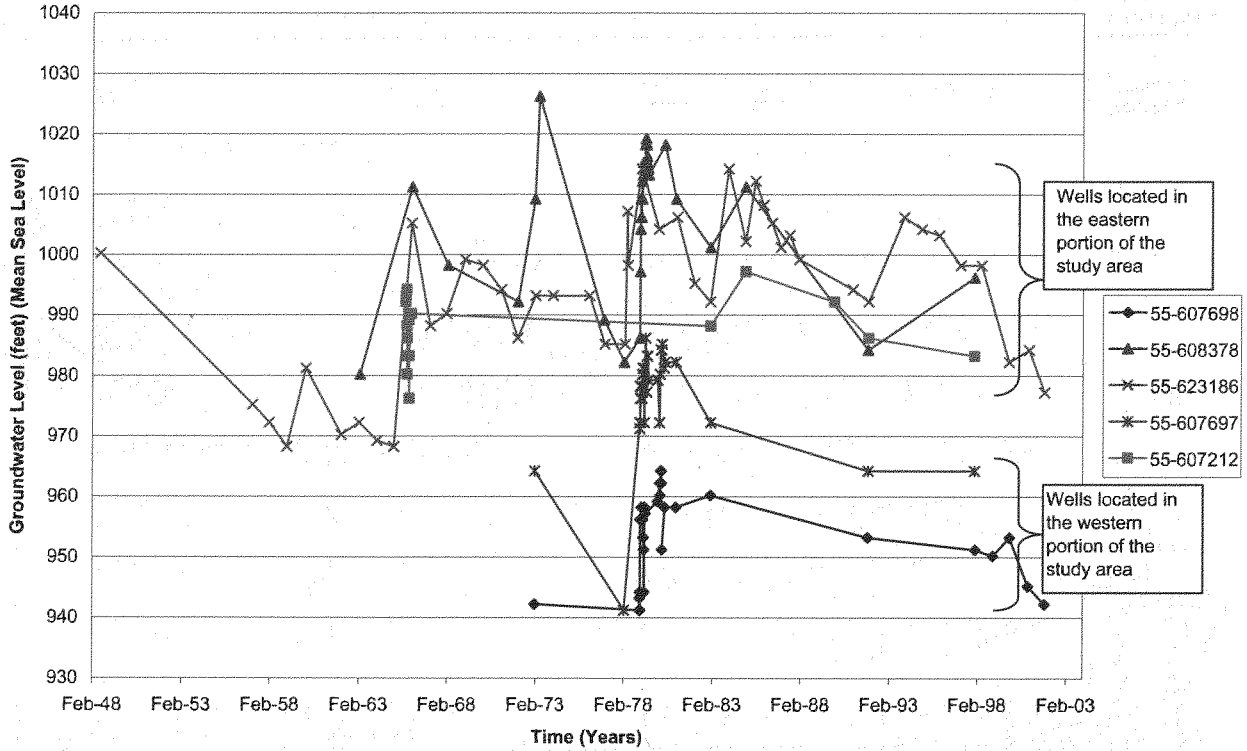

Surface Water Features
and Sampling Locations
Groundwater Quality and Hydrogeology Report
Rio Salado Oeste Project
Figure 2
Legend
Sand Streams
Scale in Miles
N

Figure 3
Selected Hydrographs in the Rio Salado Oeste Study Area



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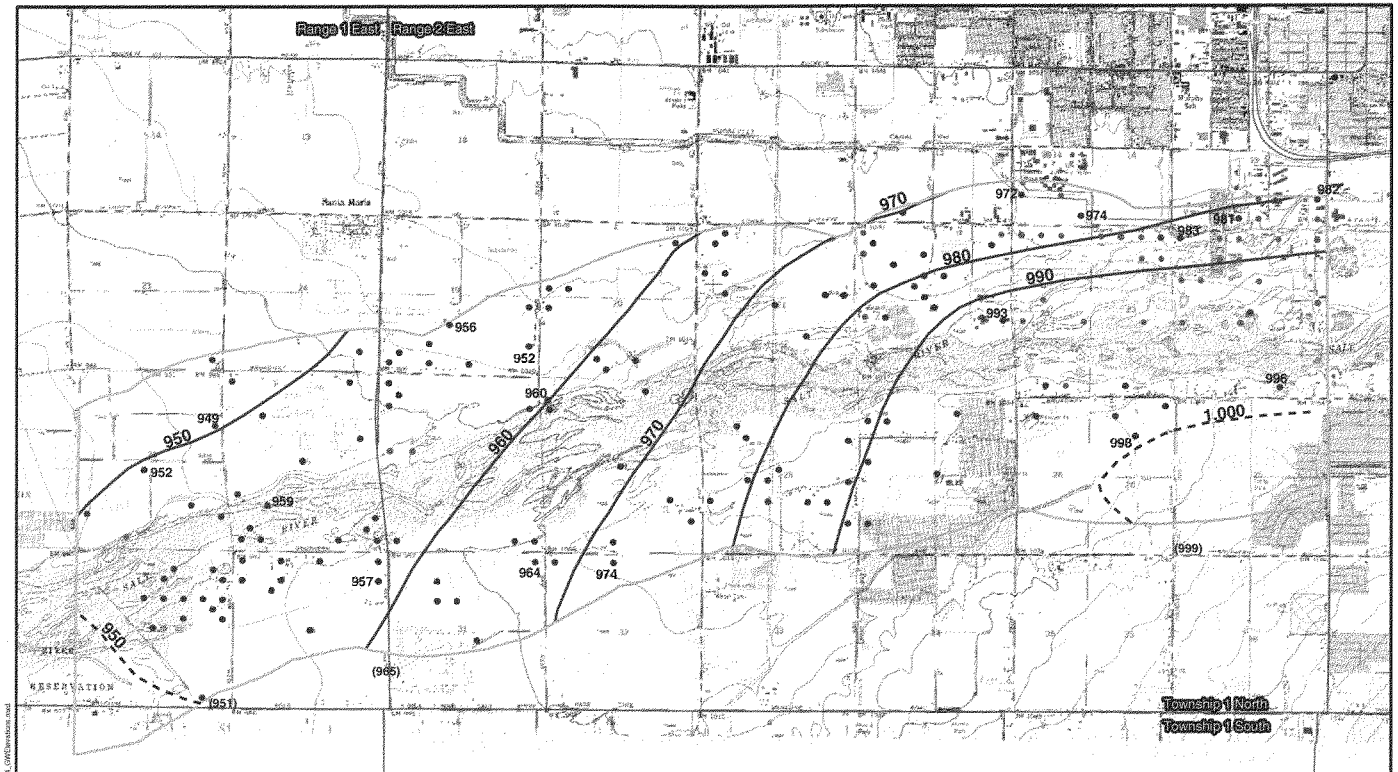
E1-00001727.15



Legend

- Rio Salado Oeste Project Boundary
- Groundwater Elevation Contour (Mean Sea Level) (Feet). Contour Interval 10 Feet
- Inferred G.W. Elevation Contour
- Township and Range Lines

ADWR Well Database

- Monitor
- Observation
- Production

(952) - Groundwater Well Elevation (Feet).
Parentheses denote values from wells outside study area used for contouring.

0 0.25 0.5 1
Scale In Miles
Map Scale 1:35,000

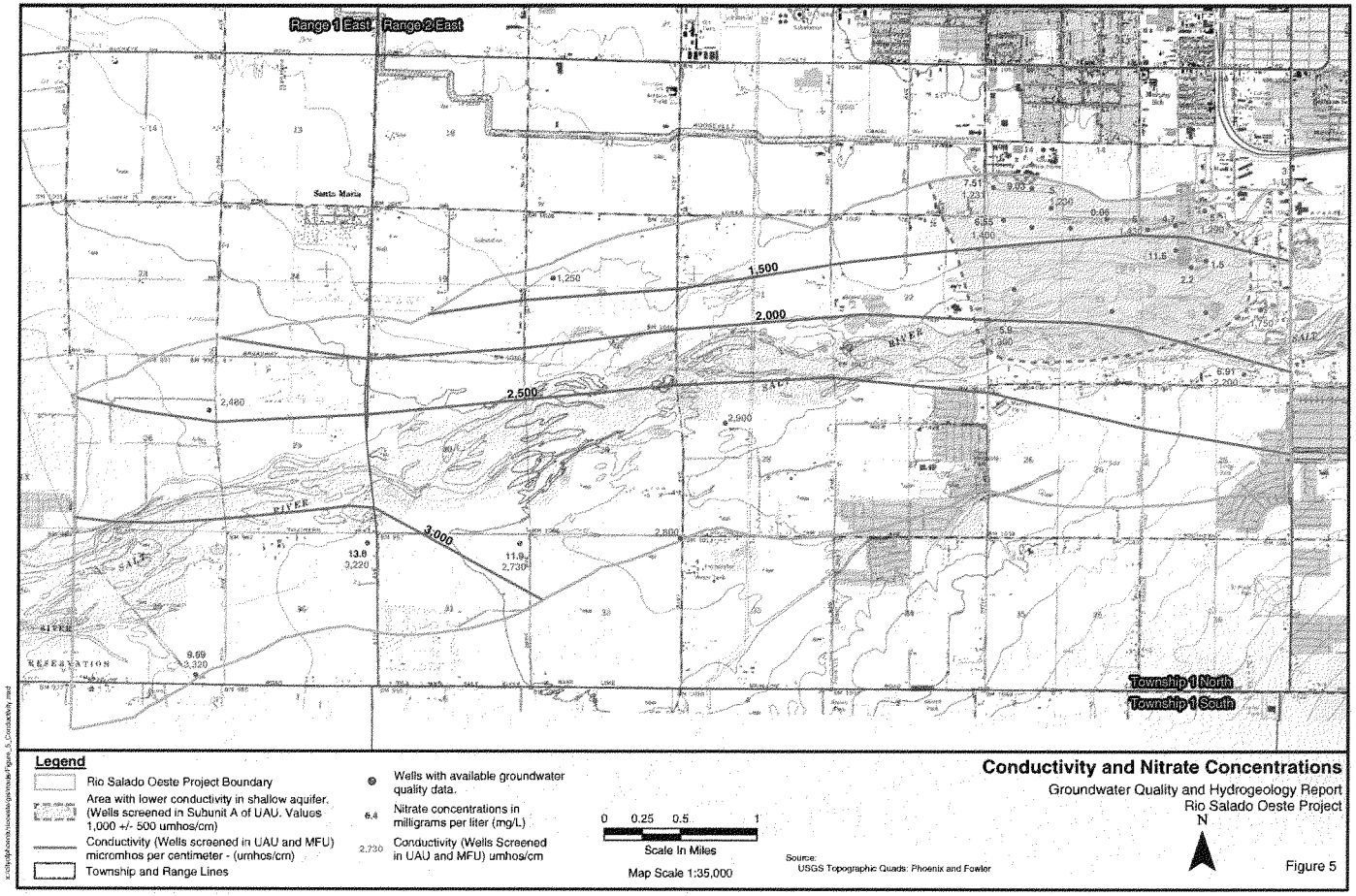
Source:
1997 Elevations from ADWR Database 2/27/02,
USGS Topographic Quads: Phoenix and Fowler

1997 Static Groundwater Elevations

Groundwater Quality and Hydrogeology Report
Rio Salado Oeste Project

N

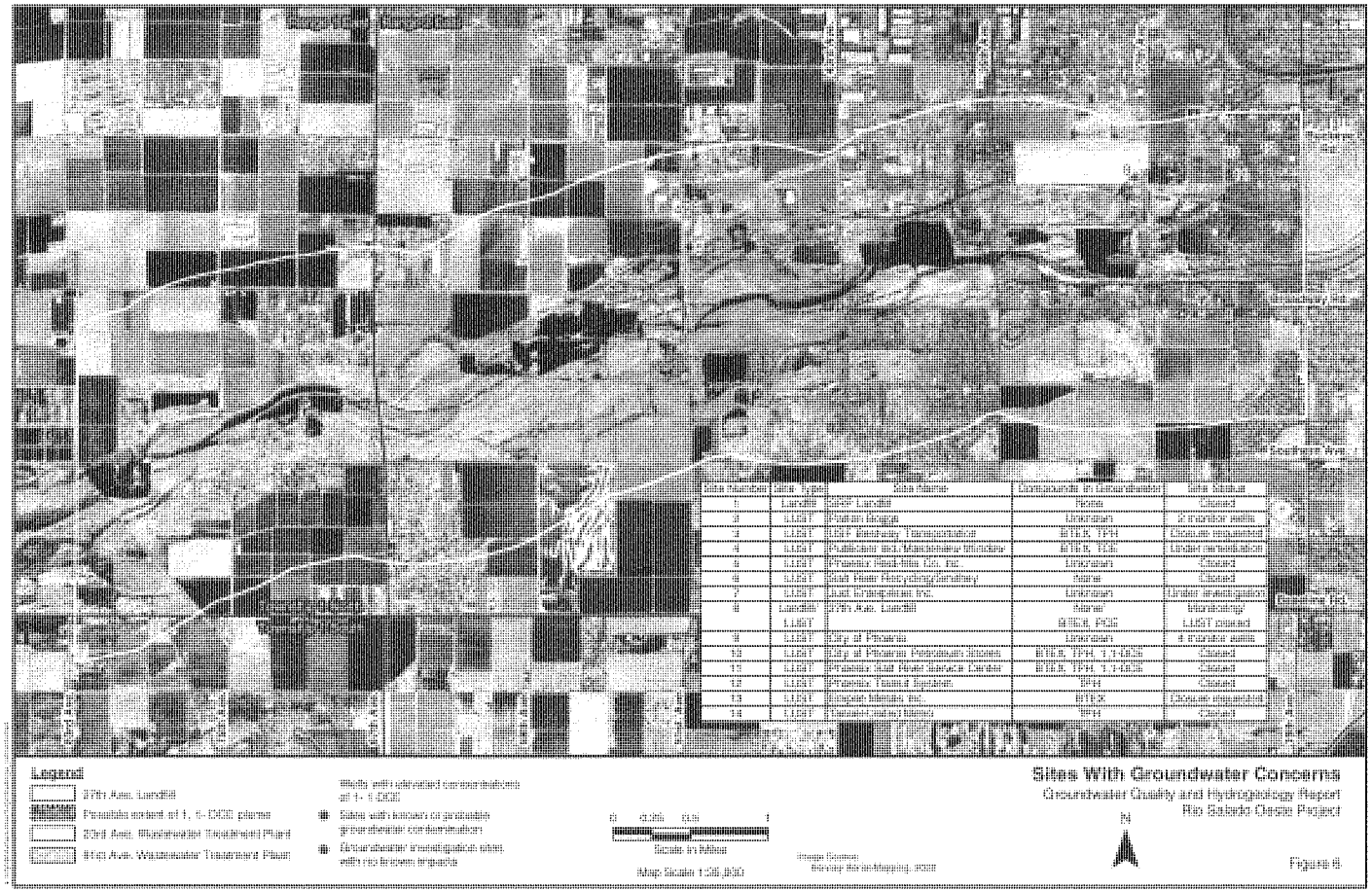
Figure 4



Conductivity and Nitrate Concentrations

Groundwater Quality and Hydrogeology Report
Rio Salado Oeste Project

Figure 5



Site Number	Site Type	Site Name	Compounds in Groundwater	Site Status
1	Landfill	SRP Landfill	None	Closed
2	LUST	Roman Rogge	Unknown	2 monitor wells
3	LUST	UST Beverly Transportation	BTEX, TPH	Closure requested
4	LUST	Publicker Ind./Mastermind Window	BTEX, TCE	Under investigation
5	LUST	Prasnick Fuel-Mill Co. Inc.	Unknown	Closed
6	LUST	Salt River Recycling/Sanitary	None	Closed
7	LUST	Ind. Enterprises Inc.	Unknown	Under investigation
8	Landfill/ LUST	27th Ave. Landfill	None/ BTEX, PCE	Monitoring/ LUST closed
9	LUST	City of Phoenix	Unknown	4 monitor wells
10	LUST	City of Phoenix Peacock Stores	BTEX, TPH, 1,1-DCE	Closed
11	LUST	Prasnick Salt River Service Center	BTEX, TPH, 1,1-DCE	Closed
12	LUST	Prasnick Tanks System	BPH	Closed
13	LUST	Empire Mines Inc.	BTEX	Closure requested
14	LUST	Dessert Lead Mines	BPH	Closed

APPENDIX A

WELL INVENTORY REPORTS

AVAILABLE UPON REQUEST

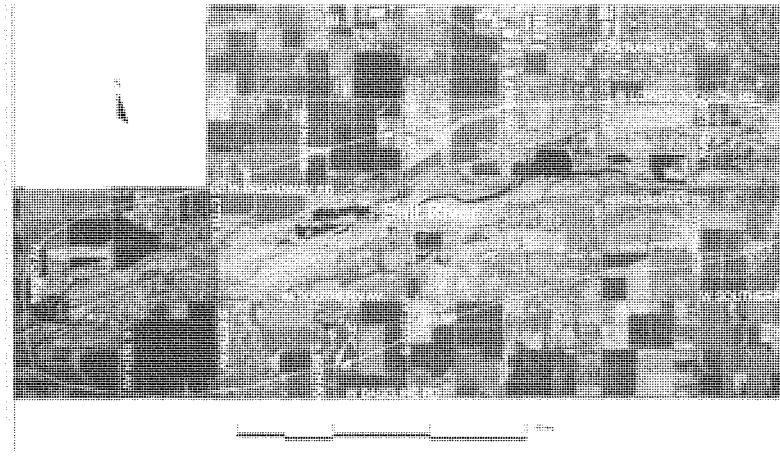
US Army Corps
of Engineers

Rio Salado Project

Oeste Area

Maricopa County, Arizona

APPENDIX E



By

Army Corps of Engineers, Los Angeles District
Engineering Division, Geotechnical Branch
915 Wilshire Blvd, Los Angeles, CA 90017

addr: CESPL-ED-G, PO Box 532711, LA, CA 90053-2325

2006

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1.0 Study Purpose. The U.S. Army Corps of Engineers Los Angeles District (USACE LAD) and the City of Phoenix (COP) initiated this study to evaluate the design and construction of a riparian habitat restoration project. The Rio Salado Oeste (Salt River East) site comprises approximately 8 river miles and the Rio Salado Phoenix environmental restoration project area abuts the study area on the east. The project lies primarily within the City of Phoenix, however, portions of Maricopa County, state and federal land is also included. The proposed project construction activities will occur mostly within the river floodplain; however, the study area encompasses overbank areas north and south of the riverbed.

USACE has produced a prior planning document; the Feasibility Study Project Management Plan dated May 2001. This Geotechnical Appendix for the Feasibility F-4 Phase (without project conditions) contains input to the study by the USACE LAD Geotechnical Branch and consists of pertinent literature and website information.

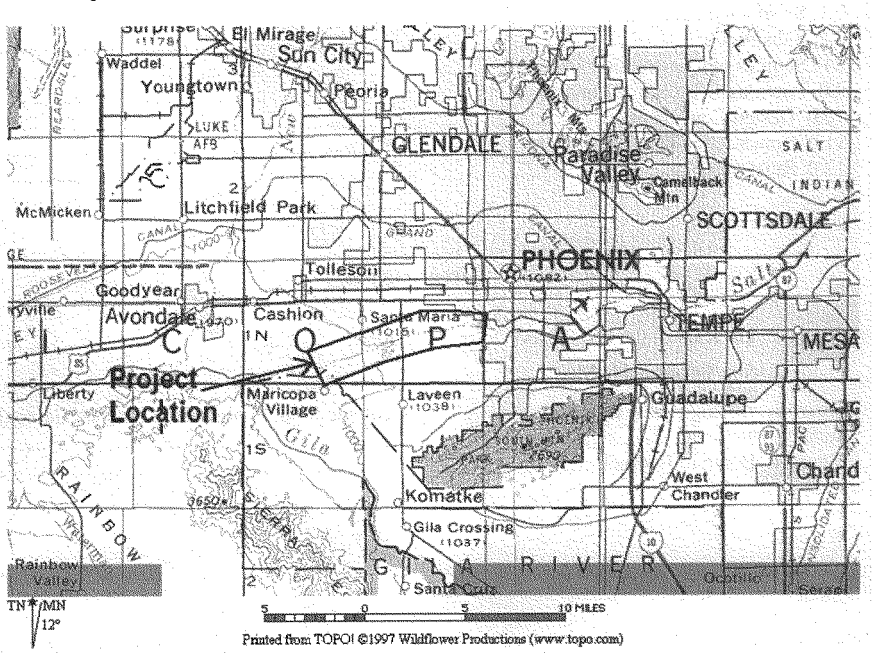

Figure 1. Location of the Rio Salado Oeste study area.

2.0 Description of Study Area. The Rio Salado Oeste study area is located southwest of Phoenix within Maricopa County, Arizona (see Figures 1 and 2). The area is approximately 8 miles long and 2 miles wide, following the centerline of the Salt River, and comprises approximately 10,000 acres. The upstream boundary of the Rio Salado Oeste Study area is 19th Avenue. From there the study area extends southwest to 83rd Avenue. The study area includes river channel and overbank areas. Topographic relief is very low to flat, ranging from about

1050 feet at the upstream (east) end of the area, gently sloping down to about 980 feet at the downstream (west) end (see Figure 2).

The Rio Salado study area is covered by the following topographic map sheets: Phoenix, Arizona 1:250,000 sheet; Phoenix, Ariz. 1:62,500 sheet; and Phoenix and Fowler, Ariz. 1:24,000 sheets.

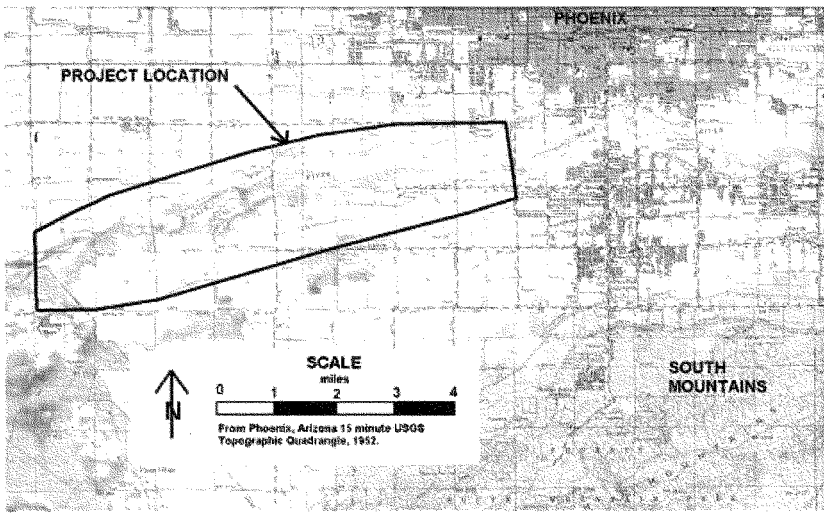

Figure 2. Site Topographic Map.

3.0 Physiography. The Rio Salado Oeste study area lies in the Salt River valley near the center of the Phoenix basin of south-central Arizona, and is geomorphically within the Gila Lowland Section of the Sonoran Desert subprovince, a small portion 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 comprises 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). The Phoenix Basin contains several small ranges, including the Phoenix, South, and White Tank Mountains. Several major rivers pass through the area, including the Rio Salado, 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. 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 7 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 and to 1,750 feet in the Buckeye Hills.

4.0 Regional Geology. The study area lies near the center of the Phoenix Basin of south-central Arizona, within the Southern Basin and Range Province. Broad, gently sloping, interconnected alluvial basins bounded by generally northwest-southeast trending mountain ranges characterize this province. Geologic structure in the area is dominated by block faulting, which produces 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.

Valley fill has been accumulating since the onset of basin and range tectonism, and reaches up to 9,800 feet thick in the interior of the Phoenix Valley. Numerous low-lying isolated bedrock 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. 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 (cemented soils) 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 by the shifting channels of streams eroding the mountains.

4.1 Faulting. Geologic structure in the study area is dominated by block faulting attributable to late Tertiary Basin and Range tectonic events. 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 (Peartree and Scarborough, 1984). Major extension ceased in the area during the late Miocene or Pliocene.

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 exhibits a very low level of seismicity, and evidence of late Quaternary faulting is sparse (Peartree 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 (Peartree and Scarborough, 1984). The nearest mapped Quaternary faults are found to the northeast of the study area along the western flanks of the Mazatzal Mountains (Peartree 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 28 miles northeast of the study area.

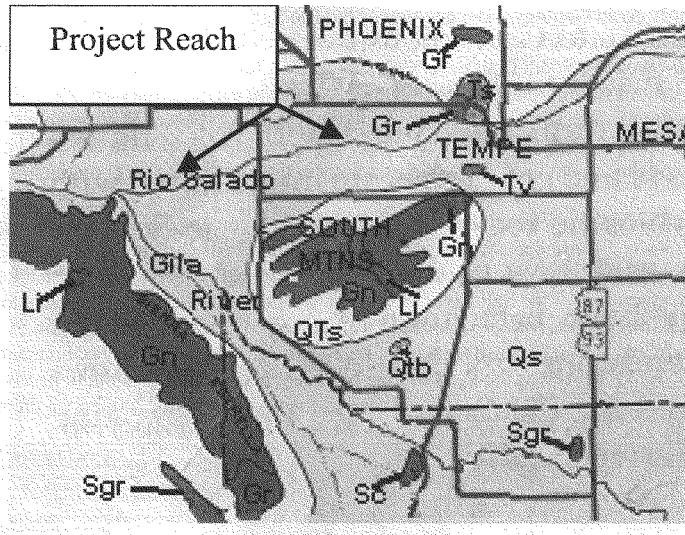

Figure 3. Geologic Map from Arizona Highway Geologic Map, Published by Arizona Geologic Society, 1967.

EXPLANATION		
Map Symbol	**Geologic Time**	**Rock Type**
Qs	Quaternary	Unconsolidated flood plain alluvium.
QTb	Quaternary	Basaltic rocks, cinder cones, dikes and necks. Includes rhyolite and andesite flows and tuffs.
QTs	Quaternary	Weakly to moderately consolidated alluvium, including Gila Group (Gila Conglomerate) in parts of central and southern Arizona. Includes terrace deposits, alluvial fans, and deposits overlying pediments of late Quaternary age. Unconformities are present in the alluvial sequence.
Ts	Middle Tertiary	Sedimentary rocks including the Hement Fanglomerate, Pantano Formation, Whitetail Conglomerate, and Locomotive Fanglomerate in southern Arizona.
Tv	Tertiary	Andesite, rhyolite, latite, dacite flows, welded tuff, and tuff.
Li	Late Cretaceous-Early Tertiary	Intrusive igneous rocks consisting mainly of granite and monzonite, usually porphyritic. Laramide Orogeny.
Gr	Precambrian	Granite.
Sgr	Precambrian	Schist and granite undivided.
Sc	Precambrian	Schist, including Yavapai, Pinal and Vishunu.
Gn	Precambrian	Gneiss.

4.2 Study Area Geology. The geology of the Rio Salado Oeste study is dominated by valley fills and alluvium associated with the Salt River channel. No bedrock outcrops in the project area, however, the South (Salt River) Mountains lie a few miles south of the project and are composed of Precambrian gneiss and late Cretaceous to early Tertiary granite and monzonite (see Figure 3). The surface materials within the Rio Salado Oeste study area are Quaternary age river sediment deposited as alluvium and, to a lesser extent, sheet wash deposited alluvium and slope deposited colluvium. This 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 silt, sand, and clay lenses. The fine sediments are derived from overbank flows. No prominent terraces of the Salt River are present within the limits of the Rios Salado Oeste project. Colluvium is formed of loose to well-cemented silt, sand, clay and gravel. The colluvium and alluvial deposits rest 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 1200 feet on the east end of the project site to 2200 feet on the west side of the project as shown on the depth to bedrock map in Figure 4 (Corkhill 1993).

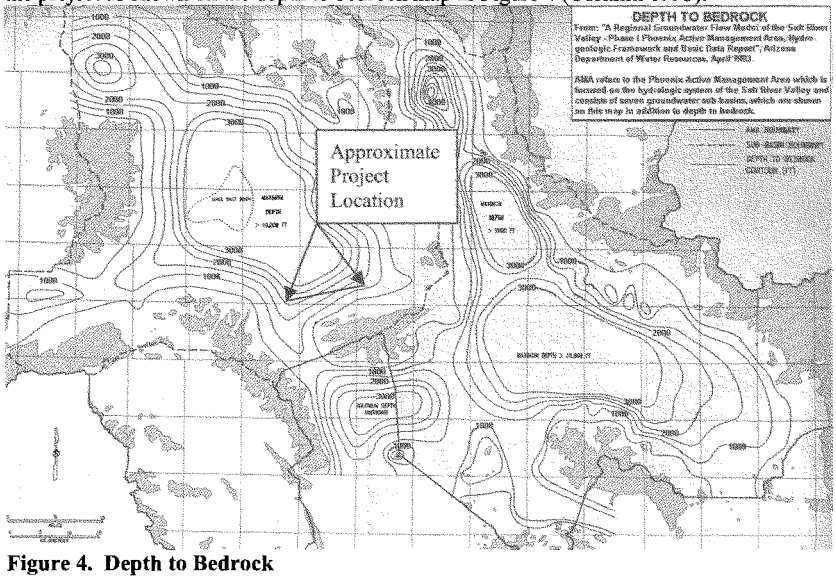

Figure 4. Depth to Bedrock

5.0 Surface and Ground Water. The Salt River in this reach is ephemeral, flowing only in response to local flooding and releases from upstream reservoirs. Downstream from the study area 3 ½ miles, below the confluence between the Gila River and Salt River, the Gila river flows perennially due in part to effluent from wastewater treatment plants.

5.1 Ground Water. 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 (USEPA 1991), and to the south by the Sierra Estrella Mountains which provide a physical boundary to the alluvial aquifer and to groundwater movement. 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
- The Red Unit.

The amount of storage and flow within the units varies considerably with area and depth (USEPA 1993). The four hydrogeologic units are derived from Phoenix Basin alluvial materials. The units are described as the following (their age increasing with descending order) (ADWR 1993):

The UAU comprises all alluvial materials at the ground surface, and extends to depths over 500 feet. It varies from 100 feet to 400 feet in thickness under the Salt River, and is thinnest near mountain fronts and bedrock outcrops. The UAU varies in thickness from 250 feet to 300 feet at the project site. This unit was formed during the final stages of alluvial development of the Phoenix Basin, approximately late Pleistocene to recent (Holocene) time. 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 canals and irrigated land, underflow along major streams, and rainfall-have become more important. Approximately 25% of groundwater withdrawal in the Phoenix basin is from this unit. A very large portion of the groundwater is used for agriculture, while little or none is used for drinking water purposes (Wilson 1991).

The MAU underlies the UAU. At the project site the MAU contact with the LAU varies from 550 feet to 1280 feet below ground surface. The thickness of the unit at this location varies from 300 feet to 1100 feet. The MAU was formed during the middle stages of alluvial development of the Phoenix Basin, approximately late Tertiary to late Pleistocene time. 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 production in the Phoenix basin is withdrawn from this unit, most of it used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson 1991).

The LAU underlies the MAU and the depth to the contact between the LAU and bedrock in the project reach varies from 1750 feet to 2380 feet. The thickness of the unit in this area is from 900 feet to 1100 feet. 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, 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 groundwater production in the basin is withdrawn from this unit, the largest portion being used for agriculture. A smaller portion of the groundwater is used for drinking water purposes (Wilson 1991).

The LAU contains a direct or fault contact with the Red Unit at an unknown depth. The Red Unit is included in the LAU and 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 rock. 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 all three of the upper 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.

Before modern development of the Phoenix basin, groundwater flowed toward the Salt River and then westward, generally following the topography of the land surface. Near Tempe and Buckeye, bedrock constrictions bring water to the surface.

The current groundwater conditions are complex and dominated by drawdown from pumping centers and recharge from agricultural irrigation, canals and flood events (ADWR 1993). Long term regional pumping has led to a groundwater divide in the east Phoenix and Tempe area of the basin. Groundwater in the west Salt River valley flows towards two large groundwater depressions. One is north of Glendale (20 miles north of the project) and one is west of Luke Air Force Base (16 miles northwest of the project site). The 1993 ADWR report had a detailed groundwater map from 1983 data that showed groundwater in the project reach flowed toward the northwest. The Groundwater Quality and Hydrogeology Report for the Rio Salado Oeste Project (URS April 2002), which compiles 1997 groundwater data, shows a generally northward trend of groundwater flow in the eastern portion of the study reach from the upstream end of the project until 30th Avenue. Downstream from 30th Avenue groundwater flow ranges from the west to northwest.

5.2 Depth to Groundwater. According to the April 2002 URS report, the average depth to shallow groundwater in the project area ranges from 20 to 50 feet below ground surface in the channel and from 60 to 80 feet below ground surface north and south of the riverbed. Groundwater depths in the immediate study area are best determined by field observations at local gravel pit "lakes", and will be addressed in the design phase of this project.

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 and 1977). 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 area soils are often sandy to gravelly, may include lenses of finer particles, and are often redistributed by water flows associated with nearby active channels.

7.0 Geologic Hazards. Geologic hazards that were considered in this report are seismicity and subsidence. Hazardous and/or Toxic Wastes (HTW) are considered in the Modified Phase I Environmental Site Assessment Rio Salado Oeste Project.

7.1 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.

Near the study area to the east, a zone (¼ mile wide) of exposed, Tertiary age inactive normal faults, exists immediately north of Tempe Butte gap. The zone trends northwest to southeast, and extends northwestward for a distance of 2.7 miles. 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, 9 miles east of the upstream end of the study area.

The proposed project is 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). About 30 earthquakes with maximum epicentral intensities between II and VI on the Modified Mercalli Intensity Scale (MM) have occurred within a 100-mile radius of the project 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, 82 miles from the project area, had a Richter magnitude of 4.7. The 1969 event, 95 miles from the project area, had a Richter magnitude between 4.4 and 5.1. The 1976 event, 90 miles from the site, had a Richter magnitude of 5.1.

The largest known earthquake to occur in Arizona was of Richter magnitude 5.7 recorded in 1959 near Fredonia, 240 miles from the project area. The seismic historical record for the last 124 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) in the project area. The most recent (1974) regional events, the "New River earthquakes", located 37 miles northeast of the project area, had recorded Richter magnitudes of 2.5 and 3.0.

Because of the relatively low and infrequent seismic activity in and near the study area, it is not expected that strong earthquake motions will have any effect this project.

7.2 Subsidence. Ground failure in the form of (pumping) subsidence and earth-fissures has occurred in areas of the Phoenix basin. Typically groundwater has declined 100 feet in land subsidence areas. The closest ground failure occurrences to the Rio Salado Oeste area is near

Luke Air Force Base, 12 miles north-northwest from the project area, where 1 to 3 feet of subsidence has been measured.

Available information suggests that subsidence in the project area has not occurred in the past and there is very little potential for subsidence to occur in the future. Therefore, subsidence is not projected to influence design or operation of the Rio Salado Oeste project.

8.0 Sources of Construction Materials. Sand and gravel borrow materials are abundant and currently being utilized in the local area, but are not expected to be needed for this construction. Two stone borrow sites have been identified as sources of construction material and may be available for potential use to a contractor. 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 locations exhibits a good service record and has previously passed all rock quality compliance tests. The quarries are:

Sun State Rock and Materials Corp.
-located at 115th Ave. and E. Beardsley Rd, Phoenix, AZ
-passed rock 1990 quality tests
-passed 1994 visual inspection
-rock type: granite
877-566-3304

Salt River Sand & Rock Company
-located at Dobson & McKellips Roads, Phoenix, AZ
-passed 1994 rock quality tests
-passed 1994 visual inspection
-rock type: green schist
480-990-1987

A more detailed evaluation of borrow materials and site specific locations (if required for construction) will be conducted by a geotechnical engineer/geologist during the design phase of this project. At that time more will be known about quantities necessary for construction.

9.0 Previous Geotechnical Investigations. A number of geotechnical field investigations in the study area were completed by engineers of the Los Angeles District and private engineering consulting firms. One relevant study was undertaken for the early planning phases of the Rio Salado Oeste project property between 35th Avenue and 51st Avenue, which lies in the center of the Oeste site. Subsurface drilling was conducted on April 9 and 10, 2001 and consisted of four (4) Rotosonic boreholes to a depth of 30 feet. All four boreholes encountered similar sediments, fine to coarse sand and gravel, with minor amounts of clay. The materials logged are described as tan/brown medium to coarse sand and coarse gravel up to 3 inches diameter. Groundwater was not reported in any of the four borings to 30 feet. All the boreholes were sampled throughout their depths and submitted to Speedie and Associates in Phoenix for laboratory grain size analysis (Parkinson, C.L., 2001).

At each surface location similar materials were found, with the addition of abundant cobbles (at least 10 inches diameter) and less clay-size materials. The project geologist personally examined the entire reach of the project area from 35th Avenue to 51st Avenue and concluded that geologic conditions to a depth of 30 feet are likely representative of the sediments encountered in the four borings referred to above. No cemented materials were encountered in these borings or in the adjoining portions of the Salt River where the project is located; therefore caliche will not be an issue during construction.

The Los Angeles District has completed similar Salt River environmental restoration projects in the general area around Phoenix. These include Rio Salado, Tres Rios and Gila River. On the Rio Salado project immediately upstream of Oeste, the same homogenous coarse sand and gravel fluvial deposits exist. There the Los Angeles District has built four (4) RCC grade control structures and thirty-two (32) buried RCC guide dikes. Geotechnical analysis was conducted for foundation conditions in the Planning, Engineering, and Design (PED) phase for that project and will be likewise undertaken during PED on Oeste. The Salt River remains the same meandering channel downstream along the Oeste reach and clearly does not change geomorphically in this short distance. The fluvial processes (floodplain aggradation and channel meandering) remain identical.

Because of the geotechnical knowledge and experience already accumulated by the Corps of Engineers in the immediate Salt River area, the Project Delivery Team (PDT) elected to forgo additional geotechnical exploration expenditures until the PED phase of this project. Additionally, since the geotechnically designed construction features are allocated less than one-percent (1%) of the total project cost, it was purposely decided by the PDT to move forward in the feasibility phase without delay, deferring additional exploration to the PED.

10.0 Design Considerations. The roller compacted concrete mix and details of the liners will be determined during the PED phase. Foundation conditions will be analyzed by several subsurface boreholes and/or trenches to furnish potential contractors with site specific information and water levels relating to construction of the permanent project structures. Existing gravel pits upstream, downstream and within the study area exhibit excellent exposures of the Recent and Holocene stratigraphy to well below the projected project depths. These gravel pits will be revisited in the PED phase of the project.

11.0 Construction Considerations. Conventional construction equipment will be used to construct the project features. The diversion and control of water requirements are minimal due to the ephemeral nature of the Salt River. Dewatering will be required to construct the grade control structure upstream of 35th Avenue. During PED phase the nearby gravel pits will be inspected and correlated with special attention to accurate groundwater levels as they relate to design and construction parameters.

Unknown volumes of waste and trash removal will be need to be addressed in the construction phase, as the banks of the Salt River have served as an uncontrolled trash dump for many years. There is a strong possibility that some of the trash may be identified as hazardous and toxic waste (HTRW) and will require additional testing and analysis before disposition.

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US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX F

MODIFIED PHASE I ENVIRONMENTAL SITE ASSESSMENT

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

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1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) and the City of Phoenix (the City) have initiated a feasibility study of the Rio Salado Oeste Project area for the purpose of evaluating the design and completion of a riparian habitat restoration project. The project site actually lies within the Salt River between 19th Avenue on the east and 83rd Avenue on the west in Phoenix, Maricopa County, Arizona. However, the north and south study boundaries for this report will be approximately Durango Street and Southern Avenue for the eastern portion, and Broadway Road and Baseline Road for the western portion, respectively. URS was retained by the City of Phoenix to conduct a Modified Phase I Environmental Site Assessment (ESA) for the Rio Salado Oeste Project (the "site" or "subject property"). This Modified Phase I ESA was conducted in accordance with URS' proposal to the City of Phoenix, dated February 4, 2002.

1.1 PURPOSE AND SCOPE OF WORK

Because of the size of the project study area, approximately 20 square miles total, a typical Phase I ESA was not possible. Consequently, a Modified Phase I ESA was decided by the City to be most appropriate for the size of the project. The basic difference being that a site reconnaissance of every property within the project area would not be conducted, or feasible. The Modified Phase I ESA was conducted to review past and current land use practices along the site corridor to identify areas of known or suspected contamination that may environmentally impact the subject property. Due to the size of the project study area and the proposed scope of work, this report will vary slightly from the methods and procedures described in the American Society for Testing and Materials (ASTM) *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* published September 2000 (Standard Designation E 1527-00).

ASTM Standard E 1527-00 defines a "recognized environmental condition" as the presence or likely presence of hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release into structures, ground, groundwater, or surface water on the subject property. The term includes hazardous substances or petroleum products even under conditions in compliance with laws. The term is not intended to include de minimis conditions that generally do not present a material risk of harm to public health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

This Modified Phase I ESA will focus on a broader aspect than identifying a specific "recognized environmental condition". The tasks completed for this project will identify

properties or areas of potential contamination and discuss steps for identifying recognized environmental conditions associated with each property (i.e. ASTM Phase 1 ESA, further document review, Phase II Investigation). The conclusions presented in this report are qualified by URS' judgement as low, medium, or high, for the potential of significant environmental contamination to exist in an area (or specific property) and is based on URS' experience in Arizona.

The Modified Phase I ESA was accomplished by, and limited to, a visual reconnaissance of the site from existing right-of-ways and public areas, a drive-by survey of the site corridor (or vicinity), a review of publicly available records (including aerial photographs), and a review of pertinent documentation presently and readily available from the client and/or through URS' standard resources. The report consists of two volumes labeled *Volume I – Report* and *Volume II – Aerial Photographs*. Volume I consists of the main report which includes the narrative description of aerial photographs, review of regulatory databases, findings, conclusions, and recommendations. Volume II consists of copies of all aerial photographs reviewed for the project. The site corridor is defined as the neighboring properties and facilities along the Salt River within an approximate distance of 1-mile north and south of the river's centerline, the nature of which may adversely affect or have affected environmental conditions at the site due to the presence and/or release of hazardous substances or petroleum products to the environment. URS' scope of services for the environmental assessment included the following elements:

- X Review aerial photographs and update the portion of the Oeste study area from 17th to 51st Avenue that was originally conducted by URS (formerly Dames & Moore) in August 1998.

- X Review aerial photographs for the portion of the Oeste project not previously discussed; 19th to 27th Avenues and 51st to 83rd Avenues. Available aerial photographs will be examined and discussed in narrative form to identify current and previous land use as well as potential sites of environmental contamination.

- X Review and interpretation of available archival topographic maps, historical land use maps of the site for information regarding historical site land use that could have involved the manufacture, generation, use, storage and/or disposal of hazardous substances.

- X Review of the following state and federal agency lists of known or potential hazardous waste sites, and sites currently under investigation for potential environmental violations as prescribed by ASTM. All databases were extended out approximately 1 mile from the Salt River centerline to include the project corridor study area (or "buffer" area):

Federal NPL site list
Federal CERCLIS list
Federal RCRA CORRACTS TSD facilities list
Federal RCRA non-CORRACTS TSD facilities list
Federal RCRA generators list
Federal ERNS list
State lists of hazardous waste sites identified for investigation or remediation:
State-equivalent NPL
State-equivalent CERCLIS
State landfill and/or solid waste disposal site lists
State leaking UST lists
State registered UST lists

X Review previous environmental reports conducted within or relating to the Oeste study area, including the "Middle Gila River Watershed Management Study Phase 2 GIS Database Update and Functionality Enhancement", prepared by Greeley and Hanson, and the "Environmental Contaminants in Fish and Wildlife of the Lower Gila River, Arizona" report, prepared by the U.S. Fish and Wildlife Service.

X Performance of an onsite visual reconnaissance of the subject property and the area within a 1-mile radius of the Salt River centerline to make visual observations of existing site conditions, activities, and types of land use and businesses within the project corridor area. URS also used this reconnaissance to field verify some of the more predominant identified sites.

X Preparation of a final report describing the research performed and presenting URS' findings and professional opinion regarding properties of potential contamination and a discussion of further steps for identifying recognized environmental conditions associated with areas and/or facilities.

1.2 LIMITING CONDITIONS

It was not the intent of URS to conduct a field reconnaissance of the entire subject property corridor and 1-mile buffer area as part of our scope of work. Our visual site reconnaissance was conducted to help interpret aerial photographs and to verify some of the more environmentally predominant sites in the area. Because URS was not granted Rights-of-Entry for any of the properties, our visual reconnaissance was conducted from right-of-ways and public areas.

1.3 LIMITATIONS OF THE PHASE I ESA

The Modified Phase I Environmental Site Assessment was prepared in accordance with the Scope of Work described in URS' proposal to the City of Phoenix, dated February 4, 2002. The work conducted by URS is limited to the services agreed to in the proposal and no other services beyond those explicitly stated should be inferred or are implied.

The findings and conclusions presented in this report are professional opinions based solely upon URS' visual observations of the site, and upon URS' interpretations of the readily available historical information, and other readily available information, as referenced in the report. These conclusions are intended exclusively for the purpose stated herein, at the site indicated, and for the project indicated.

The information provided by URS is for the exclusive use of City of Phoenix and U.S. Army Corps of Engineers. The scope of services performed during this investigation may not be appropriate for other users, and any use or re-use of this document, or the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

This study was not intended to be a definitive investigation of possible contamination within the subject property corridor and buffer area. The purpose and scope of this investigation was to determine if there is reason to suspect the possibility of contamination from properties or facilities within the site vicinity. No specific site reconnaissance, exploratory borings, soil or groundwater sampling, or laboratory analyses were performed within the subject property corridor or buffer area and, therefore, the conclusions set forth herein are made without the benefit of such investigation.

This report is intended to be used in its entirety. No excerpts may be taken to be representative of the findings of this assessment.

Opinions and recommendations presented in this report apply to site conditions and features as they existed during the course of this project, and those reasonably foreseeable. They cannot necessarily apply to conditions, features, or information of which URS is unaware and has not had the opportunity to evaluate.

2.0 SITE DESCRIPTION

Information concerning the subject property presented in the following subsections is based on a review of readily available published information and a field visit of the general subject property corridor area conducted on March 5, 2002.

2.1 PHYSICAL LOCATION AND DESCRIPTION OF PROPERTY

The Rio Salado Oeste site actually lies within the Salt River between 19th Avenue on the east and 83rd Avenue on the west in Phoenix, Maricopa County, Arizona. For purposes of this study, the north and south boundaries (or "buffer" area) will be approximately Durango Street and Southern Avenue for the eastern portion, and Broadway Road and Baseline Road for the western portion, respectively. The entire subject property is located within the following township, range, and sections of the Gila and Salt River Base Meridian;

Township 1 North, Range 2 East, Sections 13-15 and 19-32.
Township 1 North, Range 1 East, Sections 23-26, 35, and 36.
Township 1 South, Range 1 East, Section 2.

2.2 ENVIRONMENTAL SETTING

Environmental characteristics including topography, geology, and hydrogeology were evaluated based on site observations, published literature, and maps.

2.2.1 Topography

According to the United States Geological Survey (USGS) Phoenix and Fowler, Arizona 7.5-minute topographic quadrangle maps (1952, photorevised 1982), the elevation of the subject property is approximately 1,100 feet above mean sea level in the east and approximately 980 feet in the west. The general direction of surface water flow along the subject property is to the west.

2.2.2 Geology

The site is located in the Salt River Valley. The Salt River Valley is a broad alluvial basin within the Basin and Range physiographic province. The basin is almost completely surrounded by mountains composed primarily of granitic, metamorphic, and volcanic rocks and minor amounts of consolidated sedimentary rocks. The valley floor is underlain by unconsolidated to semiconsolidated basin-fill sediments. In the eastern part of the Salt River Valley area, sedimentary deposits form the main water-bearing units and consist mainly of unconsolidated and weakly consolidated clay, silt, sand, and gravel. The main water-bearing unit ranges in thickness from a few tens of feet near the mountains to more than 1,200 feet in the central part of the area (Cooley, 1973).

2.2.3 Hydrology

According to B.A. Hammett and R.L. Herther's *Maps Showing Groundwater Conditions in the Phoenix Active Management Area, Maricopa, Pinal and Yavapai Counties, Arizona - 1992,* and based on information obtained for this report, the general depth to groundwater in the area of the subject property is approximately 60-70 feet below ground surface. Although certain areas of the eastern portion of the subject property do experience heavy pumping activity 8 months out of the year, the overall general direction of groundwater flow in the vicinity of the subject property appears to be to the west.

Because the subject property is located in and along the Salt River, it is expected that it would be located within the boundaries of a 100-year floodplain. Consequently, the subject property is depicted within a 100-year floodplain according to the following Flood Insurance Rate Map Nos.; 04013C2115-E, 04013C2120-E, and 04013C2140-E, all dated July 19, 2001, published by the Federal Emergency Management Agency (FEMA).

2.2.4 Soils

URS reviewed readily available reference material providing soil types for Maricopa County. According to the U.S. Department of Agriculture Soil Conservation Service, naturally occurring on-site surface soil consists primarily of Carrizo and Brios soil in the Carrizo Series (USDA, 1977). These soils are in or adjacent to channels of the Salt River. It is bisected by small stream channels and old meander cutoffs. Once every 5 to 20 years the lower lying areas are flooded. Flooding changes the soil material and occasionally the course of the main channel. Generally this mapping unit is typically a combination of Carrizo, Brios, and Vint soils. The Carrizo soil is usually in the lowest position nearest the stream channel, the Vint soil along the outer rim, the Brios soil in the intermediate position.

The engineering classifications of the soils are also found in the USDA 1977 publication. The Brios soil is classified as a sand and very gravelly sand (SP). The Carrizo soil is classified as a very gravelly coarse sand (SW-SM) to a very coarse sandy gravel (GW-GM). The Vint soil is classified as a loamy fine sand (SM).

3.0 SITE RECONNAISSANCE

URS conducted a preliminary site reconnaissance at the commencement of this project to become familiarized with the type of properties associated with the project study area. URS traversed the major (and some of the minor) streets and roads along the north and south sides of the Salt River from 19th Avenue to 83rd Avenue. The intent of this reconnaissance was not to

observe specific properties or features, but rather to gain insight into the general existing conditions and types of properties within the project study area.

3.1 GENERAL CONDITIONS

URS viewed the project study area to observe and understand basic land use within the following seven categories; Residential, Commercial/Industrial, Landfill, Sand/Gravel Operation, Agricultural, Recreational (i.e. public parks), and River Bottom/Native (see Figure 1). To remain consistent with our historical aerial photograph review of land use, the project study area was divided into four separate portions of land; 19th - 35th Avenue, 35th - 51st Avenue, 51st - 67th Avenue, and 67th - 83rd Avenue. The following is a brief summary of general land use activities based on existing data and a preliminary reconnaissance of the project area (as shown on Figure 1 at the end of this report).

19th Avenue - 35th Avenue

Sand and gravel operations line the Salt River with no remaining native river bottom. Commercial/industrial properties flourish in this area both north and south of the river. The 27th Avenue Landfill lies north of the river bottom in an area almost surrounded by commercial/industrial properties. Only a small portion of land is occupied by residential and/or agricultural land. The following percentages are estimated for land use categories within this portion of the project study area; Residential - 3%, Commercial/Industrial – 43%, Landfill - 6, Sand/Gravel Operation - 22%, Agricultural - 26%, Recreational - 0.5%, and River Bottom/Native - 0%.

35th Avenue - 51st Avenue

Major sand and gravel operations exist in and along the Salt River with almost half the river remaining native. Large areas of commercial/industrial properties exist primarily on the north side of the river, leaving more residential properties to the south of the river. Agricultural properties are fairly sparse. The following percentages are estimated for land use categories within this portion of the project study area; Residential - 16%, Commercial/Industrial - 31%, Landfill - 0%, Sand/Gravel Operation - 26%, Agricultural - 8%, Recreational - 0%, and River Bottom/Native - 19%.

51st Avenue - 67th Avenue

Sand and gravel operations remain in and along a large portion of the Salt River with almost half the river remaining native. Almost no commercial/industrial properties exist. Although there are small pockets of residential land north and south of the river, the majority of land is still used for

agricultural purposes. The following percentages are estimated for land use categories within this portion of the project study area; Residential - 17%, Commercial/Industrial - 2%, Landfill - 0%, Sand/Gravel Operation - 17%, Agricultural - 38%, Recreational - 4%, and River Bottom/Native - 22%.

67th Avenue - 83rd Avenue

Sand and gravel operations continue to exist in and along some areas of the Salt River with a small portion remaining native. Few commercial/industrial properties exist. However, some do lie along the southern bank of the river. Although there is a small pocket of residential land north of the river, the majority of land is still used for agricultural purposes. The following percentages are estimated for land use categories within this portion of the project study area; Residential – 7 percent, Commercial/Industrial – 12 percent, Landfill – 0 percent, Sand/Gravel Operation – 23 percent, Agricultural – 49 percent, Recreational – 0 percent, and River Bottom/Native – 9 percent.

4.0 HISTORICAL AERIAL PHOTOGRAPH REVIEW

URS conducted a review of available aerial photographs to discuss and describe changes in land use within the project study area. Because of the quality and extensive coverage available at Landiscor Aerial Photography, URS concentrated our review efforts there. The review of aerial photographs included the entire project study area from 19th Avenue (on the east) to 83rd Avenue (on the west) with north and south boundaries of approximately Durango Street and Southern Avenue (for the eastern portion) and Broadway Road and Baseline Road (for the western portion), respectively. Available aerial photographs examined and discussed herein consisted of 1962 to 2002 and are contained in Volume II of this report. URS has included approximately every other year starting with 1962 and continuing until 2002. Additionally, for ease of viewing the included photographs, URS has included an overlay approximately every ten years. Because of scaling difficulties encountered by the laboratory, the overlays may have to be realigned for proper boundary placement in order to view each subsequent photograph.

The aerial photograph review consisted of viewing a photograph and then comparing it to the next available photograph in chronological sequence. Notations were made regarding changes in land use similar to the seven categories previously discussed. Specific industrial activity or land use was noted when it could be confidently identified (i.e. salvage yard, landfill, etc.) although many of the commercial/industrial activities were left unidentified (i.e. industrial complex). Because of the expanse of area covered by this project, it was not feasible to identify and record every single development or change in property that occurred. Consequently, general statements

may be made for some properties or areas that may not specifically coincide with the exact year of a photograph.

URS compiled the information according to the year of the photograph and its location within the project study area. Because of the overall size of the study area, URS divided the area into four separate portions of land consisting of approximately two miles long each; 19th - 35th Avenue, 35th - 51st Avenue, 51st - 67th Avenue, and 67th - 83rd Avenue. Within each two-mile portion of land, the area was then subdivided into quarter sections as described in the City of Phoenix Quarter Section Index Map. Basically, any given Section (1-mile square) within a Township and Range location can be divided into four quarter-sections with each of these quarter-sections already assigned a specific number (i.e. the four numbers assigned to Section 26 of Township 1 North, Range 2 East are 3-9, 3-10, 4-9, and 4-10). For discussion purposes in the narrative descriptions below, the word "quarter-section" will be denoted as QS.

19th Avenue to 35th Avenue (inclusive of Township 1 North, Range 2 East, Sections 13, 14, 23-26)

3-21 (North half of QS only); The land has been utilized primarily for agricultural purposes from 1962-2002.

3-22 (North half of QS only); The land has been utilized primarily for agricultural purposes from 1962-2002.

3-23 (North half of QS only); The land has been utilized primarily for agricultural purposes from 1962-2002.

3-24 (North half of QS only); The land has been utilized primarily for residential purposes from 1962-2002.

4-21; A racetrack (currently Manzanita Speedway) has been visible in the northwest corner of the QS from 1962-2002. Additionally, a small commercial facility has also been visible on the corner of Broadway Road and 35th Avenue from 1962-2002. Auto salvage yards begin appearing in the northeast quarter of the QS in the early-1970s and greatly expand throughout the 1970s, 1980s, and 1990s while remaining visible in 2002. The southern half of the QS is utilized for agricultural purposes from 1962-2002 with sand/gravel removal/operations occurring in the southeast corner from 1998-2002.

4-22; The land is utilized primarily for agricultural purposes with auto salvage yards along the northern edge (Broadway Road) of the QS from 1962 to the early-1980s. By the mid-1980s, some of the agricultural land has gone fallow with sand and gravel removal occurring in the

southern half of the QS. By the early-1990s, the QS has become entirely occupied by sand/gravel removal, auto salvage yards (along the northern edge), and areas of fallow agricultural land.

4-23; From 1962 to 1974, the QS is utilized for agricultural purposes. In 1976, the QS remains agricultural with two small commercial-type facilities now visible along Broadway Road. Through the remainder of the 1970s and 1980s, the northern portion of the QS expands with more commercial-type facilities and salvage yards while the remainder of the QS continues as agricultural up to 2002. However, an oval-shaped depression is visible in the southeast corner of the QS from 1982 to 2002 and appears to possibly be used as a dump with only a single structure visible.

4-24; The QS is primarily utilized for agricultural and residential purposes from 1962 to 1976. In 1978, several auto salvage yards begin to appear in the northwest quarter of the QS and expand further south up until 2002. Some remaining agricultural land is still visible but has slowly turned fallow through the years.

5-21; In 1962, the QS contained light industrial storage in the western quarter section and small sand/gravel pits in the southern half of the QS. In 1964, an industrial building along 35th Avenue was noted. An auto salvage yard was identified on 35th Avenue in 1966 until it was destroyed by flooding sometime in 1968. In the early-1970s, an auto salvage yard was identified on the north side of Broadway Road with interspersed small sand/gravel pits. By 1975, the salvage yard had expanded covering the older gravel pits. Throughout the 1980s and 1990s, the salvage yards continued operation in the south half of the QS as small sand/gravel pits were noted in the northern half.

5-22; North half of QS; Sand/gravel removal/operations seem quite prevalent throughout most of the river bottom from 1962 to 1996. By 1998, a large portion of these operations were flooded by water with continued sand/gravel removal occurring immediately surrounding the flooded areas through 2002.

South half of QS; Commercial-type facilities (auto salvage yards) line the southern edge of the QS along Broadway Road from 1962 to 2002.

5-23; North portion of QS; Although some minor sand/gravel removal occurred in the river bottom in the northern portion of the QS in the 1970s (with subsequent flooding in the early-1980s), a large expanse of sand/gravel removal occurred in the QS and in the entire area in the late-1980s, before being once again flooded through the 1990s. By 2000, the northern portion of the QS was utilized primarily as roads leading to nearby sand/gravel pits.

South portion of QS; Commercial/light industrial facilities line Broadway Road from 1962 to the mid-1970s. By 1978, it became apparent that most of the properties were now auto salvage yards that have remained along the bottom one-third of the QS to 2002.

5-24; Extensive sand/gravel removal/operations occurring in the northern half of the QS from 1962 to 2002. Based on the equipment/machinery observed in the photographs, there is likely a cement batch plant on-site also.

Commercial/light industrial/storage yard-type facilities along Broadway Road are visible in 1962 and appear to increase and expand with auto salvage yards in the early-1970s. By the mid-1980s, the salvage yards dramatically increase with junk that remains visible to 2002. One of the facilities located in the southeast corner of the QS constructs a larger building by 1994 which remains visible to 2002.

6-21; North half of QS; Land is utilized primarily for agricultural purposes from 1962 to 1974. By 1976, sand/gravel removal of the north half of the QS was visible for the initial stages of the 27th Avenue Landfill. By 1982, landfill activity began while an auto salvage yard was noted in the northwest corner of the QS with additional industrial properties visible along the western edge. By the early-1990s, the landfill appeared to be capped while industrial facilities and the auto salvage yard remained active along the western edge of the QS through 2002.

South half of QS; The south half of the QS consists of a large (effluent) recharge basin from the 27th Avenue Wastewater Treatment Plant (located to the northeast). The basin appears wet and dry throughout the years from 1962 to the mid-1980s. It then appears to remain (dry) dormant through 2002.

6-22; North half of QS; Land is used in part for agricultural purposes with a portion appearing as native river bottom from 1962 to 1974. By 1976, sand/gravel removal of the north half of the QS was visible for the initial stages of the 27th Avenue Landfill. By 1982, landfill activity was visible and by the early-1990s, the landfill appeared to be capped.

South half of QS; The south half of the QS consists of a large (effluent) recharge basin from the 27th Avenue Wastewater Treatment Plant (located to the northeast). The basin appears wet and dry throughout the years from 1962 to the mid-1980s. It then appears to remain (dry) dormant through 2002. However, a large industrial facility was visible in the southeast corner of the QS from 1993 to 2002.

6-23; North half of QS; Wastewater treatment ponds associated with the (adjacent) 27th Avenue Wastewater Treatment plant are visible in the north-central and northeast corner of the QS from

1962 to 2002. The northwest corner of the QS consists of sand/gravel removal activities in the 1960s before turning into a disorganized-type property with numerous buildings and heavily stained soil visible from 1970 to 2002.

South half of QS; The south half of the QS consists basically of native river bottom with two man-made drainage channels visible in the 1960s and 1970s; one leading from the wastewater treatment pond area and one leading from an adjacent (QS 6-24) storage lot and facility first visible in the 1960s. A road is later visible in the mid-1970s transecting one of the drainage channels. Large sand/gravel pits are prevalent in the 1980s and 1990s as one of the drainage channels still appears visible in 2002.

6-24; The starting point of a man-made drainage channel is located in the western portion of this QS and remains visible from 1962 to 2002. In 1962, the following additional observations were made; several yards (auto salvage, construction, industrial) are located along the eastern portion of the QS (west side of 19th Avenue), sand/gravel removal is occurring along the western half of the QS, and a storage area for trailers is noted in the center of the QS.

By 1966, the sand/gravel operations were replaced by a new facility in the northwest quarter of the QS, while the northeast quarter has expanded with a larger storage yard and more structures. However, sand/gravel operations now expand into the southeast corner of the QS.

By 1972, the entire east portion of the QS is filled with various facilities and yards, including one near the center that stretches ¼-mile from north to south. By 1978, the ¼-mile long facility yard now stretches west.

In 1982, a new (large) building is visible in the north-central portion and the entire QS is filled with numerous commercial/industrial facilities, yards, and buildings. Sand/gravel removal continues to occur along the southern edge of the QS while the remainder of the QS continues with ongoing industrial activities through 2002.

7-21 (South half of QS only); The land has been utilized primarily for agricultural purposes from 1962-2000. By 2002, three large facilities were visible in the southeast quarter of the QS with continued construction/development occurring in the south-central portion and agricultural land remaining in the southwest portion of the QS.

7-22; (South half of QS only); Land primarily utilized for agricultural purposes from 1962 to 1996, then becoming fallow between 1998 to 2000 and finally appearing graded in the 2002 photograph.

7-23; (South half of QS only); The west half of the QS is utilized for agricultural purposes from 1962 to 2002. The east half of this QS contains a large wastewater treatment plant with numerous ponds, buildings, and structures (including aboveground storage tanks) visible from 1962 to 2002. Although the lay-out and design of the ponds have changed throughout the years, the wastewater treatment plant has occupied the east half of this QS from 1962 to 2002.

7-24; (South half of QS only); Although some farm-type homes/properties existed in the northeast corner of the south half, the area appeared somewhat industrial in nature beginning in the 1960s, containing several large buildings and a portion of the wastewater treatment plant facilities along the western edge of the QS. By the late-1970s, the western portion contained more paved-type of facilities, whereas the eastern portion contained open-ground properties with dark soil staining, which remained visible into the late-1990s. By 2000, several facilities occupied the QS with large areas now covered by paved parking lots and unpaved storage yards.

35th Avenue to 51st Avenue (inclusive of Township 1 North, Range 2 East, Sections 15, 21, 22, 27, and 28)

3-17; Land is primarily utilized for agricultural purposes from 1962 to 1980. In 1982, commercial activity appears to begin along the western half of the QS. By 1994, a large portion of the agricultural land becomes fallow and by the late-1990s, is used for sand/gravel removal.

3-18; The land is a mixture of agricultural land and residential properties from 1962 to the late-1970s. Some of the properties then become commercial. By the late-1980s a mixture of agricultural land, residential and commercial properties are prevalent, especially in the northeast corner and along the southern edge of the QS. The northern tip of the QS contains a portion of an industrial facility (elongated buildings) from 1982 to 2002.

3-19; (North half of QS); The land is utilized primarily for agricultural purposes in to the late-1960s until residential homes begin development in the early-1970s. By the mid-1980s, some commercial development is visible and by the mid-1990s, the entire northwest quarter of the QS appears to be commercial. Conversely, the northeast quarter of the QS turns fallow and remains this way into 2002.

(South half of QS); From 1962-1964, this portion of the QS is fallow agricultural. By 1966, homes begin development at which by 1972, the area is completely developed with single-family homes which remain visible to 2002.

3-20; The land is primarily utilized for agricultural purposes with a residential subdivision in the northeast quarter and one (large) building in the northwest corner of the QS in the early-1960s.

By the late-1960s, the QS is filled with more homes as the agricultural land slowly changes to residential use. The large building in the northwest corner expands to a large (commercial) complex of several buildings by 1972. With the southeast corner still primarily vacant, the entire QS has remained relatively unchanged since the early-1970s.

4-17; (North half of QS); Native river bottom with intermittent sand/gravel removal from 1962-2002.

(South half of QS); Agricultural land with associated farm houses visible from 1962-1986. By 1988, sand/gravel operations are visible and slowly taking over the land to 2002.

4-18; (North half of QS); River bottom and riverbank from 1962 to 2002.

(South half of QS); Land utilized primarily for agricultural purposes with possible cattle lot located in the southeast corner of the QS from 1962 to 1980. A large scale sand/gravel operation (currently Vulcan) was visible from the early-1980s to 2002 along with an industrial (concrete mold) facility in the southeast corner of the QS.

4-19 (North half of QS); Land utilized primarily for agricultural purposes from 1962 to 1976. By the late-1970s, auto salvage yards were quite predominant and increasing with debris to 2002.

(South half of QS); Land utilized primarily for agricultural purposes with a farm house from 1962 to 1988. From 1990 to 2002, the land was then utilized for sand/gravel removal by the 27th Avenue Landfill; likely for capping of individual cells.

4-20; The eastern ¾ of the QS has been a residential subdivision from 1962 to 2002. The western ¼ of the QS has been a combination of native, agricultural, and residential, with a portion used just as an access road (1993-2002) to a nearby sand/gravel pit from 1962 to 2002.

5-17; (North half of QS); Land utilized primarily for agricultural purposes from 1962 to 1982 before being graded (but not fallow) from 1985 to 1998. In 2000 and 2002, sand/gravel removal is occurring within this portion of the QS.

(South half of QS); Native river bottom from 1962 to 2002.

5-18; (Northern portion of QS); The northern portion of the QS has been agricultural from 1962 to 1998 before being used for sand/gravel removal in 2000 and 2002.

(Middle portion of QS); Although minor sand/gravel removal may have occurred in the early-1960s, more predominant sand/gravel operations began in the late-1960s and continued to 2002 with major operations and buildings first visible in 2000.

(Southern portion of QS); Land is primarily native river bottom from 1962 to 2002 with a small portion in the north used for sand/gravel removal.

5-19; (North half of QS); Land is primarily utilized for agricultural purposes from 1962 to 1970. In 1972, the beginning of a large sand/gravel removal/operation is visible in the northwest corner of the QS which then expands to include the entire northern half of the QS by 1983.

(South half of QS); The southern half of the QS remains native river bottom (with some small sand/gravel removal in the southwest corner in the 1960s) until the late-1980s. At that time, the sand/gravel removal encompasses more of the southern half of the QS. By 1998, the sand/gravel appeared to diminish in activity and by 2000, equipment associated with the sand/gravel operation had been removed from the site. In 2002, the sand/gravel site (in the northwest corner) was paved and now consists of a storage yard for semi-trucks/trailers. Water still occupies the former sand/gravel pit in the east portion of the quarter while the southern portion remains native river bottom.

5-20; Although the QS is primarily native river bottom in the early-1960s, sand/gravel removal is evident in various places such as the northeast, southeast, and southwest corners of the QS. It appears that someone may have tried to farm a portion of land in the southwest corner of the QS in 1962 and 1964. In 1966, the northeast corner of the QS contained a property resembling a salvage yard that expanded in the 1970s with piles of mounded debris and winding roads visible. By the late-1980s, the piles of debris diminished (until 1996) as the buildings multiplied. By 1998, the debris piles once again increased as the site looks quite disorganized and "dirty" in 2002.

6-17; In the early to mid-1960s, the QS appears as agricultural and residential in use. In 1968, an industrial yard is noted in the southwest corner of the QS with miscellaneous parts and scrap. This yard immensely expands by 1974 to encompass the entire southwest corner of the QS and appears to now consist of a cluster of four to five businesses. In 1976, a roof truss manufacturer (previously identified as such) replaces one of the junkyards, and by 1983, expands to the south. In 1985, a large industrial building (and smaller one) is noted in the northwest corner of the QS. Also in 1985, the residence located in the northeast corner of the QS appears to become industrial in nature as some of the agricultural land turns fallow and the buildings and debris increase dramatically. In 1986, a smaller commercial building is visible in the extreme northwest corner of the QS and remains visible through 2002. By 1998, the large industrial property in the northwest corner of the QS increases with additional buildings, pavement, and the storage of over 100 tractor trailers.

6-18; The land is utilized primarily for agricultural purposes with a natural wash running through it and a residence located in the southeast corner of the QS from 1962 to 1998. A large industrial building is visible in the southwest quarter of the QS in 2000 and 2002 with the storage of large metal pieces or equipment to the south of the building.

6-19; The land is utilized primarily for agricultural purposes from 1962 to 1972. From 1974 to 1978, the QS remains agricultural with a stock yard visible in the southwest quarter. By the early-1980s, several facilities were constructed along the west half of the QS, along with an additional facility (sand/gravel operation) visible in the southeast corner. In 1988, a junk yard appeared along the southwest corner of the QS. Another facility became visible in 1998 in the center of the QS, which included a large parking lot. By 2000, the sand/gravel pit in the southeast corner has been shaped with uniform even slopes and by 2002, it appears as if it is being used as a landfill.

6-20; From 1962 to the early–1970s, most of the land was used for agricultural purposes (orchards or possibly a nursery). By 1972, a wastewater treatment facility was observed in the southeast corner of the QS. In 1974, a small sand/gravel operation was visible in the eastern middle section of the QS and an industrial facility (previously identified as a pipe yard) is first visible in the northwest corner. In 1978, auto salvage yards were visible in the northeast quarter and the western central quarter of the QS. By 1980, the orchard is completely replaced by industrial activities. In 1982, a large industrial yard is visible in the northern-central quarter section which later expands throughout the 1980s and early-1990s.

7-19 (South half of QS only); Land is utilized primarily for agricultural purposes from 1962 to 1976. However, a small building (first visible in the southeast quarter of the QS) begins to expand in the late-1970s with a junkyard. The buildings and junkyard remain visible through 2002. Back in 1978, a large portion of land is graded and two large buildings are constructed in the southwest corner by 1980. These two buildings remain visible in 2002.

7-20 (South half of QS only); Land is utilized primarily for agricultural purposes from 1962 to 1970. By 1972, two industrial complexes (with several buildings each) are visible. In 1974, a salvage yard is visible in the north, and by 1978, a second salvage yard is visible just south of the first one. The industrial complexes and salvage yards remain visible in 2002.

51st Avenue to 67th Avenue (inclusive of Township 1 North, Range 2 East, Sections 19, 20, 29, 30, and 31)

1-13 (North half of QS only); Land is utilized primarily for agricultural purposes from 1962 to 1974. From 1976 to 2002, the QS is residential.

1-14 (North half of QS only); Land is utilized primarily for agricultural purposes from 1962 to 1974 with one farm in the northwest corner of the QS. Residential homes begin development in the west portion of the QS in 1985 while the east portion remains agricultural to 2002.

2-13; Land is utilized primarily for agricultural purposes from 1962 to 1980. The development of residential homes begins in 1982 and continues to expand across the QS to 2002 with the agricultural land becoming almost non-existent.

2-14; Land is utilized primarily for agricultural purposes from 1962 to 2002.

2-15; Land is utilized primarily for agricultural purposes (with a farm house visible in the northwest corner of the QS) from 1962 to 1992. From 1994 to 2002, the QS contains a golf course.

2-16; Land is utilized primarily for agricultural purposes (with four farm house visible in the southeast corner of the QS) from 1962 to 1974. From 1976 to 2002, the farm houses have been removed and the QS consists entirely of agricultural land.

3-13; The QS primarily consists of native river bottom from 1962 to 2002 with small sand/gravel removal occurring in the northwest corner (throughout the years) and a large sand/gravel operation in the southwest corner (especially in the 1960s and 1970s and finally fading in the 1990s).

3-14; The QS consists of native river bottom from 1962 to 1985. From 1986 to 2002, the QS consists of native river bottom with a commercial business visible in the southeast corner of the QS.

3-15; The QS consists of agricultural land and native river bottom from 1962 to 2002.

3-16; The QS is utilized primarily for agricultural purposes (with numerous farm houses and related structures, especially in the 1960s and 1970s) from 1962 to 2002.

4-13; The QS consists of agricultural land (with a farm house along the west edge) and native river bottom from 1962 to 2002. However, a small oval-shaped track is visible from near the farm house from 1968 to 1974.

4-14; The north half of the QS is utilized for agricultural purposes from 1962 to 2002. The south half of the QS is river bottom with sand/gravel removal occurring from 1962 to 2002.

4-15; The northwest corner of the QS is utilized for agricultural purposes from 1962 to 1985 before sand/gravel operations take over. The remainder of the QS has sand/gravel operations

periodically occurring from 1962 to 2002 with major activity occurring in the late-1980s and 1990s.

4-16; The QS appears primarily as native river bottom with periodic sand/gravel removal in the southeast corner in the 1960s to early-1970s. Major sand/gravel operations in the southeast corner (and in the north) occur from 1980 to 1994. By 1996, the entire QS is utilized for sand/gravel removal/operations.

5-13; The QS is utilized for agricultural and residential purposes from 1962 to 2002.

5-14; The QS is primarily utilized for agricultural purposes with several large buildings along the eastern edge. The buildings appear to be farm related and may have been used as a cattle lot in the 1960s. From the early-1970s to 2000, the QS remains agricultural with several farm-type structures along the eastern edge. By 2002, the eastern portion of the QS is developed with a residential subdivision while the eastern portion of the QS has graded for upcoming residential development.

5-15; The QS is primarily utilized for agricultural purposes except for a residence/farm area along the northwestern edge. In the 1960s, the northwestern edge appears to be utilized as a cattle lot (likely associated with the one adjacent to the west in QS 5-14).

5-16; The northern half of the QS is utilized for agricultural purposes from 1962 to 2002. The southern half of the QS is native river bottom from 1962 to 1985 and then utilized for major sand/gravel operations from 1986 to 2002.

6-15; The QS is primarily utilized for agricultural purposes from 1962 to 2002 with one or two farm houses visible throughout the years.

6-16; The QS is primarily utilized for agricultural purposes from 1962 to 1994. From 1996 to 2002, the west half of the QS remains agricultural while the east half contains a large industrial facility in the southwest quarter and two industrial facilities (visible in 2002 only) in the northeast quarter of the QS.

67th Avenue to 83rd Avenue (inclusive of Township 1 North, Range 1 East, Sections 24, 25, 26, 35, 36 and Township 1 South, Range 1 East, Section 2)

01-9 (North half of QS only); The QS is utilized for agricultural and residential purposes from 1962 to 1968. From 1970 to 2002, the QS contains some commercial buildings along with the original agricultural land and residential homes..

01-10 (North half of QS only); The QS is utilized for agricultural and residential purposes (including a cattle feed lot) from 1962 to 2002.

1-9; The northwest quarter of the QS is native land and river bottom from 1962 to 2002. The northeast quarter of the QS is river bottom with a small piece of agricultural land from 1962 to 1976. From 1978 to 2002, the northeast quarter of the QS is primarily agricultural land with some native river bottom. However, a wastewater pond is visible in the northeast quarter from 1988 to 1994 with two ponds then visible from 1996 to 2002. the south half of the QS has been agricultural with some farmhouses and small commercial properties from 1962 to 2002.

1-10; The QS has been utilized primarily for agricultural purposes from 1962 to 2002.

1-11; The QS has been utilized primarily for agricultural purposes from 1962 to 2002.

1-12; The QS has been utilized primarily for agricultural purposes from 1962 to 1972. From 1974 to 2002, the QS has been half agricultural and half residential.

2-9; The north half of the QS is native river bottom from 1962 to 1984. From 1986 to 2002, a large sand/gravel operation (primarily removal) is visible from 1986 to 2002 in the north half. The south half of the QS is primarily native river bottom with a small agricultural farm in the southeast corner visible from 1962 to 2002. The southwest corner contains a small sand/gravel operation from 1962 to the early-1980s.

2-10; The northeast quarter of the QS is native river bottom from 1962 to 1970. By the early-1970s, industrial properties began to develop, and by 1980, the area began an increase in industrial activity to 2002. The northwest quarter of the QS has remained native river bottom from 1962 to 2002. The southeast quarter of the QS has been agricultural with farmhouses from 1962 to 2002. The southwest quarter of the QS has been native river bottom from 1962 to the late-1970s before becoming a horse farm which has remained visible to 2002.

2-11; The north half of the QS has been primarily agricultural from 1962 to 1968 with one building visible in 1966 and 1968. By the early 1970s, the northwest quarter of the QS was divided into several parcels with commercial/light industrial facilities slowly being constructed . In 1978, a salvage yard appeared in the lower portion of the northwest quarter and expanded slowly northward until 1986. In 1988, the northwest corner was again graded and now utilized to store sand and gravel. The south half of the QS has been utilized for agricultural purposes from 1962 to 2002.

2-12; The QS has been utilized for agricultural purposes from 1962 to 2002, except for the northwest corner, which has been industrial from 1970 to 2002.

3-9; The west half of the QS has been utilized for agricultural purposes from 1962 to the early-1980s. From 1985 to 2002, the west half has contained several large drying beds associated with the 91st Avenue Wastewater Treatment Plant. The east half of the QS has been primarily utilized for agricultural purposes (and some native river bottom) from 1962 to 1985. From 1986 to 2002, the east half is slowly engulfed by a large sand/gravel operation.

3-10; The north half of the QS is utilized for agricultural purposes from 1962 to 1994. From 1996 to 2002, the agricultural land is replaced by a large sand/gravel operation occurring in the area. The south half of the QS is native river bottom from 1962 to 2002 except for the southeast corner. The southeast corner contained a small facility visible at the corner of Southern and 75th Avenues in the middle of the river. The facility grows larger expanding to the west and then to the north with north-south elongated buildings (as many as 12) through 1976. The elongated buildings (or structures) appear to diminish through 1988 until only a single building remains through 1996. From 1998 to 2002, this portion of the QS remains vacant.

3-11; The north half of the QS is agricultural and native river bottom from 1962 to 2002. The south half of the QS is native river bottom from 1962 to 1968. A sand/gravel operation is then visible from 1970 to 2002.

3-12; Sand/gravel removal occurs in the QS from 1962 to 1974 with commercial/light industrial activity along the eastern edge of the QS. Larger scale sand/gravel operation/removal occurs in the 1980s and 1990s with continued commercial/light industrial properties along the eastern edge of the QS to 2002.

4-9; The QS is primarily utilized for agricultural purposes with two farm areas visible from 1962 to 2002.

4-10; The QS is primarily utilized for agricultural purposes from 1962 to 2002.

4-11; The QS is used primarily for agricultural purposes with two farms visible from 1962 to 1966. It then remains agricultural with a dairy farm in the northwest corner of the QS through 1974. From 1976 to 2002, the QS primarily remains agricultural, but is subdivided between several residential homes. The dairy farm in the northwest corner is visible through 2002.

4-12; The QS is entirely agricultural with a dairy farm visible in the northeast corner from 1962 to 1974. Beginning in 1976, the dairy farm expands and the remainder of the QS is subdivided between several residential homes visible to 2002.

5-10 (South half of QS only); This half of the QS is agricultural with one house visible from 1962 to 2000. However, from 1968 to 1986, a large tailwater sump is visible along the northern

edge of the QS. In 2002, the development of a subdivision is visible throughout the entire south half of the QS.

5-11 (South half of QS only); This half of the QS has been utilized for agricultural purposes from 1962 to 2002 with only a small area of ground disturbance located in the northeast corner from 1962 to 1982.

5-12 (South half of QS only); This half of the QS has been utilized primarily for agricultural purposes from 1962 to 1980 except for a residential home located in the northeast corner. From 1982 to 2002, the QS is agricultural except for a commercial development located in the northeast corner.

4.1 FINDINGS

Based on the above aerial photographs reviewed, URS has provided a summary of the findings to help delineate and identify areas (Quarter Sections) for further investigation. The following tables have been designed to generally describe the current overall use of each QS, the potential contaminant that may be associated with that land use, and a priority ranking for further investigation. The land use category identified for each QS is similar to that previously described; Residential, Commercial/Industrial, Landfill, Sand/Gravel Operation, Agricultural, Recreational (i.e. public parks), and River Bottom/Native.

For this summary, URS attempted to assign land use categories based on what the QS primarily consisted of in 2002. In some cases, a QS may have been assigned multiple categories if they appeared to consist of a large percentage of a certain use (i.e. a QS consisting of half agricultural land and half industrial land will be assigned both categories). Potential contaminants associated with a certain land use are general in nature but are listed based on URS' past experience conducting site assessments on various properties. This is not to say that other contaminants may or may not be associated with a certain land use, but rather that these contaminants may be the most commonly found. The priority ranking of Low, Medium, and High (and derivations of these) are based on the type of current land use and the potential contaminant that is usually found during associated activities. Although there may be many other contaminants found, the following guidelines were typically used; insecticides/pesticides for Agricultural, petroleum products for Sand/Gravel Operations, and petroleum products and solvents for Commercial/Industrial. If auto salvage yards or junkyards were specifically observed in a Commercial/Industrial setting, the contaminant of metals was also listed.

19th Avenue to 35th Avenue			
Quarter Section	Current Overall Land Use	Potential Containment	Priority Ranking (for Further Investigation)
3-21 (North ½ only) 3-22 (North ½ only) 3-23 (North ½ only) 7-22 (South ½ only)	Agricultural	Insecticides/Pesticides	Low- Medium
3-24 (North ½ only)	Residential	---	Low
4-24 7-21 (South ½ only) 7-23 (South ½ only) 7-24 (South ½ only)	Commercial/Industrial	Petroleum products, solvents, metals	High
4-21	Agricultural commercial/ industrial sand/gravel	Insecticides/pesticides, petroleum products, solvents, metals	High
4-23	Agricultural commercial industrial	Insecticides/pesticides petroleum products solvents, metals	High
4-22, 5-21, 5-22, 5-23, 5-24, 6-23, 6-24	Commercial/industrial and sand/gravel operations	Petroleum products, solvents, metals	High
6-21, 6-22	Commercial/industrial and landfill	Petroleum products, solvents, metals	High

35th Avenue to 51st Avenue			
Quarter Section	Current Overall Land Use	Potential Containment	Priority Ranking (for Further Investigation)
3-2, 4-20	Residential	---	Low
3-17, 4-17, 5-18, 5-19	Sand/gravel operations	Petroleum products	Medium-High
4-19, 6-17, 6-20 7-19 (South ½ only) 7-20 (South ½ only)	Commercial/industrial	Petroleum products, solvents, metals	High
3-18	Agricultural, residential commercial/industrial	Insecticides/pesticides petroleum products, solvents, metals	High
3-19	Residential and commercial/industrial	Petroleum products solvents	High
4-18, 5-20	Sand/gravel operations commercial/industrial	Petroleum products, solvents, metals	High
5-17	Native/river bottom sand/gravel operations	Petroleum products	Medium-High
6-18	Agricultural and commercial/industrial	Insecticides/pesticides petroleum products solvents	High
6-19	Commercial/industrial and landfill	Petroleum products, solvents	High

51st Avenue to 67th Avenue			
Quarter Section	**Current Overall Land Use**	**Potential Containment**	**Priority Ranking (for Further Investigation)**
1-14, 2-14, 2-16, 4-13, 5-13, 5-15, 6-15	Agricultural	Insecticides/pesticides	Low-Medium
1-13, 2-13, 3-16, 5-14	Residential	---	Low
2-15	Recreational	---	Low
3-13, 3-14	Native/river bottom	---	Low
4-15, 4-16	Sand/gravel operations	Petroleum products	Medium-High
3-15	Agricultural and native/ river bottom	Insecticides/pesticides	Low-Medium
4-14, 5-16	Agricultural and sand/gravel operations	Insecticides/pesticides and petroleum products	Medium-High
6-16	Agricultural and commercial/industrial	Insecticides/pesticides, petroleum products, solvents	High

67th Avenue to 83rd Avenue			
Quarter Section	**Current Overall Land Use**	**Potential Containment**	**Priority Ranking (for Further Investigation)**
01-9, 01-10, 1-9, 1-10, 1-11, 1-12, 2-10, 2-12, 4-9, 4-10, 4-11, 4-12, 5-11 (South ½ only) 5-12	Agricultural	Insecticides/pesticides	Low-Medium
2-9	Native/river bottom	---	Low
3-11	Sand/gravel operations	Petroleum products	Medium-High
5-10 (south ½ only)	Residential	---	Low
2-11	Agricultural and commercial/industrial	Insecticides/pesticides, petroleum products, solvents	High
3-9, 3-12	Sand/gravel operations and commercial/industrial	Petroleum products, solvents	High
3-10	Native/river bottom and sand/gravel operations	Petroleum products	Medium-High

5.0 REGULATORY AGENCY REVIEW

A review of applicable regulatory agency documents and lists of known or potential hazardous waste sites or landfills, and properties or facilities currently under investigation for potential environmental violations was conducted by Environmental Data Resources, Inc. (EDR). A list and brief description of the EPA and state agency databases reviewed is tabled below. A copy of the EDR report is presented in Appendix A.

Type of Database	Description of Database	Date of Database Revision
Federal Databases		
NPL	The National Priorities List (NPL) identifies uncontrolled or abandoned hazardous waste sites. To appear on the NPL, sites must have met or surpassed a predetermined hazard ranking system score, been chosen as a state's top priority site, pose a significant health or environmental threat, or be a site where the EPA has determined that remedial action is more cost-effective than removal action.	10/22/01
CERCLIS	The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database identifies hazardous waste sites that require investigation and possible remedial action to mitigate potential negative impacts on human health or the environment.	11/21/01
RCRA TSDs	The EPA's Resource Conservation and Recovery Information System (RCRIS) identifies and tracks hazardous waste from the point of generation to the point of disposal. The RCRIS Treatment, Storage, Disposal (TSD) Facilities List is a compilation by EPA of reporting facilities that generate, transport, store, treat, or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) but are not undergoing any "corrective action".	6/21/00
CORRACTS	RCRA TSD facilities ordered to implement corrective actions. A "corrective action order" is issued pursuant to RCRA Section 3008 (h) when there has been a release of hazardous waste or constituents into the environment from a RCRA TSD facility. Corrective actions may be required beyond the facility's boundary and can be required regardless of when the release occurred, even if it predates RCRA.	11/14/01
RCRA Generators	RCRA-regulated hazardous waste generator notifiers list; both Large and Small Quantity Generators are included in this list. (LQG – Large Quantity Generator, SQG – Small Quantity Generator)	6/21/00
ERNS	EPA's Emergency Response Notification System (ERNS) list contains reported spill records of oil and hazardous substances.	8/08/00
ROD	The EPA's Record of Decision (ROD) documents mandate a permanent remedy at a NPL site containing technical and health information to aid in the cleanup.	9/30/00
Arizona State Databases		
SPL/WQARF	A Water Quality Assurance Revolving Fund (WQARF) area (referred to as a State Priority List (SPL) site by EDR) which is also referred to as a state Superfund area, is a region designated by ADEQ for further investigation regarding environmental concerns. This designation is typically based on known areas of groundwater contamination, or past or present land uses which have been known to use and discharge chemicals that can contaminate groundwater.	6/12/01

Type of Database	Description of Database	Date of Database Revision
SHWS/ACIDS	The Arizona CERCLIS Information Data System (ACIDS) List has been used by the ADEQ Superfund Programs Section (SPS) for the past decade in tracking WQARF sites and portions of sites, potential WQARF sites, referrals, and other cases of interest to the SPS. As of March 13, 2000, there were approximately 1,500 entries on the ACIDS list. While some of the cases on this list are relevant to Arizona's Superfund Program, others are not and their inclusion may be misleading. For this reason, the SPS has elected to archive the ACIDS list, and no longer distribute it. In its stead, the ACIDS List has been replaced by the Arizona Superfund Programs List (SPL). This list is more representative of the sites and potential sites within the jurisdiction of the ADEQ SPS. According to ADEQ, the listing of properties on the ACIDS list is not an indication of liability or potential liability. Many of these properties on this list have no present involvement in WQARF or federal Superfund.	1/3/00
SWLF	State inventory of solid waste disposal and landfill sites.	11/01/00
LUST	List of information pertaining to all reported leaking underground storage tanks.	11/08/01
UST	State underground storage tank sites listing. The state of Arizona requires that owners of most underground storage tanks (USTs) register their USTs with ADEQ.	11/07/01
AZ-Spills	Releases and incidents recorded by ADEQ Emergency Response Unit.	6/30/00
Drywells	State drywell registration list. Dry wells are typically constructed on commercially-developed properties to collect rainwater surface runoff, and therefore, have the potential to introduce contaminants into the subsurface.	12/01/01

EDR compiled a list of properties or facilities located within the project study area (approximately one mile north and south of the Salt River) that appeared on one or more of the above-mentioned databases. URS reviewed the information presented by EDR and additional information presented on-line by EPA and ADEQ to identify sites that may have the potential to adversely affect environmental conditions at the subject property. A summary of the listed sites, addresses, database on which the site is listed, and the site's potential to adversely affect environment conditions at the subject property is tabled below. The tables are complied in one-mile increments north of the river and south of the river and listed separately. The identification numbers listed in the tables are those assigned for reference purposes only by EDR. Additional tables compiled by regulatory databases are included in Appendix B.

The priority ranking is based on current and prior activities as provided by the above-reference material. It should be noted that all facilities with registered USTs or listed LUSTs were ranked with a Low to Medium priority due to the potential for past and/or future contamination involving the USTs and their current status (i.e. closed/open LUST case, active/removed UST, etc.). A brief summary of all sites with a Medium or High Priority Ranking follows each of the associated tables.

7th Avenue to 19th Avenue - North of the Salt River

Although this area is outside the site boundaries as described in Section 2.1, these sites lie within one mile and are hydrologically upgradient of the subject property and therefore, may have a potential environmental affect on the subject property.

ID	Site Name	Site Address	Database	Status	Priority
Z	19th Avenue Landfill	19th Ave and Lower Buckeye Road	CERCLIS	Remedy assessment phase	High
			NPL	Status: Final	
			ROD	See additional information below	
			LUST	2 closed 1993	
			UST	0 active / 3 removed	
			SWLF	Closed	
2	Blue Circle West Leasing	2625 S. 19th Ave.	RCRIS-SQG	No violations found	Low
2	Kenworth of AZ Sunward Materials	2625 S. 19th Ave.	RCRIS-SQG	No violations found	Low
			CERC-NFRAP	1988 PA – NFRAP	
			SHWS	WVB	
2	Williams Detroit Diesel	2602 S. 19th Ave.	RCRIS-SQG	No violations found	Low
2	Neils Detroit Diesel Inc.	2602 S. 19th Ave.	UST	0 active / 3 removed	Low- Med.
2	Frontier Freightways	2465 S. 19th Ave.	RCRIS-SQG	No violations found	Low
2	Cypress Environmental	2465 S. 19th Ave.	RCRIS-SQG	No violations found	Low
2	Superior Companies	2402 S. 19th Ave.	LUST	1 Closed – 1995	Low- Med.
			UST	0 active / 1 removed	
2	Arizona Beef	2401 S. 19th Ave.	LUST	1 Closed – 1990	Low- Med.
			UST	0 active / 2 removed	
2	Marlam Industries, Inc.	2465 S. 19th Ave.	RCRIS-LQG	2 Low priority violations	Low- Med.
2	Arizona Truck & Trailer	2235 S. 19th Ave.	Dry Wells	1 Dry well	Low
2	Bradley Investment Co.	2235 S. 19th Ave.	UST	0 active / 2 removed	Low- Med.
4	Greenfield Environmental (AKA Innovative Waste Utilization)	2575 S. 16th Ave.	RCRIS-LQG	49 Violations	Medium
			RCRIS-TSD	Med. CORRACTS priority	
			CORRACTS		
4	MP Environmental	2530 S. 16th Ave.	AZ Spills	1994 incident	Low- Med.
			ERNS		

ID	Site Name	Site Address	Database	Status	Priority
10	Phoenix Tallow	2602 S. 15th Ave.	LUST	3 closed – 1999	Low- Med.
			UST	0 active / 6 removed	
13	Phoenix Metal Recycling	3210 S. 19th Ave.	RCRIS-SQG	No violations found	Low
13	Asphalt Products Transport Co.	3050 S. 19th Ave.	UST	0 active / 2 removed	Low- Med.
			AZ Spills	1993 incident	
13	Lincoln Auto	3020 S. 19th Ave.	UST	0 active / 2 removed	Low
13	Waste Management of Phoenix (AKA Universal Waste Control)	3000 S. 19th Ave.	LUST	1 closed 1996 / 1 unknown	Low-Med.
			UST	2 active/3 removed	
			Dry Wells	1 Dry well	
			RCRIS-SQG	No violations found	
19	United Metro Material Plant 11	3640 S. 19th Ave.	RCRIS-SQG	1 low priority violation	Low- Med.
			AZ Spills	1995 Diesel release	
19	Tanner-United Metro	3640 S. 19th Ave.	LUST	1 closed 1999	Low- Med.
			UST	4 active / 7 removed	

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

19th Avenue Landfill

The 19th Avenue Landfill facility is located near the southeast corner of 19th Avenue and Lower Buckeye Road in Phoenix and covers approximately 213 acres within the floodplain of the Salt River. Although the site was originally used as a sand and gravel operation, it has been a landfill since the late-1950s.

During the remedial investigation, the groundwater was found to contain low concentrations of volatile organic compounds, various heavy metals, and beta radiation. Currently, only one compound (1,1-dichloroethene) is above drinking water standards. Because groundwater in the area is used for industrial purposes only and there are no direct pathways to the City of Phoenix drinking water supply, the landfill is not considered to be a threat to public health.

A consent decree (entered in June 1992) called for capping of the landfill cells, removal and treatment of methane gas, monitoring of groundwater, and a contingency plan to treat groundwater if standards are exceeded. ADEQ is the lead regulatory agency on this EPA project through WQARF. ADEQ approved the Remedial Design Plans and Project Specifications in

May 1995 and completed the required five-year monitoring of the site. According to ADEQ, the remedy is protective of human health and the environment.

Greenfield Environmental (AKA Innovative Waste Utilization)

The Greenfield Environmental facility is located near the northeast corner of 19th Avenue and Lower Buckeye Road in Phoenix. According to information obtained from the EPA, the facility handles, stores, transports, and manages many chemicals including volatile organic compounds and various heavy metals. The types of waste management conducted at the facility include incineration, energy recovery, solidification and stabilization, and wastewater treatment.

According to EDR, Greenfield Environmental has received 49 RCRA violations between 1985 and 1996. Of the 49 violations, 41 were reported as low priority and 8 high priority. All the violations appear to have been brought back into compliance by 1998. Although the Greenfield facility releases volatile organic compounds into the air, according to the EPA the facility is currently in compliance.

7th Avenue to 19th Avenue - South of the Salt River

Although this area is outside the site boundaries as described in Section XX, these sites are within one mile and hydrologically upgradient of the subject property therefore, may have a potential environmental affect on the subject property.

ID	Site Name	Site Address	Database	Status	Priority
20	Ace Asphalt of Arizona	895 W. Elwood	LUST	3 closed 1998	Low- Med.
			UST	2 active / 3 removed	
			RCRIS-SQG	No violations found	
			AZ Spills	1988 Unknown release	
23	Laidlaw Environmental Services	888 W. Illini Street	RCRIS-SQG	3 low priority violations	Low
23	Disposal Control Services, Inc.	888 W. Illini Street	SHWS	PA/SI	Low
25	Circle K #670	4422 S. 19th Ave.	LUST	1 closed 1996	Low- Med.
			UST	0 active / 3 removed	
25	Cooley Wholesale Lumber Co.	1930 W. Broadway	LUST	1 closed date unknown	Low- Med.
			UST	0 active / 2 removed	
25	Arizona Teamsters App.	1820 W. Broadway	LUST	1 closed 2000	Low- Med.
			UST	0 active / 2 removed	
25	CSW Contractors Inc.	1824 W. Broadway	UST	0 active / 2 removed	Low
25	Industrial Recycling Solutions	2610 W. Holly	RCRIS-SQG	No violations found	Low

ID	Site Name	Site Address	Database	Status	Priority
25	Solvent Recyclean Inc.	1850 W. Broadway	RCRIS-SQG	1 low priority violation	Low
25	Circle K #1968	4305 S. 19th Ave.	UST	3 active / 0 removed	Low- Med.
25	Arizona Barrel and Can Co.	4225 S. 19th Ave.	CERC-NFRAP	Site inspection completed 1992	Low
25	Western Block Company	4021 S. 19th Ave.	LUST	1 closed 1998	Low- Med.
			UST	0 active / 4 removed	
25	19th Ave. Airstrip	NEC 19th/Broadway	SHWS	PA/SI	Low
27	Road Jammers Machinery	4300 S. 17th Ave.	LUST	1 closed 1994	Low- Med.
			UST	0 active / 3 removed	
30	Briscoe Inc.	15th Ave./Broadway	AZ Spills	1985 petroleum release	Low-Med.
30	Broadway Cardlock #23	1307 W. Broadway	LUST	1 closed 1999	Low- Med.
			UST	0 active / 3 removed	
30	Progressive Roofing	1501 W. Broadway	UST	0 active / 1 removed	Low- Med.
30	Sandvick Equipment & Supply Co.	1502 W. Broadway	UST	0 active / 1 removed	Low- Med.
30	Turners Machine Shop	1521 W. Broadway	RCRIS-SQG	No violations found	Low
30	Brown Tank & Steel	4300 S. 15th Ave.	UST	0 active / 2 removed	Low- Med.
44	CJ Joregenstein Elementary	1701 W. Roeser	AZ Spills	1998 incident	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

19th Avenue to 27th Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 5-23, 5-24, 6-23, 6-24, 7-23, and 7-24.

ID	Site Name	Site Address	Database	Status	Priority
NL	23rd Avenue Landfill	23rd Ave./ Low Buck Rd	SWLF	Closed	Low-Med.
3	Old 23rd Ave. Sludge Disp. Ponds	23rd & Low Buck Rd	SHWS	WVB	Low
5	27th Avenue Landfill	27th Ave. & Lower Buckeye Road	LUST	1 closed 1998	Low-Med.
			UST	0 active / 1 removed	
			AZ Spills	1992 incident	
			Dry Wells	1 Dry well	
			SWLF	Transfer station	
			SHWS	WVB	
5	Phoenix Union High School	2800 S. 27th Ave.	AZ Spills	1991 incident	Low

ID	Site Name	Site Address	Database	Status	Priority
6	Phoenix Transit System	2225 W. Low Buck Rd	RCRIS-SQG	No violations found	Medium
			RCRIS-LQG	1 low priority violation	
			LUST	1 closed 2000	
			UST	19 active / 0 closed	
6	COP Petroleum Storage Facility	2239 W. Low Buck Rd	Dry Wells	1 dry well	Medium
			RCRIS-SQG	No violations found	
			LUST	1 closed 1998	
			UST	0 active / 7 removed	
6	Kerley Chemical Corp.	2248 W. Low Buck Rd	AZ Spills	1986 incident	Low- Med.
			UST	0 active / 1 removed	
			RCRIS-SQG	No violations found	
			SHWS	WVB	
6	Phoenix Salt River Service Center	3045 S. 22nd Ave.	LUST	6 closed 1997 – 1999	Medium
			UST	8 active / 16 removed	
9	Empire Metals Inc.	2010 W. Low Buck Rd	LUST	2 closed 1994	Low- Med.
			UST	0 active / 3 removed	
			RCRIS-SQG	1 low priority violation	
14	Operating Engineers Road	3225 S. 22nd Ave.	UST	0 active / 3 removed	Low- Med.

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
NL – Not listed
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

Phoenix Transit System/Phoenix Salt River Service Center/COP Petroleum Storage Facility

The Phoenix Transit System, Salt River Service Center, and COP Petroleum Storage Facility are all fueling and/or maintenance yards for the City of Phoenix vehicles. They are all located at approximately 22nd Avenue and Lower Buckeye Road in Phoenix. Although the facilities do not appear to have any substantial violations, they are considered medium priority rankings due to the high number of active and removed USTs at each site.

19th Avenue to 27th Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-23, 3-24, 4-23, and 4-24.

ID	Site Name	Site Address	Database	Status	Priority
32	Yank Your Part	2104 W. Broadway	RCRIS-SQG	No violations found	Low
32	AETS	2301 W. Broadway	SWF/LF	Active (accepts PCS)	Low- Med.
33	AG Products	2630 W. Broadway	RCRIS-SQG	No violations found	Low
33	Chemical Waste Management	2301 W. Broadway	AZ Spills	8 incidents from 1984-89	Med./High
33	Onyx Environmental Services	2301 W. Broadway	RCRIS-SQG	22 low priority violations	
			RCRIS-LQG		
			CORRACTS	Low CORRACTS priority	
			CERC-NFRAP	Site inspection completed 1990	
			SHWS	PA/SI	
33	M&M Auto Storage Pool Inc	2299 W. Broadway	UST	0 active / 1 removed	Low
33	Fuelco #112	2401 W. Broadway	UST	0 active / 5 removed	Low- Med.
33	Smith Pre-Cast	2410 W. Broadway	UST	2 active / 0 removed	Low
33	AG Products	2525 W. Broadway	Dry Wells	2 Dry wells	Low
33	Alan Harris Trucking	2505 W. Broadway	UST	0 active / 1 removed	Low- Med.
33	Regent Auto & Truck Parts	2528 W. Broadway	SHWS	PA/SI	Low- Med.
33	A&S Auto Wrecking	2528 W. Broadway	SHWS	PA/SI	Low- Med.
34	Motorola (Bic)	2200 W. Broadway	AZ Spills	1984 incident	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
PCS – Petroleum contaminated soil
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

Chemical Waste Management (AKA Onyx Environmental Services)

Chemical Waste Management is a hazardous waste handler and transporter located on 23rd Avenue and Broadway in Phoenix. The facility had 22 low priority RCRA violations between 1985 through 1996 and 8 spill incidents during approximately the same time frame. According to EDR, two low priority corrective actions were completed by the facility in 1990 and 1992 (one each year). EPA conducted a preliminary assessment and site inspection at the facility in 1990. No further remedial action is currently planned by the EPA.

27th Avenue to 35th Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 5-21, 5-22, 6-21, 6-22, 7-21, and 7-22.

ID	Site Name	Site Address	Database	Status	Priority
15	Maricopa By-Products Inc.	3602 W. Elwood St.	UST	0 active / 6 removed	Low-Med.
			SHWS	WVB	
15	Copperstate Express Lines	3044 S. 35th Ave.	RCRIS-SQG	No violations found	Low
15	Quality Block Company Inc.	3035 S. 35th Ave.	LUST	3 closed 1997	Low-Med.
			UST	0 active / 3 removed	
			SHWS	WVB	
15	Arizona Precast	3045 S. 35th Ave.	SHWS	WVB	Low
22	Metal Management of Arizona	3640 S. 35th Ave.	AZ Spills	1999 Auto shreds fire	Low-Med.
22	Salt River Recycling / Smithey	3640 S. 35th Ave.	LUST	1 closed 1999 / 2 2000	Low-Med.
			UST	0 active / 3 removed	
22	Smithey Recycling Company	3649 S. 35th Ave.	SHWS	WVB	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

27th Avenue to 35th Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-21, 3-22, 4-21, and 4-22.

ID	Site Name	Site Address	Database	Status	Priority
31	Vista Construction	2836 W. Broadway	UST	2 active / 0 removed	Low-Med.
31	Royden Construction Co	2844 W. Broadway	UST	0 active / 4 removed	Low-Med.
31	Enviro-Solv	2844 W. Broadway	AZ Spills	2000 incident	Low-Med.
			RCRIS-SQG	No violations found	
31	Construction Yard	2850 W. Broadway	UST	0 active / 2 removed	Low-Med.
31	Unknown	2744 W. Broadway	AZ Spills	1995 incident	Low
35	All-A-Matic Transmissions	3011 W. Broadway	AZ Spills	1993 incident	Low
35	Swift Transport	3106 W. Broadway	RCRIS-SQG	No violations found	Low
36	Bob Auto and Pickup Wrecking	3408 W. Broadway	RCRIS-SQG	No violations found	Low
36	Western States Petroleum	3331 W. Broadway	AZ Spills	1985 gasoline release	Low
36	Urban Forest Products Co.	3330 W. Broadway	AZ Spills	1995 incident	Low
36	Fuelco #113	3331 W. Broadway	LUST	1 closed 1993	Low-Med.
			UST	0 active / 3 removed	
36	Liquid Air Co.	3332 W. Broadway	AZ Spills	1985 incident	Low
36	Rotman Properties	3250 W. Broadway	LUST	1 unknown closed date	Low-Med.
			UST	0 active / 2 removed	

ID	Site Name	Site Address	Database	Status	Priority
36	Ricketts Trucking Inc	3434 W. Broadway	LUST	1 Closed date unknown	Low-Med.
			UST	0 active / 4 removed	
36	Phillips 66 Company	3449 W. Broadway	UST	0 active / 4 removed	Low-Med.
36	Manzanita Speedway	35th Ave / Broadway	SHWS	WVB	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

35th Avenue to 43rd Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 5-19, 5-20, 6-19, 6-20, 7-19, and 7-20.

ID	Site Name	Site Address	Database	Status	Priority
1	Circle K #8870	3501 W. Low Buck Rd	UST	3 active / 0 removed	Low-Med.
1	Rio Salado Auto Body	2801 S. 35th Ave.	RCRIS-SQG	No violations found	Low
			SHWS	WVB	
1	EMCO Recycling	3700 W. Lower Buckeye Road	LUST	1 closed 1999	Low-Med.
			UST	0 active / 4 removed	
			AZ Spills	2 1996 incidents	
1	Unknown	3650 W. Low Buck Rd	SHWS	WVB	Low
1	ChemCon Inc.	3702 W. Low Buck Rd	RCRIS-SQG	1 low priority violation	Low-Med.
			CORRACTS	Low CORRACTS priority	
1	Copperstate Metals Inc.	3720 W. Low Buck Rd	RCRIS-SQG	1 low priority violation	Low-Med.
			AZ Spills	2 incidents (1986/1988)	
			CERC-NFRAP	Discovery Assessment	
			SHWS	WVB	
1	Desert Transformer Inc.	3751 W. Low Buck Rd	LUST	1 closed 1999	Low-Med.
			UST	0 active / 3 removed	
1	RJ Ruff & Co.	3883 W. Low Buck Rd	LUST	1 closed 1998	Low-Med.
			UST	0 active / 3 removed	
1	Reuter Equipment Co.	3816 W. Low Buck Rd	UST	0 active / 3 removed	Low-Med.
1	Unknown	39 Ave. / Low Buck Rd	AZ Spills	1 incident (2000)	Low-Med.
1	CAVCO Industries Inc.	2602 S. 35th Ave.	UST	0 active / 2 removed	Low-Med.
			Dry wells	7 Dry Wells	
1	CAVCO Industries Inc.	2502 W. Durango	UST	0 active / 2 removed	Low-Med.
1	Castle MFG, Inc.	3702 W. Low Buck Rd	SHWS	WVB	Low

ID	Site Name	Site Address	Database	Status	Priority
1	Dagleys	2455 S. 35th Ave.	SHWS	WVB	Low
1	Angel Auto	2450 S. 35th Ave.	SHWS	WVB	Low
7	Mardian Construction Company	4044 W. Low Buck Rd	LUST	2 closed 1996	Low-Med.
			UST	0 active / 4 removed	
7	Zieman MFG	4025 W. Low Buck Rd	RCRIS-SQG	No violations found	Low-Med.
			UST	0 active / 1 removed	
8	Phoenix Redi Mix Company Inc.	3635 S. 43rd Ave.	RCRIS-SQG	No violations found	Low-Med.
			LUST	5 closed 1998-1999	
			UST	0 active / 9 removed	
8	Glenn Wienberger Landfill	3425 S. 43rd Ave.	RCRIS-SQG	No violations found	Low
			UST	1 active / 0 removed	
			SWLF	Closed	
8	A&K Partnership	3211 S. 43rd Ave.	UST	0 active / 2 removed	Low-Med.
8	Publicker Ind / Masterview Window	3065 S. 43rd Ave.	LUST	1 closed date unknown	Low-Med.
			UST	0 active / 1 removed	
8	USF Bestway Transportation	3045 S. 43rd Ave.	LUST	1 closed 1988	Low-Med.
			UST	1 active / 4 removed	
			RCRIS-SQG	No violations found	
8	Stanton Industries of Arizona	4215 W. LBR	UST	0 active / 1 removed	Low-Med.
11	C and M Enterprises	3240 S. 37th Ave.	RCRIS-SQG	No violations found	Low
17	Sunrise / Scorpio Steel Inc.	3420 S. 39th Ave.	LUST	3 closed 1997	Low-Med.
			UST	0 active / 2 removed	
17	All Valley Wrecker	3401 S. 39th Ave.	UST	0 active / 2 removed	Low-Med.
21	Reynolds Aluminum Plant Ponds	43rd Ave. / Salt River	AZ Spills	1 incident 1998	Low
			SHWS	WVB	

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

35th Avenue to 43rd Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-19, 3-20, 4-19, and 4-20.

ID	Site Name	Site Address	Database	Status	Priority
38	CalMat Yard	4830 S. 43rd Ave.	LUST	1 closed 1990	Low-Med.
			UST	0 active / 1 removed	

ID	Site Name	Site Address	Database	Status	Priority
42	Tatel Inc.	5250 S. 43rd Ave.	UST	2 active / 0 removed	Low-Med.
42	Coreslab Structures Inc.	5026 S. 43rd Ave.	LUST	1 closed 2000	Low-Med.
			UST	0 active / 3 removed	

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

43rd Avenue to 51st Avenue – North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 5-17, 5-18, 6-17, and 6-18.

ID	Site Name	Site Address	Database	Status	Priority
16	Royden Construction Company	3423 S. 31st Ave.	UST	0 active / 2 removed	Low-Med.
16	RPS Inc.	3410 S. 51st Ave.	RCRIS-SQG	No violations found	Low
16	FedEx Ground	3410 S. 51st Ave.	AZ Spills	1996 Diesel release	Low-Med.
			UST	1 active / 0 removed	
16	Arizona Truss Fabricators	3207 S. 51st Ave.	LUST	1 closed 1990	Low-Med.

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

43rd Avenue to 51st Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-17, 3-18, 4-17, and 4-18.

ID	Site Name	Site Address	Database	Status	Priority
43	Arizona Oil Recyclers Assoc.	5040 S. 51st Ave.	RCRIS-SQG	No violations found	Low
			AZ-Spills	1992 oil release	
48	A-1 Tire Company	4825 W. Southern	AZ-Spills	1990 fire	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

51st Avenue to 59Th Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 4-15, 4-16, 5-15, 5-16, 6-15 and 6-16.

X No Sites

51st Avenue to 59Th Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 2-15, 2-16, 3-15, and 3-16.

X No Sites

59Th Avenue to 67th Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 4-13, 4-14, 5-13, and 5-14.

X No Sites

59Th Avenue to 67th Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 1-13, 1-14, 2-13, and 2-14.

ID	Site Name	Site Address	Database	Status	Priority
49	USA Tire Recycling	5922 W. Southern	AZ Spills	1992 fire	Low
51	Arnold Machinery Company of AZ	6024 W. Southern	RCRIS-SQG	No violations found	Low-Med.
			UST	1 active / 0 removed	
52	Mobile Soil Processing Unit	5922 W. Southern	RCRIS-SQG	No violations found	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

67th Avenue to 75th Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-11, 3-12, 4-11, and 4-12.

ID	Site Name	Site Address	Database	Status	Priority
28	Farm	7502 W. Broadway	UST	0 active / 2 removed	Low-Med.
28	Marbella	75th Ave / Broadway	Dry wells	9 Dry wells	Low

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

67th Avenue to 75th Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 1-11, 1-12, 2-11, and 2-12.

ID	Site Name	Site Address	Database	Status	Priority
47	Iron Horse Equipment Corp	7316 W. Southern	RCRIS-SQG	No violations found	Low
53	Western Meat Company	7201 W. Southern	LUST	1 closed 1997	Low-Med.
			UST	0 active / 2 removed	

Notes:
ID – Map ID (see Figure 2)
NFRAP – No further remedial action planned
PA/SI – Preliminary Assessment/Site Investigation
WVB –Sites with this notation have been investigated as part of the West Van Buren (WVB) WQARF program

75th Avenue to 83rd Avenue - North of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 3-09, 3-10, 4-09, and 4-10.

X No Sites

75th Avenue to 83rd Avenue - South of the Salt River

City of Phoenix Quarter Section Index Map Numbers: 1-09, 1-10, 2-09, and 2-10.

X No Sites

6.0 PREVIOUS REPORT REVIEW

URS reviewed two previous assessments provided by the City of Phoenix: Middle Gila River Watershed Management Study Phase 2 (Greeley, 2001) and Environmental Contaminants in Fish and Wildlife of the Lower Gila River, Arizona (U.S. F&W, 1997). Although the study areas of neither report were inclusive of the entire subject property, the general subject matter as it pertains to conditions along rivers such as the Gila or Salt was reviewed.

The 1997 Fish and Wildlife report summarizes the investigation of work conducted along the lower Gila River and the associated agricultural canals (see Appendix C). From 1994 through 1995, six study sites were investigated along the lower Gila River watershed between 59th Avenue and Painted Rock Dam. According to that report, organochlorine pesticides (including DDT, DDE, dieldrin, and chlordane), polychlorinated biphenyls (PCBs), and metals (including primarily aluminum, copper, mercury, nickel, selenium, vanadium, and zinc) were detected in the fish and wildlife along the watershed study area. The high levels of pesticides were found to be directly related to those agriculturally applied within the area. Based on the overall agricultural use along the lower Gila River watershed, similar pesticide contamination may exist

in areas of heavy agricultural use along the Salt River. The source for metals contamination was not discussed in the report.

The Phase 2 report summarizes the comprehensive study of the Gila River watershed. The purpose of the report was to consolidate data obtained during the Phase 1 and 2 studies and to enhance the current database of this information. Included in this report is information concerning groundwater and surface water quality, stormwater issues, land use, etc. as they pertain to water resource. Although the information contained in this report was not directly used in this ESA, the data was included in URS' Groundwater Quality and Hydrogeology Report.

7.0 CONCLUSIONS AND RECOMMENDATIONS

URS conducted this Modified Phase I Environmental Site Assessment of the Rio Salado Oeste Project area for the purpose of identifying potential sites of contamination as part of the due diligence process of evaluating the design and completion of a riparian habitat restoration project. The project site lies within the Salt River between 19th Avenue and 83rd Avenue in Phoenix, Maricopa County, Arizona. This study was also conducted to help delineate and identify areas for further investigation. The findings of this study have been accomplished primarily by two tasks and are presented with separate findings above. URS' recommendations are presented below for each of the two primary tasks;

7.1 CURRENT AND HISTORICAL AERIAL PHOTOGRAPHS

The findings of our current and historical aerial photograph review have identified several areas by Quarter Section (QS) for further investigation. Each area has been identified with a Priority Ranking of Low, Medium, or High (or derivation therein). URS recommends that areas with a Medium-High or High priority ranking be further investigated by first conducting a "windshield survey", since Rights-of-Entry to many of these sites will not be able to be obtained. The windshield survey report would be conducted to observe and document the environmental conditions of a facility (or area) as much as possible to determine the potential for past or future contamination of the project area. Based on the information obtained during the windshield survey, the City of Phoenix may wish to conduct an ASTM Phase I Environmental Site Assessment on the identified site (or area).

Because a large portion of the project study area has been utilized for agricultural purposes for many years, insecticide/pesticide residuals may be present in soils. It is beyond the scope of this project to assess the specific impact of current or former insecticide/pesticide use in the project study area. Former studies (as presented in Section 6.0) show that pesticide use can have a dramatic negative impact to fish and wildlife in the surrounding area. Consequently, further

investigation should be conducted to specifically address the potential for insecticides/pesticides to impact the Rio Salado Oeste project area from past (or current) agricultural use.

7.2 REGULATORY AGENCY REVIEW

The findings of the Regulatory Review have identified specific facilities for further investigation and again assigned a Priority Ranking of Low, Medium, or High (or derivation therein). URS recommends that the facilities (or sites) listed as Medium or High be further investigated by reviewing specific regulatory files associated with each to determine the potential for past or future contamination of the project area. Based on the information obtained during the regulatory records review, the City of Phoenix may wish to conduct an ASTM Phase I Environmental Site Assessment on the identified site (or facility).

8.0 REFERENCES

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U.S. Geological Survey, 7½-Minute Topographic Quadrangle Map, "Phoenix, Arizona" 1952, Photorevised, 1982.

APPENDIX A

EDR DATABASE REPORT

AVAILABLE UPON REQUEST

APPENDIX B

SUMMARY OF SITES BY REGULATORY DATABASE

AVAILABLE UPON REQUEST

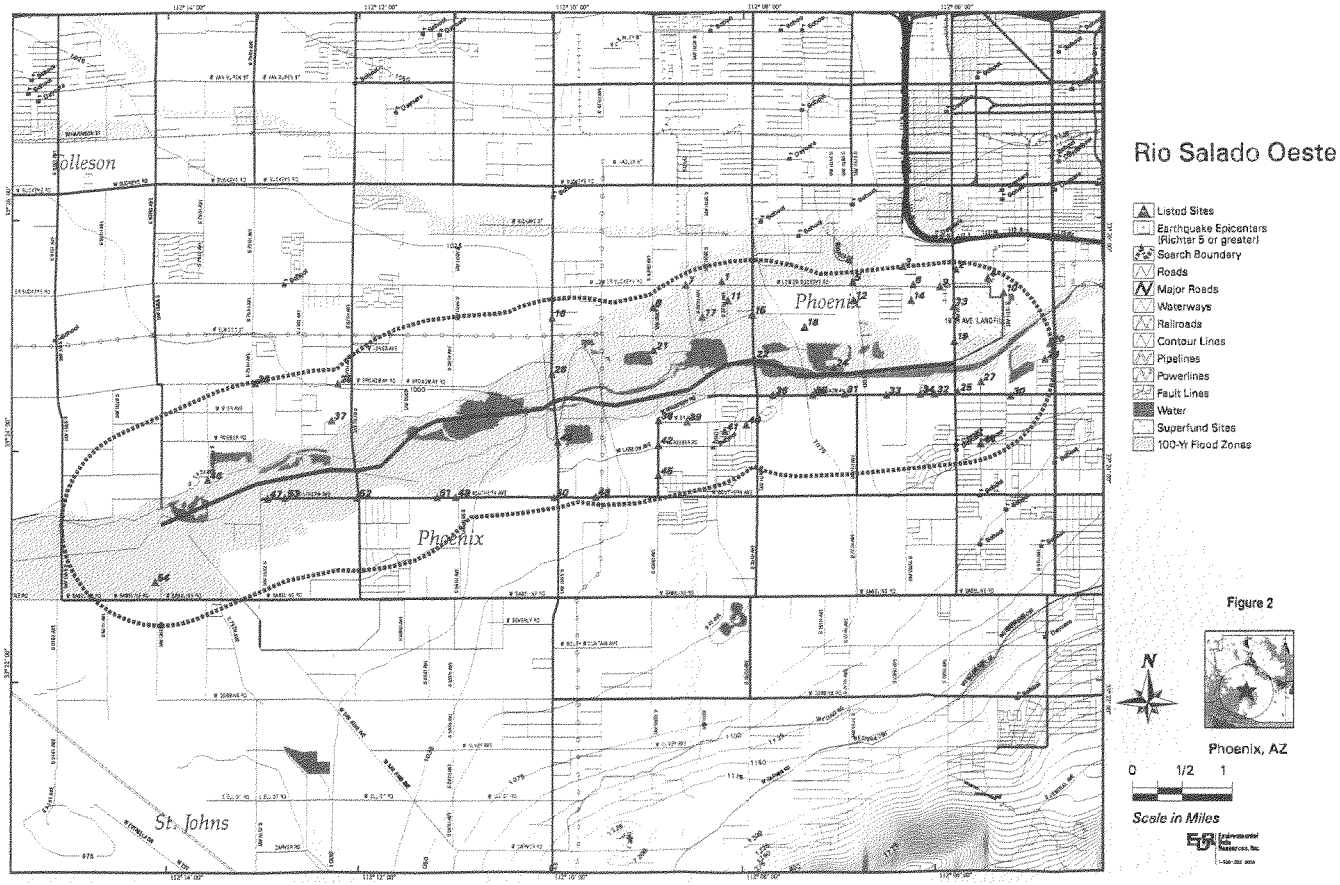
APPENDIX C

REPORT - ENVIRONMENTAL CONTAMINANTS IN FISH AND WILDLIFE OF THE LOWER GILA RIVER, ARIZONA

AVAILABLE UPON REQUEST

FIGURES

Existing Land Use
Groundwater Quality and Hydrogeology Report
Rio Salado Crossing Project
Figure 1
Legend
Residential
Commercial/Industrial
Agricultural
Recreational
Vacant
Major Roads/Freeway
Landfill/Closed Operations
Scale in Miles
Map Source:
Map Date: 1/25/2008


Rio Salado Oeste
Listed Sites
Earthquake Epicenters (Richter 5 or greater)
Search Boundary
Roads
Major Roads
Waterways
Railroads
Contour Lines
Pipelines
Powerlines
Fault Lines
Water
Superfund Sites
100-Yr Flood Zones
Figure 2
Phoenix, AZ
N
0 1/2 1
Scale in Miles
Tolleson
Phoenix
Phoenix
St. Johns

US Army Corps of Engineers

Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX G

Economics

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, ECONOMICS GROUP
LOS ANGELES, CALIFORNIA 90053-2325

Rio Salado Oeste Feasibility Study
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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 (19th Avenue to 83rd Avenue) in Phoenix, Arizona.

METHODOLOGY

Methodology employed for this economic analysis is in accordance with current principles and guidelines and standard economic practices, as outlined in the *Planning Guidance Notebook – ER 1105-2-100*. 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 FY 2006 price levels utilizing the current Federal Discount rate of 5 1/8 percent. The period of analysis is 50 years. The Base Year for economic computations is 2010.

STUDY AREA

Location

The study area is located along the Salt River, in Phoenix, Arizona, between 19th Ave and 83rd Avenue. The study area is located in between the authorized Rio Salado and Tres Rios project areas. The study area includes portions of the City of Phoenix, Maricopa County, state and federal land. **Figure 1** shows the location of the Rio Salado Oeste study area. **Figure 2** provides an aerial view of the 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 take advantage of existing open water bodies, in the river and adjacent properties, as potential restoration sites. Discharges from the 23rd Avenue Waste Water Treatment Plant, as well as underground water supply currently used for agricultural purposes, could be utilized to supplement surface water sources of water for restoration and other needs. There is also an opportunity to link other upstream and downstream projects to provide a continuous restoration and flood control corridor. These would include the authorized Rio Salado project, located immediately upstream of the project area, and the Tres Rios project, located immediately downstream of the project area.

FIGURE 1
RIO SALADO OESTE STUDY AREA LOCATION

U. S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

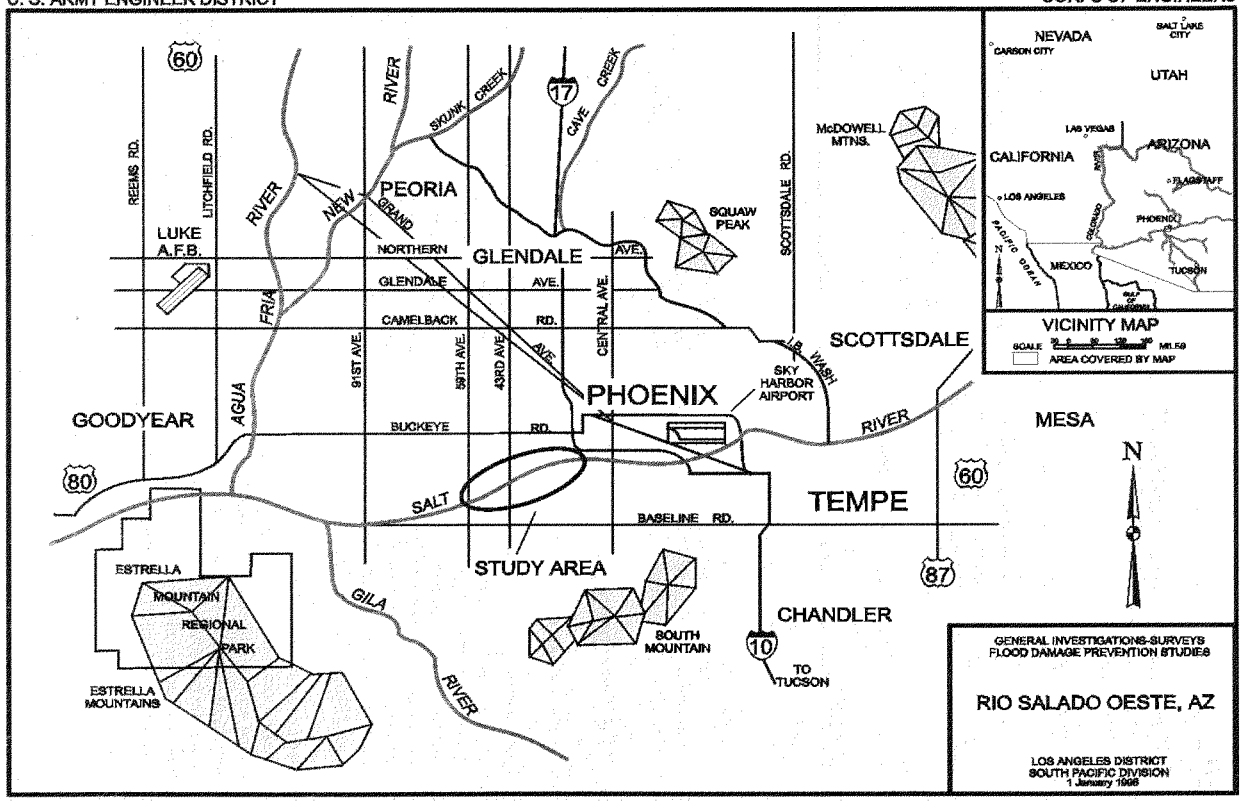
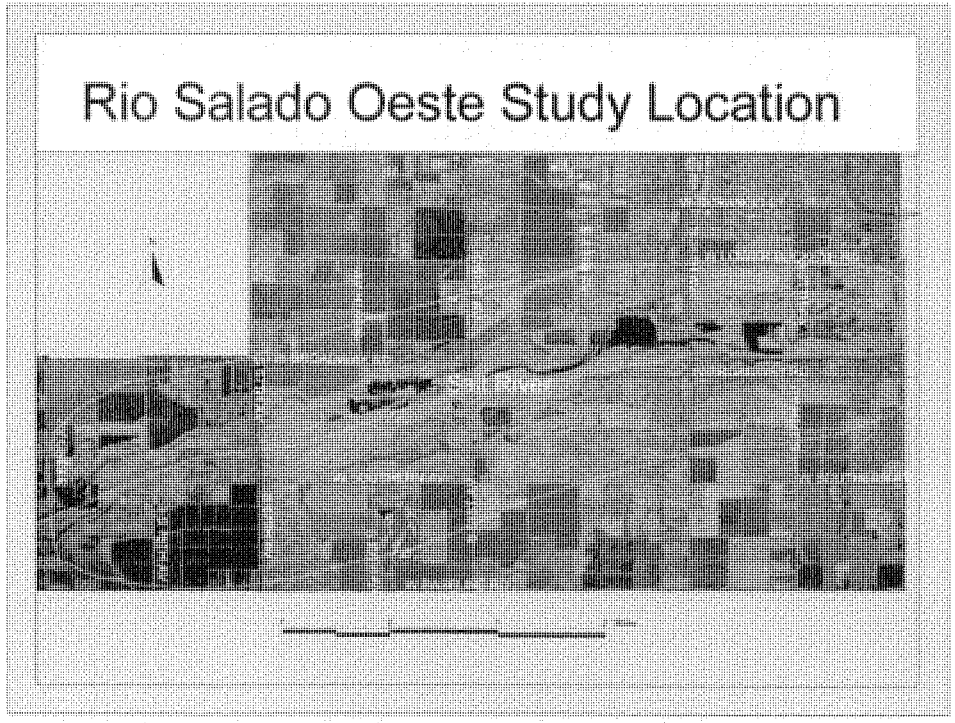


FIGURE 2
RIO SALADO OESTE STUDY AREA – AERIAL VIEW



Flooding

Flood flows along the Salt River through the Study Area that result from frequent flooding events are generally contained within the channel banks. However, during less frequent events, such as the 100-year and 500-year events, hydrologic and hydraulic analyses indicate that under existing conditions, there is a potential for significant flood damages. During these low-probability events, flood flows may overtop the channel banks and break out, primarily to the south of the River, and inundate many residential, industrial and agricultural properties. However, there are two anticipated actions that it is assumed will be taken under without-project conditions that will significantly reduce the potential for flooding in the Study Area.

The first important assumption is that improvements will be made to the 35th Avenue Bridge that crosses the Salt River. The configuration of this bridge contributes to the flooding problem in the Study Area. A hydraulic analysis has been conducted to determine the impact the proposed improvements will have on flooding in the Study Area. This analysis indicates that the flooding problem will be significantly reduced, and most structures that are currently susceptible to flooding during major events will no longer be threatened. Although flood damages with the planned bridge improvements would be limited, there still might have been opportunities to reduce potential food damages by implementing projects to increase the conveyance capacity of the Salt River through specific areas, particularly in the vicinity of 35th Avenue.

The second assumption relates to future aggregate mining operations within the Salt River. In 2003 the City of Phoenix purchased approximately 250 acres of riverbed between 35th and 51st Avenues. They have been working on a plan to lease the property for aggregate mining in a manner that allows aggregate to be removed while leaving a river cross section suitable for restoration. The likely alternative to have excess material removed from this reach and leave it in a state suitable for restoration will include an active channel varying in width from 300-600 feet and at the approximate elevation of the existing thalweg. Approximate 5 million tons of river material will be removed for this to occur. Once permitting and lease agreement is completed the City will allow aggregate to be removed as specified. The City has confirmed that this area would be leased for mining under both with and without-project conditions.

The impact of the proposed aggregate mining on flood damages is significant. An analysis of water surface profiles that incorporate the expected channel geometry after mining is completed shows that water surface elevations in the reaches where the mining will take place are significantly reduced. These same reaches also happen to be those with the highest damage potential under existing conditions.

Recreation

The City of Phoenix and Maricopa County have experienced tremendous population growth. While the number of parks has steadily increased in the greater Phoenix area, it has not kept pace with the growth in population. The current supply of recreation in the Study Area is insufficient, based upon local and national standards of required acres of recreation facilities per capita. This deficit is anticipated to increase in the future due to continued population growth in the Study Area.

There are no formal existing recreation or environmental education opportunities associated with the existing Salt River corridor in the Study Area. The 27th Avenue Solid Waste Recycling Facility (just north of the river) has an existing environmental education master plan. The facility provides tours for children and adults. The 23rd Avenue Waste Water Treatment Plant also does environmental education programming and touring for water treatment. These existing facilities provide an opportunity to link environmental education that could be developed for a restored river corridor. Upstream of the Study Area, the Rio Salado Project will include over ten miles of trails, an environmental education facility and passive recreation opportunities.

Passive recreation facilities are also planned downstream for the Tres Rios project. There are opportunities to link recreation facilities at the Study area with those that will be constructed upstream and downstream.

Population

The study area is located in central Maricopa County and extends through the city of Phoenix. As of July 2003, Maricopa County had a population of 3.39 million (the fourth highest in the nation). From 2000 to 2003, County population grew by over 317,000, representing an average annual growth rate of over 3.3 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 1.42 million in 2004, or by about 2.4 percent on an annual basis. About 41 percent of the County population resides within the City of Phoenix, although this ratio is declining, due to higher growth rates outside the city.

Population Projections

The following table displays population estimates and growth projections for Maricopa County and the City of Phoenix, obtained from the Maricopa County Association of Governments (MAG) and US Census websites. Strong growth for the County and City is expected through year 2050, although the rates of growth will be substantially lower than those experienced the past decade.

Table 1
Projected Population & Annual Growth Rate (AGR)
Maricopa County and the City Phoenix

Year	Maricopa County	AGR	City of Phoenix	AGR
1995	2,529,000		1,154,000	
2000	3,072,000	4.0	1,321,000	2.7
2010	3,710,000	2.0	1,544,000	1.6
2020	4,516,000	2.0	1,796,000	1.5
2050	7,265,000	1.6	2,568,000	1.2

Source: US Census and Arizona Department of Economic Security

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.

The City of Phoenix is divided into 14 Urban Villages, with each addressing problems and needs related to the implementation of the General Plan. The two main villages in the study area are the Estrella Village to the north of the River and the Laveen Village to the south. Estrella Village encompasses about 41 square miles and is bounded by Interstate 10 on the north, 19th Avenue on the east, the Salt River on the south and 107th Avenue on the west. The Laveen planning area encompasses about 28 square miles and extends south of the Salt River and north of South Mountain between 27th Avenue and the Gila River Indian Community. The combined population in these two planning areas as of 2000 was approximately 53,000. The area experienced an annual growth rate of about 4.2 percent over the prior five years. MAG projections indicate that the

population for this area is expected to increase to about 86,000 by the year 2010 (or nearly five percent per year). Hence, this area is anticipated to experience high growth, outpacing the city and county as a whole.

The Study Area also includes a portion of the Rio Montaña subarea of the South Mountain Village. Rio Montaña encompasses about 10.4 square miles and extends from 27th Avenue to South Central Avenue, south of the Salt River and north of South Mountain Preserve. The Study Area therefore excludes that portion of Rio Montaña east of 19th Avenue. Rio Montaña had a population of about 26,000 as of 1995, although a significant portion of this total is upstream of the Study Area.

The Estrella Village Plan, approved by the Phoenix City Council in March 1999, projects that this planning area can accommodate a population of nearly 105,000. The current plans for Laveen (*Laveen: A Guide for Development*, prepared by the City of Phoenix South Area Planning Team) indicate that this planning area can accommodate a population of about 95,000. Hence, the planning areas extending along the Salt River through the study area have buildout population estimated at about 200,000 (excluding that portion of Rio Montaña between 27th and 19th Avenues).

Land Use

Based upon the City of Phoenix General Plan (Revised February 2001), most of the land area on the north side of the Salt River between 19th Avenue and 59th Avenue is zoned industrial, with some high-density residential between 43rd Avenue and 60th Avenue. From 60th Avenue to 83rd Avenue, the primary land use is low-density residential. South of the Salt River, there is some land between 19th Avenue and 35th Avenue zoned commercial. Otherwise the prevailing land use designation is low to medium density residential.

As noted earlier, Estrella Village and Laveen Village are the two primary planning areas that lie adjacent to the Salt River between 19th Avenue and 83rd Avenue. Estrella Village is characterized by an ample supply of undeveloped land, large parcels, natural and scenic amenities and excellent transportation access. As noted on the City of Phoenix website, the village also poses unique challenges given the isolation of its existing residential neighborhoods and the extensive industrial activities that have developed over the years. Approximately 62 percent of the Village is undeveloped, either vacant or with agricultural uses. However, there are 21 residential developments in various phases of approval and development.

The Laveen Village contains largely undeveloped and agricultural properties. Primary agricultural crops grown in the area include cotton, citrus and corn. The area has been valued by farmers, equestrians and those looking for solitude and mountain access. However, development pressures have increased in this area due to its proximity (about seven miles) to downtown. This pressure is expected to increase along with access to the future South Mountain Loop transportation corridor. There are twelve residential developments in various phases of approval and development in the Laveen Village area, which is anticipated to result in a doubling of population over the next decade.

The Rio Montaña planning area is also primarily comprised of agriculture, vacant land, and low-density residential uses. In fact, these categories, along with open space, represent over 85 percent of the space in this planning area.

Housing Unit Projections

According to the US Census and MAG, the ratio of persons per housing unit in the city and county is about 2.5. Assuming that this ratio holds in the future, 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
Maricopa County and the City of Phoenix

	Maricopa County		City of Phoenix	
Period	Population Inc.	HU Inc.	Population Inc.	HU Inc.
2000-2010	638,000	255,000	223,000	89,000
2010-2020	806,000	322,000	252,000	101,000
2020-2050	2,749,000	1,100,000	772,000	309,000
Total	4,193,000	1,677,000	1,247,000	499,000

Table 2 shows that roughly 1.68 million new housing units would be needed in the county and about 499,000 in the city between 2000 and 2050 to accommodate projected future population increases.

Based upon the Proposed Land Use Map and Plan Element for Phoenix and the interactive maps supplied by the Maricopa County Association of governments obtained through the Internet, the residential land for the County and City will be developed at an average density ranging from two to five dwelling units per acre. The publication, *Valley Vision 2025* (February 2000), also posted on the MAG website, specifies an assumed density in the region of about 3.7 dwelling units per acre. Based upon this ratio, about 453,000 additional acres in the county, and about 135,000 additional residential acres in the city would need to be developed between 2000 and 2050.

MAG data indicate that, as of 1995, there were about 329,000 acres of residential property in the County. However, the General Plan shows that nearly ten times that amount is designated for future residential development. Most of that land is currently designated vacant, although it is assumed that a significant portion of existing agricultural land will be used in the future for residential development.

The current plans for Estrella and Laveen Villages project the number of dwelling units at buildout in these areas will be approximately 38,300 and 35,000, respectively. With a combined buildout population of about 200,000 and a combined number of dwelling units of about 73,000, the corresponding projected ratio of persons/household in the study area is about 2.74, which is slightly higher than the county average

Non-Household Projections

Commercial, industrial, office and public property currently represents about 39 percent of total residential development in area based upon 1995 data from MAG. Assuming that this ratio reflects future non-residential development requirements, the County, non-residential development through 2050 for the County is expected to total about 177,000 acres. The corresponding total for the city is about 53,000 acres.

According to 1995 land use data, there are 3,033,408 acres of vacant land in Maricopa County. Hence, it is not anticipated that the County will be completely built out by the end of the period of analysis. *Valley Vision 2025* states that there is enough vacant and planned land to adequately meet the demand for housing between now and 2025 without putting abnormal pressure on market prices, noting that less than ten percent of the 9,200 square miles in the region have been developed.

Summary

Rapid population growth is anticipated for the City of Phoenix as well as Maricopa County as a whole. Significant development of residential and non-residential land will be required to accommodate the projected growth. In the Study Area, existing land uses are primarily comprised of agriculture, industrial and low-density residential. It is anticipated that additional low-to-medium density residential development will take place due to the close proximity of the area to the City core. Existing vacant lots and agriculture land will likely be converted to residential uses.

Employment & Economy

The Phoenix area population growth illustrated above 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.

Statistics obtained from the City of Phoenix indicate that greater Phoenix accounts for 64 percent of Arizona=s workforce, with a labor force exceeding 650,000. Inmigration and high graduation levels from Arizona State University have provided local employers with a quality labor force. Primary industries in the area include aerospace and electronics manufacturing, business services, travel and tourism and information processing. Phoenix is also the state capital and home to the Maricopa County government, as well as many Federal government services. The following table provides breakdown of employment by industry in the greater Phoenix area.

Table 3
Greater Phoenix Employment by Industry

Services	33%
Trade	24%
Government	12%
Manufacturing	10%
Finance, Insur., & Real Estate	8%
Construction	7%
Transport., Comm. & Utilities	5%
Ag. & Mining	1%

Source: Arizona Dept. of Economic Security (December 2000)

From 1998 to 2003, non-farm payroll employment in Maricopa County increased by nearly 158,000. The largest increases have come in the construction, services and trade sectors. By far, the largest employer in the Phoenix area is the State of Arizona, which employs approximately 60,000. The City and County are also major public sector employers. Among private sector employers, information technology businesses have provided a large influx of employment to the area. As shown on Table 4 below, several high-tech firms, including Honeywell, Inc., Raytheon Co. and Intel Corporation, are now among the area's five largest employers.

Table 4
Greater Phoenix Largest Private Employers

Wal-Mart Stores, Inc.	19,189
Honeywell Inc.	13,303
Banner Health Systems	12,408
Raytheon Co.	10,100
Intel Corp.	9,575
Albertsons, Inc.	9,500
Bashas' Supermarkets	9,282
Wells Fargo & Co.	9,100
Kroger Co.	9,053
Target Corp.	8,778

Source: Arizona Republic:Tthe Republic 100 (2003)

The substantial growth in employment opportunities has helped maintain low unemployment rates in the Phoenix area in recent years. For example, unemployment rates in the Phoenix-Mesa Metropolitan Area (4.1 percent as of July 2006) have remained below the state (4.79 percent) and the national rates (4.7 percent).

To accommodate the population expansion in the area, more than 39,000 new residential building permits were issued in the greater Phoenix area in the first nine months of 2003 alone, exceeding the total for the entire year of 2002 according to the *Phoenix Business Journal* (December 1, 2003). According to information obtained from the City of Phoenix, over 30 percent of the housing stock has been constructed in the past 10 years. Most of the newer homes are constructed in master-planned communities, offering such amenities as lakes, golf courses and bike trails. New homes in the area are reasonably priced compared to other metropolitan areas. Low housing costs are a primary factor making the overall cost of living in Phoenix among the lowest of major U.S. metropolitan areas.

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. What little vegetation that does exist is mostly limited to salt cedar, an exotic non-native species with little habitat value.

There are a large number of open water areas along the Salt River, mostly the results of gravel mining.

Adjacent to several of these there is dense vegetation including some cottonwood and willows as well as cattails and bulrush.

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 0-1.0 scale, where 0.00 represents the low functional capacity for the wetland, and 1.0 represents the high 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

FCI functions have been developed specifically for the desert southwest ecosystem along the Salt River. 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 0, 1, 6, 26, and 51 (Target Year 0 being existing conditions and 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
Rio Salado Oeste Study Area
Without Project AAFCUs

	T0	T1	T6	T26	T51	AAFCUs
F1	414	414	414	414	414	414
F2	749	746	744	742	742	743
F3	452	443	436	439	439	439
F4	783	799	814	826	826	821
F5	496	485	472	465	465	468
F6	669	659	647	645	645	647
F7	589	585	580	578	578	579
F8	748	744	740	737	737	738
F9	531	523	514	508	508	511
F10	401	401	437	438	438	435
Avg	583	580	580	579	579	**580**

As shown in Table 5, AAFCUs are projected to remain fairly stable over the planning horizon. The AAFCU value of 580 will be the basis for comparison when assessing the potential benefits of proposed restoration alternatives.

Flood Damages

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 from Granite Reef Dam 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 downstream bridges through Phoenix were forced to close during that flood except the Central Avenue Bridge. 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. Total flood damages throughout Arizona during this storm were estimated at over $250 million in current dollars.

Information regarding damages estimates specific to the study reach were not available. However, current hydrologic data for the Salt River through the Study Area shows that peak discharges for the 50-year, 100-year and 200-year events are approximately 135,000 cfs, 165,000 cfs and 200,000 cfs, respectively. Current hydraulic analysis indicates that there are very few structures in the 50-year floodplain, and most floodplain structures are outside the 100-year floodplain. Therefore, it is likely that damages throughout the Study Area reach were limited during these storms.

Floodplain Boundaries & Reach Definitions

As specified earlier in the report, there is potential for significant flood damages under *existing* conditions. However, the planned improvements to the 35th Avenue Bridge and the aggregate mining that will take place from 35th to 51st Avenues will virtually eliminate damages in the adjacent reaches. **Figure 3** shows the Base Year floodplain boundaries which reflect the proposed bridge improvements being in place, but *do not reflect the assumed aggregate mining*. As shown on Figure 3, the floodplain is primarily confined within the channel, with only minor flooding even for the 500-year flood event. **Figure 4** shows a comparison of the 500-year floodplains for existing and Base Year conditions with the assumed bridge improvements. As clearly shown on Figure 4, potential flood damages without the planned bridge improvements would be significantly higher. Additional floodplain delineations showing Base Year floodplain boundaries with both the bridge improvements and the mining have not been prepared. However, water surface profiles have been developed, and an analysis of these water surface profiles shows that the potential for flooding in the 35th Avenue area is greatly reduced.

The following presents a summary of the analysis of potential flood damages WITHOUT the assumed aggregate mining. It was previously assumed that the aggregate mining would only take place under the with-project conditions, and accordingly, the without-project flood damage analysis did not reflect the impact of the mining. Also, price levels for the structure inventory & damages represent FY05 price levels.

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. 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 5** shows floodplain reach Boundaries. **Table 6** below provides a summary of reach characteristics, including approximate upstream and downstream boundaries. The "R" and "L" designations denote that the reach only includes the areas on the north (Right, looking downstream) or south (Left) side of the river, respectively.

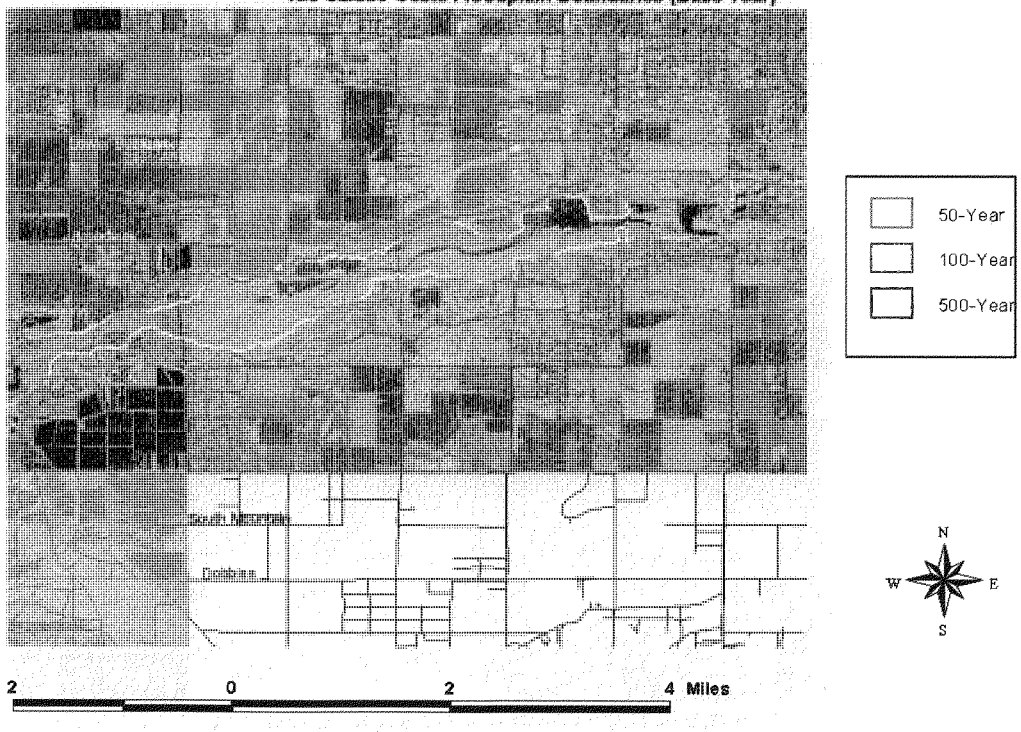
Table 6
Rio Salado Oeste
Floodplain Reach Definitions

Reach Name	Upstream Limit	Downstream Limit	Notes
1L	75th Ave.	91st Ave.	Only a few structures in this reach.
2L	67th Ave.	75th Ave.	Small # of industrial and agric. properties along Southern Ave., some residential along Baseline Road
2R	67th Ave.	75th Ave.	Small # of Structs at NW corner of Roeser & 67th
3L	51st Ave.	67th Ave.	Residential development at downstream end –NW of Baseline and 67th. Removed under Base Year Conds.
4L	43rd Ave.	51st Ave.	Small Number of Structures along 51st Ave. North of Southern.
4R	43rd Ave.	51st Ave.	Includes a few structures just west of 51st Ave. adjacent to floodway.
5L	35th Ave.	43rd Ave.	Large residential dvlpmt.in this reach on south side of River. Most of development removed from floodplain under Base Yr. conditions.
5R	35th Ave.	43rd Ave.	Mostly industrial structures, concentrated south of Lower Buckeye, between 35th & 39th Aves.
6L	27th Ave.	35th Ave.	Limited industrial/commercial development, primarily along Broadway Road
6R	27th Ave.	35th Ave.	Mostly industrial structures, concentrated along east side of 35th Ave., Lower Buckeye to floodway.
7R	19th Ave.	27th Ave.	Small number of structures near 27th Ave. on north side of Salt River under Existing Conditions – Removed under Base Year conditions.

NOTE – DOES NOT REFLECT ASSUMED W/O PROJECT MINING FROM 35th to 51st Ave.

Figure 3

Rio Salado Oeste Floodplain Boundaries (Base Year)



NOTE – DOES NOT REFLECT ASSUMED W/O PROJECT MINING FROM 35th to 51st Ave

Figure 4
Rio Salado Oeste 500-Year Floodplains - Existing & Base Year

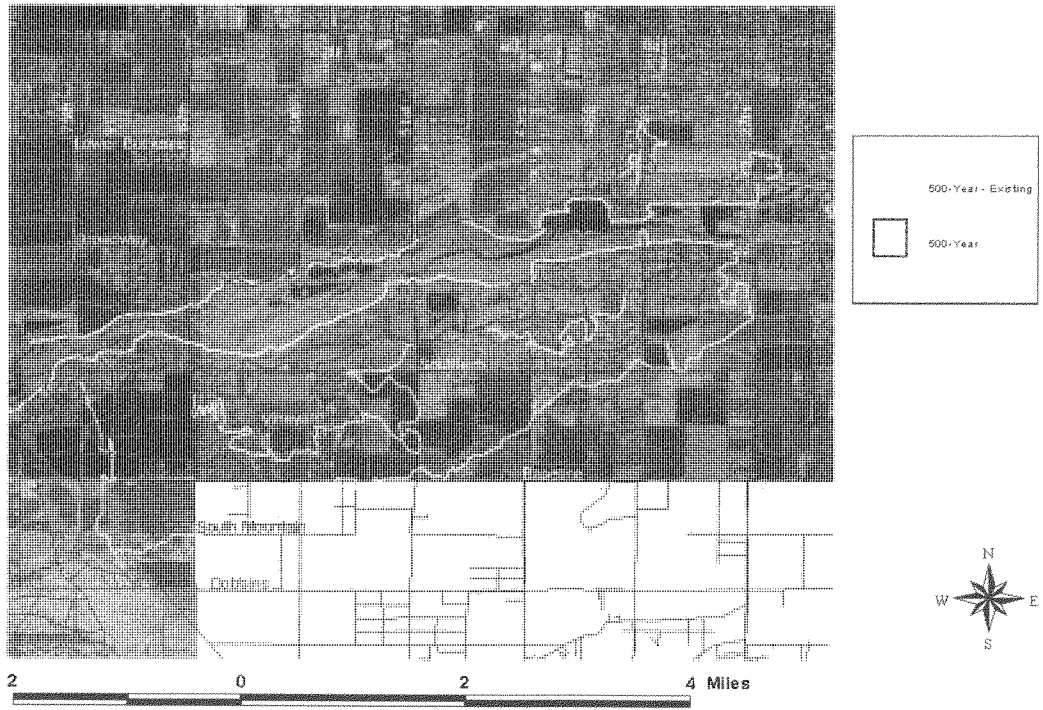
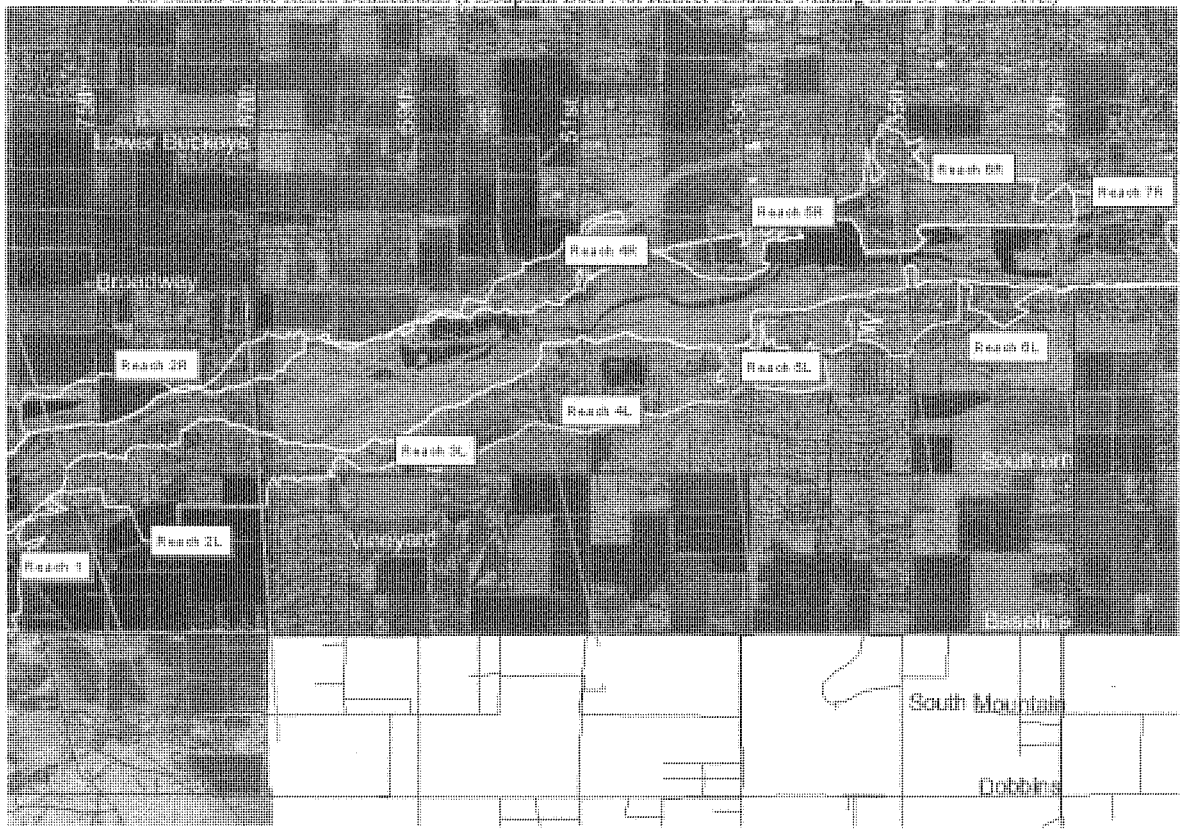


FIGURE 5

Rio Salado Oeste Reach Delineations (Floodplain Does Not Reflect Assumed Mining from 35th to 51st Ave.)



As indicated in the notes in Table 6 and as can be seen in Figure 5, Reach 5L contains the majority of floodplain structures. This area contains about 200 structures, primarily residential (including both single-family residences and mobile homes). Structures in this area are generally of fair to low-cost construction. Most single-family residential structures are of block construction. It is likely that most, if not all of these structures would be removed from the floodplain with the anticipated aggregate mining reflected in the delineation.

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
Rio Salado Oeste 100 & 500-Year Floodplains
Number of Structures

Structure Type	100-Year	500-Year
SFR	15	207
MH	19	22
Industrial/Agric.	78	114
Office/Commercial	27	43
Public	0	0
Total	139	386

Table 7 shows that there are approximately 386 structures in the Rio Salado Oeste floodplain. Of this total, most (59 percent) are residential. Roughly 139 structures are located within the 100-year floodplain boundaries (about 36 percent of the structures in the 500-year floodplain).

Table 8
Rio Salado Oeste 500-Year Floodplain
Number of Structures by Reach

Location	Number of Structures
Reaches 2R through 7R (All North of River)	70
Reaches 1L, 2L (S. of River, West of 67th)	36
Reach 3L (S. of River, 67th to 51st)	8
Reach 4L (S. of River, 51st to 43rd)	5
Reach 5L (S. of River, 43rd to 35th)	195
Reach 6L (S. of River, East of 35th)	72
Total	386

As indicated in Table 8, more than half of floodplain structures are located in Reach 5L, and about 19 percent are located in Reach 6L. There are very few structures located within the floodplain on the north side of the Salt River. Most are industrial and storage structures located in Reaches 5R and 6R.

Value of Structures & Contents

Depreciated structure 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/Agriculture 171%
- Office 80%
- Public 33%

Tables 9 and 10 provide a summary of floodplain structure and content values, respectively, by structure category and reach.

Table 9
Rio Salado Oeste 500-Year Floodplain
Value of Structures & Contents By Structure Type
(In $Millions)

Structure Type	Struct Val	Cont Val	Total
SFR	10.5	5.3	15.8
MH	1.3	0.6	1.9
Industrial/Agric.	11.4	19.4	30.8
Office/Commercial*	5.6	5.2	10.8
Public	0	0	0
Total	28.8	30.5	59.3

** Structure & content values and damages calculated separately for office and commercial structures, but added for report purposes.*

Table 10
Rio Salado Oeste 500-Year Floodplain
Value of Structures & Contents By Reach
(In $Millions)

Location	Struct Val	Cont Val	Total
Reaches 2R through 7R (All N. of River)	11.7	15.7	27.4
Reaches 1L, 2L (S. of River, West of 67th)	2.8	3.3	6.1
Reach 3L (S. of River, 67th to 51st)	1.0	0.5	1.5
Reach 4L (S. of River, 51st to 43rd)	0.3	0.2	0.5
Reach 5L (S. of River, 43rd to 35th)	8.8	5.0	13.8
Reach 6L (S. of River, East of 35th)	4.2	5.8	10
Total	28.8	30.5	59.3

As displayed on Tables 9 and 10, the total estimated value of property in the floodplain is about $59.3 million.

Although nearly 51 percent of floodplain structures are located in Reach 5L, the value of property in this reach is only about 23 percent of the total value for the 500-year floodplain. This is attributable to the fact that almost all of the structures in Reach 5L are fair/low cost residential structures, whereas other reaches include more higher-value industrial and commercial structures. Table 9 shows that although residential structures (i.e., single family residences and mobile homes) represent about 59 percent of total floodplain structures, they only account for about 30 percent in terms of value.

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 about0.7 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 Rio Salado Oeste 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 2-foot interval digital elevation model in GIS format. 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 0.6 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-RAS 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 (2010)

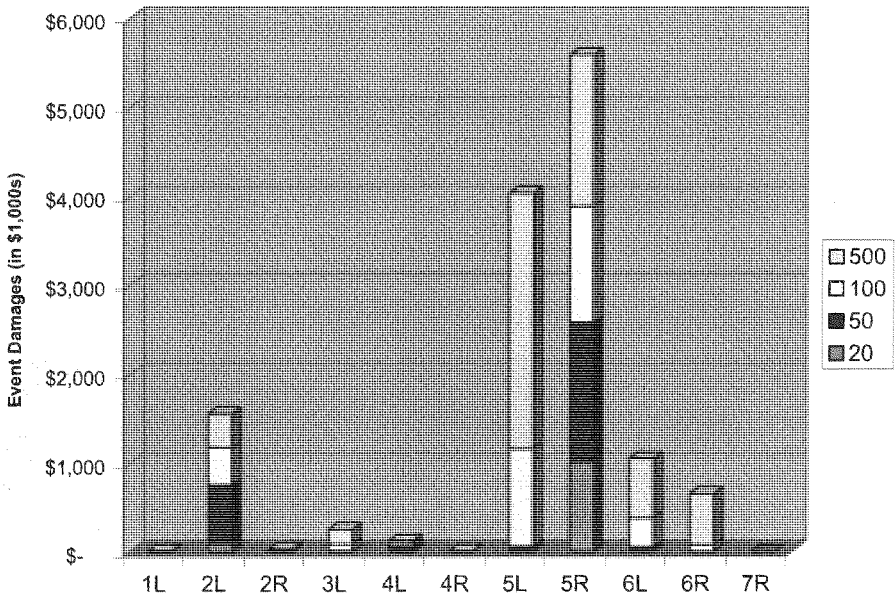
Without project damages by event for Base Year conditions, as calculated by the HEC-FDA program, are shown in **Tables 11** and on **Figure 6.** The non-damaging event is approximately the 10-year event. However, most reaches do not incur damages until less frequent events. Damages calculated for the 20-year event are approximately $1.14 million. A majority of these damages are attributable to one parcel within Reach 5R. There are approximately 11 industrial structures on this parcel (located adjacent to the floodway on the west side of 35th Avenue) owned by a metal scrap recycling business.

Damages increase significantly for the 50-year event, and approximately double subsequently for the 100-year and 500-year events. A majority of damages for these flood events are expected to occur in Reaches 5R and 2L (primarily industrial properties) and 5L (which is the reach with the large residential development discussed previously).

Table 11
Rio Salado Oeste
Without Project Damages By Reach & Event (Base Year – 2010)
(in $1,000s)

Reach	10	20	50	100	500
1L	$ -	$ -	$ -	$ 1	$ 13
2L	$ -	$ 88	$ 754	$ 1,183	$ 1,561
2R	$ -	$ -	$ -	$ 8	$ 30
3L	$ -	$ -	$ 10	$ 87	$ 254
4L	$ -	$ 4	$ 52	$ 90	$ 125
4R	$ -	$ -	$ -	$ -	$ 10
5L	$ -	$ -	$ 59	$ 1,163	$ 4,039
5R	$ 38	$ 1,050	$ 2,615	$ 3,929	$ 5,633
6L	$ -	$ -	$ 52	$ 378	$ 1,056
6R	$ -	$ -	$ 2	$ 78	$ 659
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 38	$ 1,142	$ 3,544	$ 6,917	$ 13,380

Figure 6
Rio Salado Oeste
Without Project Structure & Content Damages by Frequency & Reach



Expected annual damages by reach and structure type are shown on Table 12. Damages to industrial and agricultural structures and contents, primarily located in Reaches 2L and 5R, comprise most of the expected annual damages. This is attributable to the fact that these two reaches contain structures that are within close proximity of the floodway, and therefore are susceptible to more frequent flood events. It should be noted that these results reflect planned bridge improvements at 35th Avenue. Preliminary analysis indicates that expected annual damages without these improvements would be substantially higher (approximately $670,000 vs. $245,000).

Table 12

Rio Salado Oeste Without Project Expected Annual Damages – Base Year (in $1,000s)					
Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
1L	$ -	$ -	$ -	$ -	$ -
2L	$ 8	$ 26	$ 2	$ -	$ 35
2R	$ -	$ -	$ -	$ -	$ -
3L	$ 2	$ -	$ -	$ -	$ 2
4L	$ 2	$ -	$ -	$ -	$ 2
4R	$ -	$ -	$ -	$ -	$ -
5L	$ 31	$ 4	$ 1	$ -	$ 36
5R	$ -	$ 138	$ 17	$ -	$ 155
6L	$ 1	$ 6	$ 3	$ -	$ 10
6R	$ 1	$ 3	$ 1	$ -	$ 5
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 45	$ 177	$ 24	$ -	$ 245

Results – Future Conditions (2059)

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 recompute expected annual damages under future conditions. Table 13 summarizes the results.

Table 13 Rio Salado Oeste Without Project Expected Annual Damages – Future Conditions (2059) (in $1,000s)					
Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
1L	$ -	$ -	$ -	$ -	$ -
2L	$ 4	$ 16	$ 1	$ -	$ 21
2R	$ -	$ -	$ -	$ -	$ -
3L	$ 2	$ -	$ -	$ -	$ 2
4L	$ 1	$ -	$ -	$ -	$ 1
4R	$ -	$ -	$ -	$ -	$ -
5L	$ 8	$ 4	$ 1	$ -	$ 13
5R	$ -	$ 98	$ 14	$ -	$ 112
6L	$ 1	$ 5	$ 2	$ -	$ 8
6R	$ -	$ 1	$ 1	$ -	$ 2
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 16	$ 124	$ 19	$ -	$ 159

Without project expected annual damages actually decrease from about $245,000 under Base Year conditions to about $159,000 under future conditions (a drop of about 35 percent). Water surface elevations are generally lower throughout the Study Area under future conditions due primarily to projected channel degradation and resulting increases in channel capacity (refer to Hydraulic appendix for details).

Equivalent annual damages were computed based upon forecast annual damages using a discount rate of 5 1/8% (see Table 14).

Table 14 Rio Salado Oeste Without Project Equivalent Annual Damages (50 Yrs. 5 1/8%) (in $1,000s)					
Reach	SFR/MH	Ind/Ag	Office/Com	Public	Total
1L	$ -	$ -	$ -	$ -	$ -
2L	$ 7	$ 23	$ 2	$ -	$ 32
2R	$ -	$ -	$ -	$ -	$ -
3L	$ 2	$ -	$ -	$ -	$ 2
4L	$ 2	$ -	$ -	$ -	$ 2
4R	$ -	$ -	$ -	$ -	$ -
5L	$ 24	$ 4	$ 1	$ -	$ 29
5R	$ -	$ 126	$ 16	$ -	$ 142
6L	$ 1	$ 6	$ 3	$ -	$ 10
6R	$ 1	$ 2	$ 2	$ -	$ 5
7L/7R	$ -	$ -	$ -	$ -	$ -
Total	$ 37	$ 161	$ 24	$ -	$ 222

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 acre. 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 and undeveloped acreage are not included. 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 Rio Salado Oeste Without Project Cleanup Costs (in $1,000s)		
Event	Acres	Costs
20	11	$ 55
50	70	$ 350
100	105	$ 525
500	387	$ 1,935
Expected Annual Damages		$ 24

Table 16
Rio Salado Oeste

Without Project Expected Annual Cleanup Costs By Reach (in $1,000s)	
Reach	**Expected Annual Costs**
2L	$10
3L	$1
4L	$0
5L	$4
6L	$3
Total South of River	$18
2R	$0.5
5R	$5
6R&7R	$0.5
Total North of River	$6
Total – All Reaches	**$24**

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 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 Rio Salado Oeste Without Project Temporary Housing Costs (in $1,000s)		
Event	**Structures**	**Costs**
20	2	$ 3
50	6	$ 9
100	14	$ 21
200	41	$ 62
500	212	$ 318
Expected Annual Damages		**$ 1.6**

Note that the number of residential structures shown in Table 17 as sustaining inundation for the 100-year and

500-year events differs from the number of estimated floodplain structures shown in Table 7. This is because the structure counts shown in Table 7 are based strictly on floodplain delineation maps overlaid onto aerial photography of the study area. These floodplain boundaries are based upon median discharge values and do not account for the probabilistic ranges of values for either discharge or stage. The figures in Table 17 are based upon the results of the HEC-FDA model, which incorporate risk and uncertainty in such areas as frequency/discharge, stage/discharge, and structure elevation, i.e., Table 17 represents expected values resulting from the simulation model.

Table 18 shows expected annual without project temporary housing costs by reach.

Table 18
Rio Salado Oeste
Without Project Expected Annual Temporary Housing Costs
By Reach (in $1,000s)

Reach	Expected Annual Costs
2L	$0.4
3L	$0.1
4L	$0.1
5L	$0.9
6L	$0.1
Total South of River	$1.6
Total North of River	$0
Total – All Reaches	**$1.6**

Without Project Flood Damage Analysis Summary

Without project flood damages are summarized on Table 19.

Table 19
Rio Salado Oeste

Without Project Equivalent Annual Damages (In $1,000s)				
Reach	**Structure & Content**	**Cleanup**	**Temp. Housing**	**Total**
2L	$ 32	$ 10	$ 0.4	$ 42
3L	$ 2	$ 1	$ 0.1	$ 3
4L	$ 2	$ -	$ 0.1	$ 2
5L	$ 29	$ 4	$ 0.9	$ 34
6L	$ 10	$ 3	$ 0.1	$ 13
Total - S. of River	$ 75	$ 18	$ 1.6	$ 95
5R	$ 142	$ 5	$ -	$ 147
6R	$ 5	$ 0.5	$ -	$ 6
Total - N. of River	$ 147	$ 6	$ -	$ 153
Total	$ 222	$ 24	$ 2	$ 247

Notes: Damages for Reaches Not Shown are Minimal

As shown on Table 19, equivalent annual damages are concentrated in a few reaches. Reach 5R accounts for about 60 percent of total without project damages. This reach contains a small concentration of industrial structures along 35th Avenue, primarily south of Lower Buckeye Road. There are several parcels with multiple structures that are within the 50-year floodplain, and just outside of the 20-year floodplain. The risk and uncertainty analysis indicates that these structures may be flooded by events more frequent than the 20-year event.

On the south side of the Salt River, Reach 2L has the highest amount of expected annual damages. Damages in this reach are attributable to the close proximity of several structures to the floodway on the north side of Southern Avenue between 75th and 67th Avenues.

The highest concentration of residential damages is located in Reach 5L. Although there are nearly 200 structures in this reach, damages are limited due to the low per unit structure values and because most are outside the 100-year floodplain. Most of the structures in this reach are located just southwest of Broadway Road and 35th Avenue.

The only other reach with significant damages is Reach 6L. This reach includes industrial and commercial structures located along Broadway Road between 35th and 27th Avenues.

Impact of Assumed Aggregate Mining on Without Project Damages

A detailed analysis of without-project flood damages reflecting the assumed mining operations between 35th and 51st Avenues has not been completed. However water surface profiles have been developed for with-project alternatives which reflect the impacts of both the mining and the features of the alternatives. It has been determined that the impacts of the mining, particularly in Reach 5 area, are significant. In fact, it appears that the additional channel capacity created by this mining will greatly reduce the potential for any flooding in this area. As this was the primary damage area under previous assumptions, the removal of the flood threat for this area essentially leaves only minor residual flooding, primarily in Reach 2, under without-project conditions.

Recreation

As demonstrated earlier in this report, the Phoenix 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 Phoenix Parks, Recreation and Library Department, the Arizona Game and Fish Department and other agencies, the proposed habitat and recreation features would attract visitors throughout the Phoenix Valley region. 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, 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 approximately 15 miles west of Gila Bend on the Gila River.
- 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

- 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. 35 miles northeast of Phoenix)..
- Canyon Lake: Maricopa County (approx. 30 miles east of Phoenix).
- Lake Pleasant: Maricopa and Yavapai County (approx. 25 miles north of Phoenix).
- Saguaro Lake: Maricopa County (approx. 25 miles east of Phoenix).

Maricopa County

- Estrella Mountain Regional Park: 19,200 acres located three miles south of Goodyear.
- Thunderbird Park/Adobe Dam
- Cave Buttes Recreation Area

Municipal Parks & Other Recreation Areas

Papago Park	South Mountain Park
Case Abbot Recreational Area	Phoenix Municipal Stadium
Phoenix Zoo	A.S.U. Sun Devil Stadium
Phoenix Mountain Preserve	Moeur Park
Tempe Beach Park	Playa Margarita
El Prado Park	Lindo Park
Rio Salado Industrial Park	Echo Canyon Recreation Area
Encanto Park	Estaban Park
Hayden Park	Green Valley Park
Nuestro Park	Nueve Park
Harmon Park	Barrios Unidos
Alkire Park	University Park
Canal Park	McKellips Lake Park
Eldorado Park	Indian School Park
Chapparal Park	Vista del Camino Park
Coffelt Park	Cesar Chavez Park

Estrella Mountain Regional Park, South Mountain Park and Papago Park are three of the largest recreation areas listed above which are nearby the study area. Estrella Mountain Regional Park is owned and managed by Maricopa County Parks and Recreation Department. The rugged and scenic Sierra Estrella Mountains are the most dominant feature of Estrella Mountain Regional Park. The terrain of these mountains is characterized by very steep slopes, numerous rock out-crops, shallow soils and sparse desert vegetation.

The County has developed a master plan for the 19,200-acre park, located approximately 20 miles southwest of downtown Phoenix. The master plan envisions the preservation of scenic desert wilderness areas while incorporating sensitive development of recreational facilities and activities. The Plan accommodates the expected annual demand of 1 million visitors while insuring that the existing Sonoran Desert environment remains in its existing condition. In fact, 90 percent of the park will remain essentially untouched. The remaining 10 percent will be sensitively utilized for educational, camping, picnicking, and sporting activities.

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 the city, 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 study area 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 City of Phoenix has, until the recently constructed Rio Salado and Tres Rios projects and the upstream Tempe Town Lake, consisted of dry river bottom. As a result, virtually no recreation activities took place.

The only improved recreation area adjacent to the Salt River was Rio Salado Park, which is located at 12th Street and Elwood. The park encompasses about 14 acres and contains picnic facilities and racquetball and basketball courts. Most of the users are employees who work at industrial businesses located in the area. According to the City of Phoenix Parks Department, fewer than 200 people visit the park on a weekly basis (or less than 10,400 annually). There are currently no plans for expansion of the park, and visitation is not expected to increase in the absence of a Corps project.

The following shows the names and annual visitation for other community parks in the Phoenix area.

Park	Visitation	Features
Hayden Park	121,000	14 acres, with picnicking, softball, basketball, playground, restrooms
Estaban Park	58,000	62 acres, with picnicking, softball, soccer, volleyball, tennis, playground, restrooms
El Prado	61,000	40 acres, with swimming pool, softball, picnicking, playground, restrooms
Cesar Chavez	310,000	353 acres, with 25 acre lake with fishing/ sailing/canoeing, picnicking, restrooms
Encanto	1,200,000	63 acres, with fishing lagoon, 18-hole golf course, clubhouse, swimming pool, racquetball, tennis, basketball, softball, children's play area
Echo Canyon	350,000	387 acres, with hiking trails, mountain biking, horseback riding

The Rio Salado Project stretches from an upstream limit of Interstate 10 to a downstream limit of 19th Avenue

(which is the upstream limit for this study) and is comprised of environmental restoration and passive recreation components along the Salt River. Approximately five miles (and 580 acres) of the Salt River has been 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 and was just recently completed. Recreation project features include parking lots, information kiosks, a visitor center, overlooks, shade structures, bridges, trails, an equestrian 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 just downstream of the Study area will also provide recreation opportunities. The Tres Rios Project is located immediately downstream of the Study Area, beginning at the 91st Avenue Wastewater Treatment Plant. 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.

Recreation Demand

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 in greater Phoenix, the only recreation facilities located within wetland/riparian habitat areas are those provided adjacent to 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., South Mountain) 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 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 25 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 in the middle of the Phoenix metropolitan area, which has a population exceeding three million. Portions of the study area are located within minutes of downtown Phoenix, and are thus easily and quickly accessible to the public. In addition, a major freeway (Interstate 10) and several major bridges cross the Salt River. 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.

4) Activities: Proposed 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); 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, and walking all ranked in the top ten.

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 City of Phoenix Parks Recreation and Library Department's *Long Range Plan (Draft, September 2001)* (LRP) describes national standards that have been established for various types of recreation. These standards indicate desired and ideal service levels on a per capita basis. 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.

The standard established by the City is 4.5 acres of developed park space per 1,000 residents, although historical NRPA standards are higher. According to the LRP, the 4.5-acre standard (rather than a higher level) was selected because the area has Desert Parks, Sonoran Desert Preserves and Mountain Preserves,

which also provide recreation activities. Even though the preserves do not provide a wide range of recreation opportunities like neighborhood, community and district parks, they do provide additional open space and some amenities (such as multi-use trails) on portions of the land.

There are currently about 132 parks covering about 4,086 acres within the City. As noted earlier, the population in Phoenix is about 1.4 million. Hence, the existing service level is about 2.9 acres per thousand residents. This figure is well below the desired standard of 4.5, and the supply deficit will become worse with the anticipated rapid population growth in the future. For example, by 2020, the population in the City is expected to reach 1.8 million. With no additional parks, the ratio of parks per thousand residents would worsen to 2.3. Based upon an expected population of 2.6 million by 2050, the corresponding ratio would be about 1.6. As noted in the LRP, over 2,800 acres of additional parks would be required over the next decade to both meet the desired standards and keep up with the population influx.

The LRP specifically discusses the Study area by noting that the new growth areas of Estrella and Laveen continue to present a problem as they are developing and growing faster than previously projected. For example, in the Central Phoenix planning area, which includes Estrella Village, the existing service level is only about 2.4 acres per thousand residents.

Trails would likely be an important component of any recommended plan for the Study area. According to the LRP, nearly 100 miles of new trails would be needed in the City by the year 2010 to meet the established standard of one mile per 8,000 residents. The LRP specifically notes the desire to implement new trails to link with those of the Rio Salado project.

As the above analysis indicates, the Phoenix area lacks sufficient recreation resources. As noted in the City of Phoenix *Sonoran Preserve Master Plan*, although the amount of dedicated open space has continually increased within the City and County, the acreage per capita has decreased. Unless a significant number of recreation facilities are built, the projected population growth will make the existing deficit become worse.

Recreation Opportunities

While water is a highly attractive feature for recreationists, park trails and facilities have presently been planned away from the Gila River. Once the County completes its Sun Circle Trail System through this reach of the Gila and Salt Rivers, recreation use patterns are expected to expand throughout the study area. The Sun Circle Trail, a component of the National Recreation Trail system, comprises a 110-mile loop encompassing the Phoenix metro area. The trail offers a unique opportunity for hiking, horseback riding and bicycling throughout the urban area. Approximately 70 percent of the Sun Circle trail system is in place. The County has an agreement with the Maricopa County Flood District to establish the Sun Circle Trail within the flood control district corridor from Skunk Creek to the Gila River - Salt River confluence. The Rio Salado Oeste Project is an excellent opportunity to designate a segment of the Sun Circle Trail. This will benefit Tres Rios, Rio Salado, and Rio Salado Oeste with a major non-motorized travelway connecting the three river restoration projects to the other valley areas.

The Rio Salado Oeste 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 Laveen and Estrella Planning Areas. Rio Salado Oeste will provide a habitat and recreational connection to the desert riparian habitat corridor created by the Rio Salado and Tres Rios Projects. By connecting the seven-mile gap between the two projects, Rio Salado Oeste will enhance the unique recreation and education opportunities for residents and out-of-town visitors. Drawing on a population base of over three million in the Valley, it is estimated that visitation to the Rio Salado Oeste

project will 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 Rio Salado Oeste project would employ design components ranging from areas adapted for special needs to multi-lingual signage.

WITH PROJECT CONDITIONS

Environmental Resources

The following provides an analysis of alternatives developed to provide ecosystem restoration benefits. Note that Alternative 1 represents the No Action Plan, or Without Project Condition, which has already been described earlier in this report.

Description of Alternatives

Below is a summary description of the restoration alternatives. Please refer to the Main Report and Environmental Impact Statement for a more detailed description of these alternatives.

Alternative 2

Storm water and Channel: This alternative includes the modification of existing storm-water outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state. This could include grading and terracing the river corridor from 19th avenue to 83rd avenue. No additional water source is included in this alternative.

Alternative 3

Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive: This alternative includes the features described in alternative 2 and ads a supplemental water supply in the form of effluent. At locations identified as suitable throughout the project area cottonwood/willow and mesquite cover types will be restored. This alternative would also address the management, control and removal of invasive species within the study area. Two types of irrigation (drip and flood) will be evaluated for each.

Alternative 4

Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent: This alternative adds restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue.

Alternative 5

Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake: Added to this alternative is lake restoration at the existing gravel pits at 29th and 37th Avenues.

Alternative 5A

Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake: Instead of restoration of both gravel pit lakes to permanent water for fishing this alternative includes regrading to incorporate the pits to the floodplain and restoration of wetland and riparian habitat.

Alternative 5B

Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake: This alternative is similar to 5 and 5A. However it includes the restoration of one gravel pit to a lake and the other to a wetland/riparian area.

Additional Alternatives Developed to Address HQUSACE Policy Review Comments

Four additional alternatives were developed to assure that the Cost Effectiveness and Incremental Cost Analysis provided an evaluation of alternatives covering a full range of both output and cost, and considered separability and justification of major project features. These alternatives include:

Partial: This alternative restores only the portion of Salt River from 19th to 35th Avenues without any restoration of existing gravel pit lake. It includes capture of storm water from only 4 outfalls. Approximately 270 acres are required for this alternative and restored areas include 15 acres of emergent wetlands, 30 acres of cottonwood-willow, 30 acres of mesquite, and 75 acres of riparian scrub. In addition the low flow channel would encompass approximately 48 acres.

Refine 1: This alternative includes restoration of the river channel from 19th to 83rd Avenues, modification of existing storm water outfalls and restoration of associated habitats and restoration of the two existing gravel pit lakes. Approximately 1024 acres are required to implement this alternative. Acres restored with this alternative include: cottonwood-willow 210, mesquite 56, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 2: This refinement restores the river from 19th to 83rd Avenues and includes the same features as Alternative 5A but is scaled back to restore much less cottonwood-willow and mesquite habitats. Approximately 1300 acres are required to implement this alternative. Acres restored include: cottonwood-willow 204, mesquite 110, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 3: This refinement also restores the river from 19th to 83rd Avenues without restoration of the gravel pit lakes and less acreage of cottonwood-willow and mesquite. Approximately 1130 acres are required to implement this alternative. Acres restored include: cottonwood-willow 169, mesquite 102, wetlands 92, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

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 20 shows the results.

	Without Project	Alt 1	Alt 3	Alt 4	Alt 5	Alt 5A	Alt 5B	Partial	Refine 1	Refine 2	Refine 3
T0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T1	580	619	689	691	766	791	778	609	732	736	626
T6	580	627	716	717	796	822	809	611	749	754	649
T26	579	635	751	755	828	857	842	616	771	776	674
T51	579	633	771	775	851	879	865	612	779	785	682
Avg (T0-T51)	580	631	742	745	820	847	833	613	764	767	667
Increase (T0-T51)		**51**	**162**	**165**	**240**	**267**	**253**	**33**	**184**	**187**	**87**

As shown on Table 20, the proposed alternatives result in increased AAFCUs (relative to without project conditions) ranging from 33 for Alternative Partial to 267 for Alternative 5A.

Cost Estimates

Table 21 which follows displays the derivation of average annual costs by alternative. Total first costs range from $21 million for Alternative Partial to $187 million for Alternative 5.

	Alt 2	Alt 3	Alt 4	Alt 5	Alt 5A	Alt 5B
Construction	$ 12,227	$ 41,500	$ 39,496	$ 92,549	$ 67,556	$ 80,052
Contingency (25%)	$ 3,057	$ 10,375	$ 9,874	$ 23,137	$ 16,889	$ 20,013
PED/EDC (11%)	$ 1,345	$ 4,565	$ 4,345	$ 10,180	$ 7,431	$ 8,806
S&A (6.5%)	$ 795	$ 2,697	$ 2,567	$ 6,016	$ 4,391	$ 5,203
Real Estate	$ 21,994	$ 36,313	$ 36,313	$ 49,485	$ 49,485	$ 49,485
Subtotal	$ 39,417	$ 95,449	$ 92,594	$ 181,367	$ 145,752	$ 163,560
Monitoring & Adapt. Mgmt.	$ 697	$ 2,365	$ 2,251	$ 5,275	$ 3,851	$ 4,563
Total First Cost	**$ 40,114**	**$ 97,815**	**$ 94,845**	**$ 186,642**	**$ 149,603**	**$ 168,123**
IDC	$ 2,020	$ 8,724	$ 8,463	$ 19,066	$ 15,322	$ 17,195
Gross Investment	$ 42,134	$ 106,539	$ 103,308	$ 205,708	$ 164,925	$ 185,318
Annualized Investment Cost	$ 2,353	$ 5,949	$ 5,769	$ 11,486	$ 9,209	$ 10,348
Associated Cost (Water Supply)	$ -	$ 312	$ 331	$ 654	$ 817	$ 811
O&M	$ 101	$ 1,698	$ 1,698	$ 2,224	$ 2,080	$ 2,137
Total Annual Cost	**$ 2,454**	**$ 7,959**	**$ 7,797**	**$ 14,364**	**$ 12,106**	**$ 13,296**

TABLE 21 (Cont)
RIO SALADO OESTE STUDY AREA
WITH PROJECT AVERAGE ANNUAL COSTS BY ALTERNATIVE (in $1,000s)

	Partial	Refine 1	Refine 2	Refine 3
Construction	$ 8,457	$ 47,909	$ 39,149	$ 16,084
Contingency (25%)	$ 2,114	$ 11,977	$ 9,787	$ 4,021
PED/EDC (11%)	$ 930	$ 5,270	$ 4,306	$ 1,769
S&A (6.5%)	$ 550	$ 3,114	$ 2,545	$ 1,045
Real Estate	$ 8,438	$ 31,319	$ 39,625	$ 32,375
Subtotal	$ 20,488	$ 99,589	$ 95,413	$ 55,295
Monitoring & Adapt. Mgmt.	$ 482	$ 2,731	$ 2,232	$ 917
Total First Cost	**$ 20,971**	**$ 102,320**	**$ 97,644**	**$ 56,212**
IDC	$ 1,050	$ 10,469	$ 10,030	$ 5,813
Gross Investment	$ 22,021	$ 112,789	$ 107,674	$ 62,025
Annualized Investment Cost	$ 1,230	$ 6,298	$ 6,012	$ 3,463
Associated Cost (Water Supply)	$ 53	$ 276	$ 286	$ 212
O&M	$ 365	$ 980	$ 2,011	$ 2,003
Total Annual Cost	**$ 1,648**	**$ 7,553**	**$ 8,309**	**$ 5,678**

Note – O&M Costs include annualized equivalent values of projected replanting costs, invasive species control, channel, wetland and lake regrading and excavation costs, and water supply and irrigation system related costs.

Cost Effectiveness & Incremental Cost Analysis

Average Cost per Average Annual Function Capacity Unit

Table 22 summarizes average annual output and cost by alternative, as well as average annual cost per AAFCU.

TABLE 22
RIO SALADO OESTE STUDY AREA
AVERAGE ANNUAL COSTS PER AVERAGE ANNUAL FCU BY ALTERNATIVE
(in $1,000s)

Alternative	AAFCU	AA COST	AAC/AAFCU
Alt 2	51	$ 2,454	$ 47.94
Alt 3	162	$ 7,959	$ 49.02
Alt 4	165	$ 7,797	$ 47.19
Alt 5	240	$ 14,364	$ 59.76
Alt 5A	267	$ 12,106	$ 45.30
Alt 5B	253	$ 13,296	$ 52.59
Partial	33	$ 1,648	$ 49.34
Refine 1	184	$ 7,553	$ 41.05
Refine 2	187	$ 8,309	$ 44.52
Refine 3	87	$ 5,678	$ 65.41

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 23A shows the cost effective plans.

TABLE 23A
RIO SALADO OESTE STUDY AREA
COST EFFECTIVENESS ANALYSIS
(in $1,000s)

	AAFCU	AA COST	AAC/AAFCU
Partial	33	$ 1,648	$ 49.34
Alt 2	51	$ 2,454	$ 47.94
Refine 3	87	$ 5,678	$ 65.41
Refine 1	**184**	**$ 7,553**	**$ 41.05**
Refine 2	187	$ 8,309	$ 44.52
Alt 5A	**267**	**$ 12,106**	**$ 45.30**

As shown above, there six cost effective plans. Alternatives 3, 4, 5 and 5B are not cost effective because they have a higher cost than other alternatives while providing less environmental benefits.

Incremental Cost Analysis

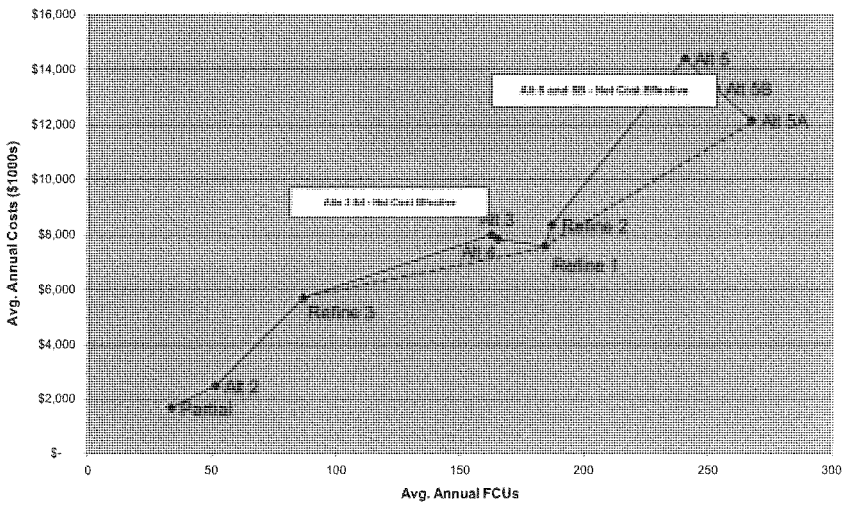
Incremental Cost Analysis goes beyond cost effectiveness analysis to identify "best buy" plans. Best Buy plans are those that have the lowest incremental average annual cost per incremental increase in output. For the alternatives formulated for this study, there are two Best Buy Plans – Alternative Refine 1 and Alternative 5A. Table 23B shows the results of the Incremental Cost Analysis.

TABLE 23B
RIO SALADO OESTE STUDY AREA
INCREMENTAL COST ANALYSIS
(in $1,000s)

	AAFCU	Incremental AAFCU	AAC	Inc AAC	Inc. AAC/AAFCU
Refine 1	184	184	$ 7,553	$ 7,553	$ 41.0
Alt 5A	267	83	$ 12,106	$ 4,553	$ 54.7

Alternative Refine 1 has the lowest average annual cost (AAC) per AAFCU, and therefore is a Best Buy plan. However, Alternative 5A, the other Best Buy plan, has the greatest output while having only a 10 percent higher AAC per AAFCU relative to Alternative Refine 1. Figure 7 shows the AAC for each alternative, and Figure 8 shows the AAC per AAFCU for the cost effective alternatives. Figure 9 shows the incremental AAC/AAFCU for the Best Buy Plans.

Figure 7
Rio Salado Oeste
Cost Effectiveness Analysis



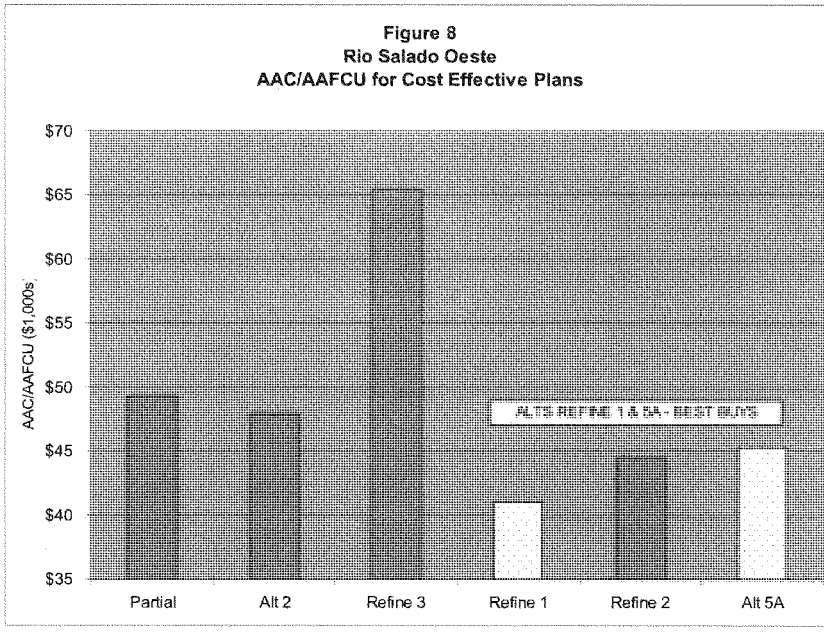
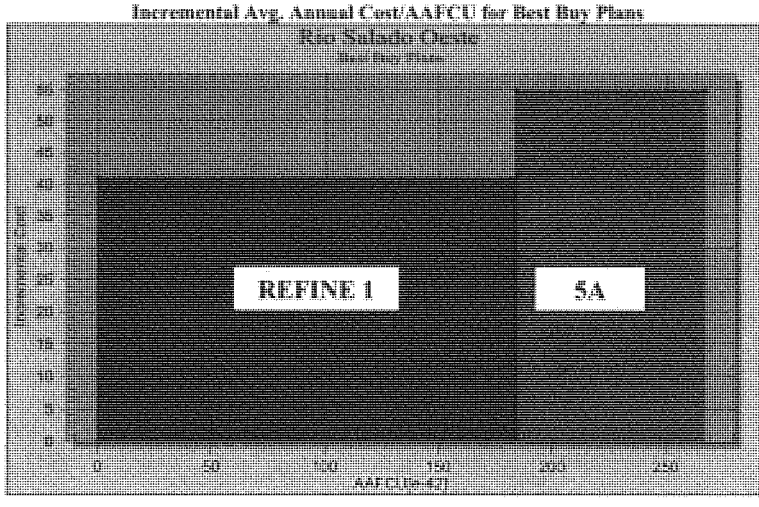


Figure 8
Rio Salado Oeste
AAC/AAFCU for Cost Effective Plans
$70
$65
$60
$55
$50
$45
$40
$35
AAC/AAFCU ($1,000s)
Partial
Alt 2
Refine 3
Refine 1
Refine 2
Alt 5A

Figure 9


Incremental Avg. Annual Cost/AAFCU for Best Buy Plans
Rio Salado Oeste
REFINE 1
5A
0
50
100
150
200
250

Recommended Ecosystem Restoration Plan

Based upon the CE/ICA analysis, Alternative 5A has been identified as the NER Plan. The AAC/AAFCU for Alternative 5A is about ten percent higher than Alternative Refine 1, and the incremental AAC per incremental AAFCU is about 33 percent higher than Alternative Refine 1. However, Alternative 5A provides 83 AAFCUs more than Alternative Refine 1, representing an increase in output of over 45 percent. It was determined that the significantly higher benefits for Alternative 5A more than outweighed the incremental costs, leading to the conclusion that this alternative should be identified as the NER Plan. Because this plan is also the locally preferred alternative, Alternative 5A is the Recommended Plan.

MCACES Cost Estimate

Table 24 shows the MCACES cost estimate for the Recommended Plan. The First Cost and Average Annual cost are slightly higher than the costs shown for Alternative 5A in Table 21. This is primarily attributable to a higher real estate costs than were assumed during completion of the CE/ICA analysis.

TABLE 24
RIO SALADO OESTE - RECOMMENDED PLAN
MCACES Cost Estimate (Billions, FY08 PL 51 Tasks)

		Alt 5A
Construction	$	66,343
Contingency (20%)	$	13,269
Subtotal	$	79,612
PED/EDC (11%)	$	8,757
Subtotal	$	88,369
S&A (6.5%)	$	5,744
Total Construction Cost	$	94,113
Real Estate (Including 25% Contingency)	$	55,900
Subtotal	$	150,013
Monitoring & Adapt. Mgmt.	$	3,765
Total First Cost	$	153,776
IDC	$	15,770
Gross Investment	$	169,547
Annualized Investment Cost	$	9,467
Associated Cost (Water Supply)	$	817
O&M	$	2,083
Total Annual Cost	**$**	**12,367**

Flood Damage Analysis

An assessment has been completed of residual flood damages in the Study Area under the Recommended Plan. One important factor in the with-project flood damage assessment is a key assumption relating to actions to be taken by the Local Sponsor. In 2003 the City of Phoenix purchased approximately 250 acres of riverbed between 35th and 51st Avenues. They have been working on a plan to lease the property for aggregate mining in a manner that allows aggregate to be removed while leaving a river cross section suitable for restoration. The likely alternative to have excess material removed from this reach and leave it in a state

suitable for restoration will include an active channel varying in width from 300-600 feet and at the approximate elevation of the existing thalweg. Adjacent to that channel will be 500 foot wide terraces. Approximate 5 million tons of river material will be removed for this to occur. Once permitting and lease agreement is completed the City will allow aggregate to be removed as specified.

As described in the Without-Project section of this report, the impact of the proposed aggregate mining on flood damages is significant. An analysis of the water surface profiles shows that water surface elevations with the proposed project are generally lower throughout the Study Area, resulting in the reduced potential for flood damages. However, because of the proposed mining in the 35th Avenue area, the water surface elevations in the reaches adjacent (Reaches 4-6) are especially reduced. These same reaches also happen to be those with the highest without-project damage potential. Since the water surface profiles incorporate both the gravel mining and restoration features, it is not possible to ascertain the reduction in flood damages attributable to each.

The following table shows the reduction in equivalent annual structure and content damages resulting from the Recommended Plan AND assumed aggregate mining.

Table 25
Rio Salado Oeste
With Project Flood Damage Analysis
Recommended Plan – All SA (in $1,000s)

Reach	W/O Project*	With Project	Reduction
1L	$ -		$ -
2L	$ 32	$ 22	$ 10
2R	$ -	$ -	$ -
3L	$ 2	$ 1	$ 1
4L	$ 2	$ 1	$ 1
4R	$ -	$ -	$ -
5L	$ 29	$ -	$ 29
5R	$ 143	$ -	$ 143
6L	$ 10	$ -	$ 10
6R	$ 4	$ -	$ 4
7L/7R	$ -	$ -	$ -
Total	$ 222	$ 24	$ 198

* Without Project does not reflect impact of aggregate mining.
Note – Includes Structure & Content Damages Only.

As shown above, the potential for flood damages is essentially eliminated under the with-project condition assumptions for reaches five and six, and are substantially reduced for the other reaches. A significant portion of the reduced damages is attributable to the assumed future aggregate mining operations, which is really a without-project assumption that is not reflected in the without-project damage estimate. Hence, most of the damages reduced, or benefits, can not be attributed to the features of the Recommended Plan. However, the Recommended Plan does generally result in reduced water surface elevations throughout the study area, as can be shown in Table 25 for Reach 2 (which is not impacted by the planned mining). Therefore, it can be stated that the Recommended Plan provides incidental flood damage reduction benefits, but the amount of these benefits is uncertain.

Before environmental restoration alternatives were finalized and the assumptions relating to proposed

aggregate mining were developed, potential single-purpose alternatives were formulated to reduce flood damages, primarily in Reaches 5 and 6. Alternatives analyzed included channel improvements, levees, floodwalls and relocation. The only economically viable alternative identified was constructing floodwalls to protect parcels owned by a single property owner. Because of Corps policies relating to single beneficiaries, it is unlikely that a Federally cost-sharable alternative could be identified. However, due to the subsequent analysis documented above showing that flooding related problems will essentially be eliminated in these reaches, there is no need for additional flood damage reduction measures anyway.

Recreation

Overview of Methodology

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 describe 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.

There are several techniques available for projecting visitation. These include regional and site-specific use estimating models, the similar project method, and the capacity method. Since it has been established that there is substantial unmet demand for recreation in the market area, the method which will be utilized to estimate visitation is the capacity method. The capacity method involves the estimation of annual recreation use based on instantaneous resource or facility capacities and expected daily, weekly and seasonal use patterns. As specified in *National Economic Development Procedures Manual - Recreation* (IWR Report 86-R-4, p. 13-14), *Because the capacity method does not involve the estimation of site-specific demand, its use is valid only when it has been otherwise determined that sufficient need exists in the market area of the proposed project to accommodate the project's calculated capacity...The capacity method has its greatest potential for use in urban settings when it is immediately obvious that sufficient need exists for the opportunities that the proposed project could provide.*

Unit day values have been calculated by assigning points to each activity (based upon Federal guidelines) and then converting total points to dollar recreation values (per Economics Guidance Memorandum 06-03 conversion table). Point values are derived by ranking the potential recreation resource according to five different criteria:

TABLE 26
Unit Day Point Values

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 2006) can range from $3.19 to $9.57 per recreation day.

Proposed Recreation Alternatives

The City of Phoenix has developed a Recreation Plan. A copy of the analysis conducted by the City is included in the Recreation Appendix of the Feasibility Report. Please refer to this document for a detailed description of the proposed recreation plan. The plan's goal is to provide opportunities for visitors of all ages from varied backgrounds to enjoy the environmental resource created by the restoration project while developing an awareness, knowledge and understanding of desert riparian habitats and its interrelatedness to the environment as a whole.

Major project features include parking lots, information kiosks, overlooks, shade structures, bridges, multi-use trails, restrooms, signage and landscaping. Recreation activities provided by the plan include: walking, hiking, biking, horseback riding, roller blading, picnicking and birding. Scenic overlooks will be included for the enjoyment of the restored desert riparian habitat. Information kiosks 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.

Benefit Analysis

Visitation Projections

Visitation at the resource will be limited based upon the available parking in the area. Phoenix's design includes several parking lots with a total of 500 spaces. Visitation data maintained by the City for other recreation sites indicates an average number of visitors per vehicle of 2.75. In addition, it is estimated that ten percent of visitors arrive to the site by an alternative mode of transportation, e.g., bicycle, foot traffic and public transportation.

Annual visitation has been estimated for both winter (October - May) and summer (June - September) seasons. In addition, visitation has also been broken down by prime time (weekends and holidays) and non-prime time (weekdays). The following summarizes the results:

Table 27
Rio Salado Oeste
Recreation Plan
Baseline Visitation Estimate

	Days	Turnover/Day	Visits*
Winter (Oct-May)	243		
Prime Time	78	1.50	160,875
Non-Prime Time	165	0.50	113,438
Winter Total			274,313
Summer (Jun-Sep)	122		
Prime Time	36	1.00	49,500
Non-Prime Time	86	0.25	29,563
Summer Total			79,063
Grand Total (By Vehicle)			353,375
Add - Arrive by Alternative Mode (10%)			35,338
Total Visitation			388,713
Less Transfers (10%)			38,871
Baseline Visitation for Benefit Analysis (Rounded)			350,000

* Note - Based Upon Parking Capacity of 500 Spaces & Avg. of 2.75 Persons/Vehicle

Transfers are expected to be minimal due to the unique recreation opportunities and setting offered at the restoration site. The City expects the primary transfers to be in the categories of education field trips, bird watchers, passive nature watchers, canal joggers and recreational cyclists. Annual transfers were estimated at ten percent of total visitation. Excluding transfers, annual visitation is estimated at 350,000.

The above visitation projections were also compared to standards established by the National Recreation & Parks Association (NRPA), regarding trail usage and capacity. 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 proposed recreation plan includes approximately 16 miles of multipurpose trails. With baseline visitation projected at 350,000, this equates with a value of about 21,875 users per year per trail mile, which supports that the proposed facilities should be able to accommodate the projected visitation. Further, the proposed facilities should also be able to support likely increases in visitation over time, as the general population growth in the Study Area will inevitably increase demand and use of the facilities.

Unit Day Point Value Estimates

A panel of Phoenix Parks, Recreation and Library department personnel including Park Managers, Recreation Supervisors, Recreation Coordinators, and Landscape Architects reviewed the recreation plan in light of its location within the planned environmental restoration study area and derived the point values for the Unit Day Value analysis. Point values were revisited in accordance with comments received from HQUSACE on the Draft Report. The following are the revised point values.

Criteria	Range of Point Values	Assigned Value

Recreation Experience	0-30	24
Availability of Opportunity	0-18	8
Carrying Capacity	0-14	14
Accessibility	0-18	18
Environmental	0-20	12
Total	0-100	76

Recreation experience was rated very high, although most recreation activities could be described as general recreation. This is because of the context within which the recreation takes place. There are very few recreation sites in the market area located in a riparian and wetland environmental setting. This enhances the value of these activities. Items that would be considered high value would include bird watching, urban fishing, wildlife viewing and environmental education opportunities. The assessment of what is considered high-value is study area dependent. EGM 06-03 specifies that this determination is based upon whether such activities are uncommon to the region. Even accounting for recreation activities provided by, or to eventually be provided by the Rio Salado and Tres Rios projects, the recreation experience provided by Rio Salado Oeste will be uncommon to the regional market area, and it could therefore be argued that even the other more general activities could be considered high value in this context. The criteria for a point range of 17 to 23 for this category is more than one high value activity, whereas the criteria for the point range of 24 to 30 is numerous high value activities. The number and type of activities, including high-value activities, justifies a point value in the highest range. However, there are not "numerous" high value activities. In light of these considerations, a revised point value for this category of 24 out of 30 was selected.

The point value assigned for the availability of opportunity considered that this project, along with the Rio Salado and Tres Rios projects, although separately evaluated, will be linked together to provide a more comprehensive recreation opportunity to the region. Accordingly, the assessment of the availability was based upon other similar recreation outside of this Salt River recreation corridor. There are no local parks that offer a similar recreation experience to the proposed recreation plan, and therefore, even if considering Rio Salado and Tres Rios, this would only represent two similar facilities. The point value range for several facilities within one hour is 4 to 6, whereas the range for one or two within one hour is 7-10. Giving consideration to the opportunities provided by Rio Salado and Tres Rios, a revised point value for this category of 8 out of 18 was selected.

The project's parking and road access will be designed to maximize recreational values. The plan includes 500 parking spaces, and is located in an urban area with easy accessibility to major highways and thoroughfares. Visitation is anticipated from personal motorized vehicles, as well as via bicycles and public transportation. Accordingly, the top point rating was assigned for carrying capacity and accessibility. Please refer to the City's recreation analysis for additional details.

For the environmental point value assessment, the major items to consider include geology, topography, water and vegetation. The point values assessed focused on the recreation site itself, and not on surrounding urban areas. Within the project site, due to the environmental restoration focus of the project, it is assumed that the area will in fact have excellent esthetic qualities. Although some commercial and industrial areas are adjacent to the project area, the esthetics of these areas are anticipated to improve due to urban renewal efforts along the overall Rio Salado area. Overall, a very high esthetic quality is justified, and in consideration of the scarcity of this type of environment in the region, it could be argued that the quality would be considered outstanding. However, in consideration of areas surrounding the project area and issues cited above, an environmental value of 12 was applied.

EGM 06-03 provides ranges for point value to dollar value conversion. The dollar value corresponding with a point value of 76 is $8.254. This point value was applied to projected annual visitation to derive the annual value of the recreation resource. The resulting annual recreation value totals $2,889,000.

Recreation Costs & Benefit/Cost Analysis

Table 28, which follows, details the cost estimates for the proposed recreation plan.

Table 28
Rio Salado Oeste
Recreation Plan
Expected Annual Costs

First Cost		
Site Preparation	$	925,000
Parking Lots (500 Spaces)	$	750,000
Entry Roads	$	600,000
Sidewalks & Ramps	$	240,000
Multi-Use Trails	$	282,000
Bridges & Culverts	$	75,000
Access Control	$	875,500
Security Lighting	$	400,000
Signage	$	166,000
Picnic/Trail Shelters	$	1,205,000
Restroom Facilities	$	1,250,000
Utilities	$	840,000
Park Furniture	$	155,500
Interpretive Guidance Media	$	112,500
Subtotal - Construction	$	7,876,500
Contingency (20%)	$	1,575,300
Subtotal	$	9,451,800
PED/EDC (11%)	$	1,039,698
Subtotal	$	10,491,498
S&A (6.5%)	$	681,947
Total First Cost	**$**	**11,173,445**
Interest During Construction	$	573,000
Gross Investment	**$**	**11,746,445**
Annualized Investment Cost	$	655,900
OMRR&R	$	800,000
Total Annual Cost	**$**	**1,455,900**

Average annual benefits have been estimated at $2,889,000, and average annual costs are estimated at about $1,456,000. Therefore, the proposed recreation plan is economically justified, with net benefits of $1,433,000 and a benefit/cost ratio of 1.98.

US Army Corps of Engineers
Los Angeles District

Rio Salado Oeste
Maricopa County, Arizona
Feasibility Report

Appendix H

Real Estate Plan

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
LOS ANGELES, CALIFORNIA 90053-2325

NARRATIVE SUMMARY

1. Project Location:

Rio Salado Oeste translates into Salt River- West. The Area is located within Maricopa County, Arizona and consists of an 8-mile reach of the Salt River. This project lies immediately between the Rio Salado and the Tres Rios environmental restoration projects, both authorized and currently under construction and sponsored by the City of Phoenix. The Rio Salado study area extends from 19th avenue, the lower end of the Rio Salado project, to 83rd Avenue, the point of commencement for the Tres Rios Project. The entire area where environmental restoration features will be implemented is within the 100 year floodplain. Restoration of this reach of the Salt River will provide connectivity and a corridor of environmental restoration on the Salt River through the city. The project is also aimed at providing some measure of flood damage protection and a holistic approach to the hydraulic and riparian processes and functions of the Salt River.

2. Estimated Values:

A gross appraisal has been completed for the project. The total LERRD estimates which includes amounts for contingencies and incidental expenses is $55,900,000.

3. Easement Estate:

An easement for land owned by Maricopa County will be requested in accordance with ER 405-1-12, Chapter 12 paragraph 12-9 (e).

Appendix H: Draft Real Estate Plan
Rio Salado Oeste
Phoenix, Arizona
Feasibility Study

Abstract of Project Data:

Project Name: Rio Salado Oeste , Phoenix, Arizona

Location: City of Phoenix , Arizona

Project Purpose: Environmental Restoration

Acreage: Lands Required for Environmental Restoration (Alt. 5A) 1,500 Total Acres;

Project Sponsor: City of Phoenix.

1. Purpose of this Report:

The purpose of this Real Estate Plan (REP) is to support the Feasibility Study decision document in the process of preparing a complete Feasibility Report, and a Chief's Report to Congress and ultimately an approved new project start in subsequent WRDA authorization.

2. Environmental Restoration Purposes and Related Project Features.

The Rio Salado Oeste, (Salt River -West) Study is being performed to investigate water resources related issues and ecosystem restoration opportunities on this reach of the Salt River.

The Salt River has experienced large-scale channel and environmental degradation over the last century. The construction of upstream dam and reservoirs for irrigation and reclamation coupled with the impacts of urbanization have resulted in the loss of critical riparian habitat and overall ecosystem degradation on the Salt River basin. Prior to development and urbanization in the Phoenix area, the Salt River flowed as a major perennial river, fed by the snowmelt and watersheds of the lands upon the Mogollan Rim and northeastern Arizona. In the early 1900's the construction of irrigation dams on the Salt River diverted water for agricultural and urban uses. Urbanization and development along the Salt River corridor further changed the natural river system. The habitat became severely degraded and disrupted due to these sudden changes. In conjunction, the basin experienced reduced flows, both in terms of surface flows surviving into the Phoenix reach and in the depth and availability of groundwater needed to support a riparian community. Today only isolated fragments of a once healthy riparian system, once capable of sustaining the Hohokam and Pima cultures, remain.

All of the acreage to be acquired for this project will be allocated to the project purpose of environmental restoration and credited accordingly for cost sharing purposes. There are no separable recreation lands and no separate recreation component. Any

recreational use described in the report falls under the heading of incidental recreation use.

The project footprint has been determined through the application of sound real estate principles including blocking out along regular and definable boundaries; minimizing severance; and maintaining usable and economic remainders. The project footprint is the minimal area needed to accommodate the construction, operation, maintenance, repair and replacement of the proposed project and will be the area potentially credited toward the project.

Restoration features of the selected alternative include grading and terracing the river channel to form a more natural channel state from 19th Avenue to 83rd Avenue. The project will also include water detention and retention measures to contain water and hold it in the river system to sustain riparian vegetation and communities. Along the project area there will be various associations and plantings of cottonwood/willow communities as well as mesquite bosques and wetland and riparian cover types. Irrigation systems will be developed. The selected alternative also includes the control of invasive species such as Salt Cedar.

Major Land Owners/Classes

The following present the major land uses and categorizes of ownership of the 1500 acres to be acquired within the project footprint of the project.

Landowner/Class	**Type of Land**	**Acreage**
City of Phoenix	Riverbed/Open Space	410
Maricopa County	Bridge rights of way/floodplain	110
State of Arizona	River bed/Open Space	65
Sand and Gravel	Materials Extraction	690
BLM- (City has Existing Lease)	River bottom	160
Other Private	Various	65
Total		1500

*acres have been rounded and are approximate

3. Description of Lands owned by Non-Federal Sponsor – City of Phoenix.

The City owns approximately 400 acres. In addition the City has an indefinite Lease on BLM lands on another 160 acres. The City manages operates and maintains the land under the lease, including all expenses for operation and maintenance responsibilities. It is recommended that the city perfect its lease to obtain a Recreation and Public Purposes Patent, thus acquiring the land in fee simple title. This parcel includes 160 acres of project land situated within the river corridor and floodplain. The acquisition of

this BLM land through a Recreation and Public Purposes Patent is perfectly feasible and achievable by the City of Phoenix. The City of Tempe obtained such a Patent for its Town Lake Project on the Salt River. The United States Patent conveys full "fee simple title" to the land.

The comprehensive plan would contemplate that privately held lands within the river corridor be acquired to support a public use and managed for their natural amenities and open space attributes that are important to the quality of life.

The land within the study area includes a number of privately owned parcels. Other parcels are owned by the State of Arizona and Maricopa County. The City of Phoenix is also acquiring some of this private land as opportunities arise in an ongoing effort at regenerating this urban corridor for public use. The City is acquiring this land independently of the proposed Rio Salado Oeste Project and Feasibility Study. By letter dated June 22, 2005, the City was provided with a written notice concerning the acquisition of lands in advance of project authorization.

Based upon the City of Phoenix General Plan (dated February 2001) most of the land adjacent to the project that is usable and developable and situated on the north side of the river corridor between 19th avenue and 59th Avenue is zoned industrial with some residential use predominately between 43rd avenue and 60th avenue. Westward of 60th avenue to 83rd avenue, the land outside of the 100-year floodplain and beyond the floodplain is zoned residential. The majority of the land on the south side of the Salt River is characterized by residential zoning. *The BLM (Federal Government) owns one parcel near 67th Avenue.*

Within the 100-year floodplain, where the environmental restoration features will be located, the land ownership includes private owners, sand and gravel operators, the State of Arizona, Maricopa County and the City of Phoenix. Because the land is within the river corridor and within the floodplain, there is a high degree of public agency ownership of the river basin and corridor.

4. Non- Standard Estates:

Approval of non-standard easement estate for land owned by Maricopa County will be requested in accordance with ER 405-1-12 Chapter 12-9 (e).

5. Existing Federal Project:

There is no existing Federal or local cooperation project within this study area.

6. Federal Lands, Interests or Reservations:

There is one parcel of BLM land in the vicinity 67th Avenue containing 160 acres of land. This parcel is situated within the confines of the river and within the floodplain influence. The City has an indefinite Lease for Recreation and Public Purposes. It is recommended that the City acquire a Recreation and Public Purposes Patent, thus acquiring fee ownership of this parcel.

If the City does not obtain its Recreation and Public Purposes Patent from BLM, the City of Phoenix may require the assistance of the Corps of Engineers in acquiring this parcel. These determinations will be made subsequently in the PED phase and prior to PCA signing and project construction. If the sponsors lack authority or cannot acquire Federal owned land for procedural or other reasons, it is recommended that the sponsor enlist the assistance of the Corps in acquiring the land on its behalf. All acquisition expenses, including payments for appraised value or just compensation would be a Non-Federal Sponsor cost. Acquisition on behalf on the Non-Federal sponsor, if necessary, would be a by a separate reimbursable agreement.

7. Navigation Servitude:

The Salt River is not navigable; therefore navigation servitude is not being invoked for this project.

8. Project Maps:

The Project Real Estate Map is provided with this Real Estate Appendix as Figure -1. Additional maps are included in the Main Report and may be located in the Table of Contents and List of Figures.

9. Construction or Project Induced Flooding:

Appropriate measures will be taken for the care and diversion of water, if any, during construction. There will be no construction induced or project induced flooding on lands. The appropriate hydraulic and hydrologic studies and assessments have been performed to avoid any induced flooding as a result of the project or its features.

10. Baseline Cost Estimate:

A gross appraisal of the Lands, Easements, Rights-of-ways, Relocations and Disposal Areas (LERRDS) has been obtained. Including administrative incidentals and estimated contingencies, the project LERRD estimate is $55,900,000. This figure is reflected in the project cost summaries submitted with the main report.

11. Crediting for LERRD's:

Crediting will follow standard procedures as set out in a model Project Cooperation Agreement (PCA). No Credit will be afforded to any lands or interests previously acquired and credited for any applicable Corps of Engineers Project.

Credit will only be applied to the acreage within the "project footprint", namely the lands or corridor required for the Recommended Plan of improvements to be included in the Federal/Local Sponsor environmental restoration plan. Lands outside of the project requirements and lands that may be acquired for the sponsor's own purposes would not be creditable LERRD's.

Corps policy prescribes that credit will <u>not</u> be afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible. This might apply, for example, to lands acquired with funding from Department of the Interior agencies such as Fish and Wildlife Lands purchased with Federal funds.

12. Mineral Activity:

Sand and gravel extraction activities are present within the study area. If at the time of valuation and acquisition of specific parcels, these activates are still present on lands to be acquired for the project, the appropriate valuation and highest and best use determinations will be applied as to any sand and gravel operations. It is contemplated that sand and gravel extraction will be diminishing and allowed to "play out" prior to the time that project implementation actually proceeds. Since this project is in the planning stages (contingent on future WRDA authorization), project construction may be several years in the future. At the time of this writing it is thought that a WRDA Authorization for the Rio Salado Oeste Project may occur in 2008, perhaps later, and that actual physical construction is not anticipated until 2010.

As has been the practice on the Tres Rios and Rio Salado projects, the in place value of any merchantable sand and gravel and "common variety materials" has been incorporated into the valuation of river bottom lands where such materials exist and where it has been found appropriate by the appraiser to include in the lands' valuation. This has been fully considered when developing a gross appraisal and "LERRD" estimate.

There is no timber activity in this xeric /riparian environment of the desert southwest.

13. Sponsor's Capability Assessment.

The non-federal sponsor is a duly organized municipal organization 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. The sponsor has previously participated in other Corps of Engineers' Local Cooperation Projects such as the Rio Salado and Tres Rios projects. Both of these are similar large scale environmental restoration efforts. The City of Phoenix has demonstrated its capabilities in acquiring real estate and performing the related obligations of a Non-Federal Sponsor. A capability assessment has been completed and shows the City of Phoenix is highly capable of undertaking this project and fulfilling the responsibilities of a Non-federal Sponsor.

14. Estates:

The recommended standard estate for environmental restoration projects is fee simple title. However, in accordance with ER 405-1-12 Chapter 12 paragraph 9, a permanent easement estate is recommended for use on this project for lands owned by Maricopa County.

15. LERRD Acquisition Schedule.

The sponsor has already to begun to acquire some lands, based on a possible WRDA authorization. It is thought that project construction might not commence until Fiscal 2010. The City already owns approximately 25% of the lands in the overall project area. The City thus would have at least 30 months and possibly more to acquire the LERRDS before the first construction contract was let. Based on the City of Phoenix record with the Tres Rios project this is well within its capabilities. It is anticipated that the project

will be constructed in phases as available construction funding is appropriated. *For example*, the project may be divided into separate reaches or phases, e.g.

19th to 35th Avenues 2 miles
35th to 51st Avenues 2 miles
51st to 67th Avenues 2 miles
67th to 83rd Avenues 2 miles

There are approximately 20 -25 parcels in each of these reaches. By proceeding to develop the total project in separate phases and construction contracts, the City of Phoenix should have no difficulty in acquiring the LERRDS for each of these phases. A more detailed land acquisition schedule would be developed following WRDA authorization, and during the PED phase, and during the time to negotiate and approve the PCA for implementation. The exact project phasing would be developed in concert with the Sponsor and based on funding capabilities. The dictates of Federal funding would be more influential on the project schedule than the capability to acquire right-of-way (LERRDS) in a phased implementation approach. Project phasing would be developed after WRDA approval during PED and development of a PCA in close coordination with the Non Federal Sponsor by the Project Delivery Team, and is anticipated to closely follow the dictates and availability of Federal funding for construction.

16. Facility Relocations:

To date the necessity for any facility relocations in the project area is not anticipated. Further engineering and design work will refine requirements for facility relocations during subsequent phases of the study and Pre-Construction Engineering and Design (PED), if a project is approved for implementation.

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. An Attorney's Opinion of Compensability will be generated for each facility/utility relocation that is required for the project which will be performed by, and credited to, the Non-Federal Sponsor under the definitions and terms of the PCA.*

Because the project is aimed at maximizing environmental restoration outputs in the river channel, it is contemplated that the physical relocation of utilities and pre-existing facilities will be avoided in formulation and design. This will enable the project to concentrate its funding and resources on environmental outputs rather than utility infrastructure. Physical relocation of existing utilities, particularly underground utilities, will be avoided as the outputs are realized by the resulting riparian habitat on the surface. A guiding principle of this project is that the surface habitat can be restored without disturbing or removing underground utilities.

17. Relocation Assistance (URA Relocations):

The City of Phoenix will accomplish all property acquisitions in accordance with Public Law 91-646, as amended, and the Uniform Regulations as promulgated by the U.S. Department of Transportation. The property within the project footprint is largely unimproved. It does not appear that any displacements of businesses or residences will be required due to the design and configuration of the project.

18. Attitude of Landowners; Other Matters

There is no focused or organized landowner opposition to the project. The sponsor will be conducting landowner and public information meetings to promote understanding of the project and how the landowners will be affected. The City has acquired lands upstream and downstream of the study reach for other Corps projects (Tres Rios and Rio Salado). The City has only had to condemn in isolated cases. The City has handled these projects successfully without causing any widespread landowner antipathy toward its land acquisition efforts.

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 take areas.

19. Hazardous Waste Assessments Known or Suspected Contaminants:

The sponsor fully understands its responsibilities for assessing the properties for any potential or presence of hazardous waste materials as defined and regulated under CERCLA. There are no known "Superfund" sites or sites presently under CERCLA remediation or response orders identified in the project area. There are no known presences of any substances in the project area that are regulated under CERCLA or other environmental statutes or regulations. Assessments and site investigations for the presence of such substances have not been conducted to date. The LERRD estimate is predicated on the assumption that all lands and properties are clean and require no remediation. The model PCA conditions contain specific terms and conditions governing the sponsor's responsibility for environmental cleanup for CERCLA regulated substances. Hazardous Waste Assessments are covered as a project cost under the model PCA.

20. Recreation:

There is no identified separable land (i.e., land acquired exclusively for recreation purposes for this project). All lands are allocated for the project purpose of environmental restoration. There are incidental recreation features included in the selected plan such as access points and interpretive and educational materials. These features do not require additional or separable project land.

21. Statement of Risks.

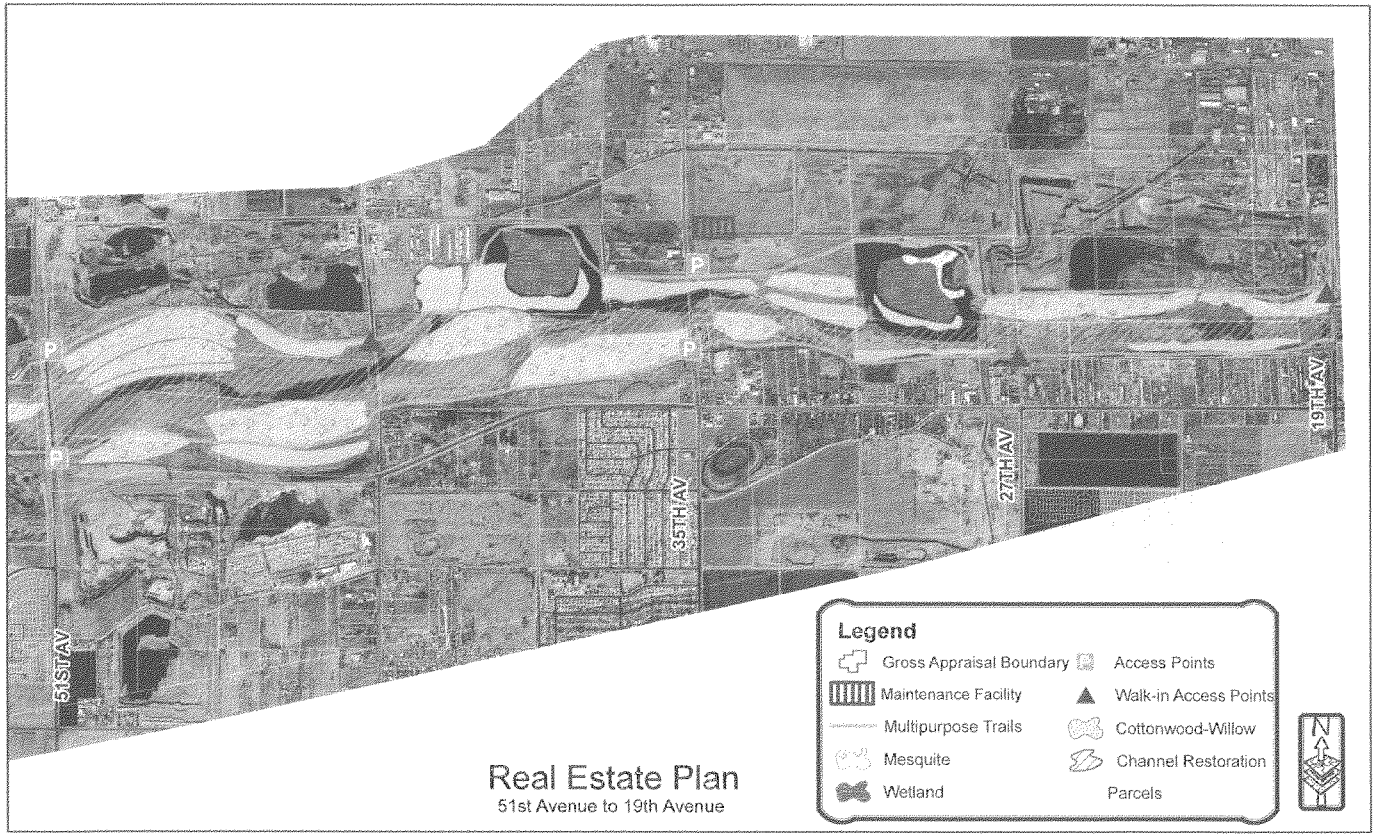
The sponsor has been notified in writing (June 22, 2005) about the attendant risks of acquiring land in the project area prior to Congressional authorization of a cost shared project. The City of Phoenix has participated with the Corps on two other large scale environmental restoration projects and is very much aware of the timelines and approval processes required to obtain a WRDA authorization.

22. Report Content:

This report follows the requirements of ER-405-1-12, Chapter 12 and was prepared using the information on the project formulation that has been provided. Comments received during internal Corps review have been incorporated.

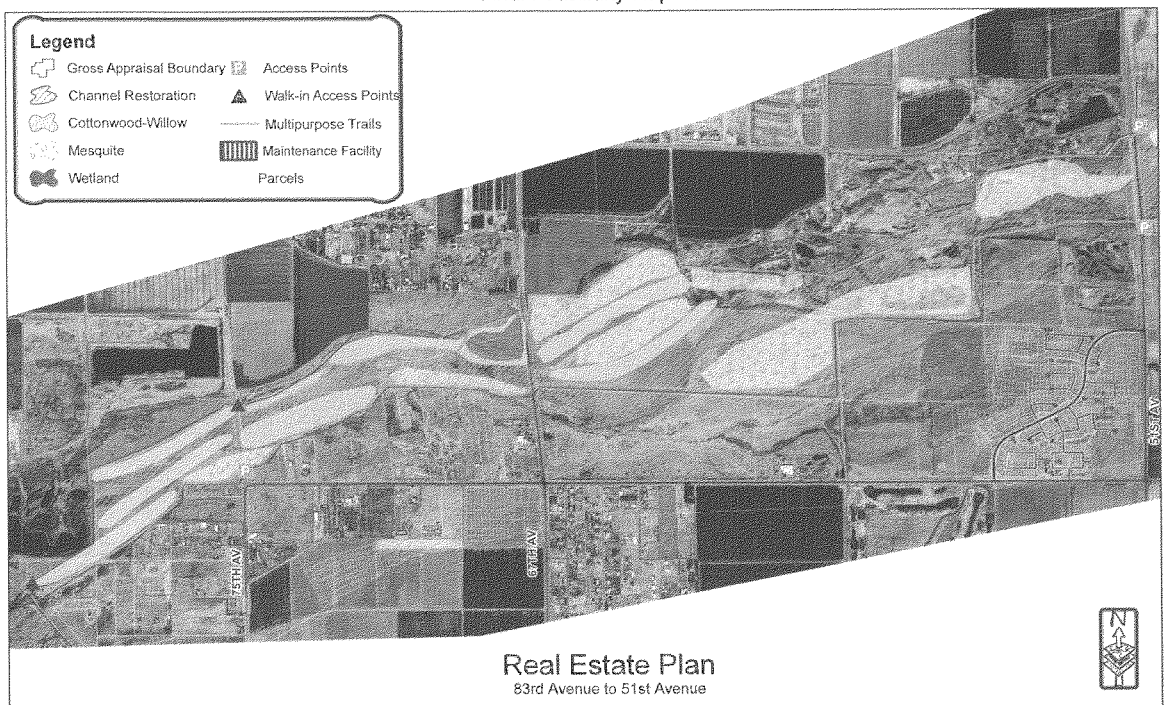
September 2006

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Real Estate Plan
51st Avenue to 19th Avenue

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Real Estate Plan
83rd Avenue to 51st Avenue

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Salt River-Phoenix, Arizona

Appendix I
Functional Assessment

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

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Introduction

The Rio Salado Oeste Ecosystem Restoration Feasibility Study is being conducted as a joint effort between the U.S. Army Corps of Engineers (USACE), Los Angeles District and the Non Federal Sponsor, the City of Phoenix (COP). The purpose of the study is to evaluate problems and opportunities related to ecosystem restoration, flood damage reduction and recreation. This analysis is meant to quantify ecosystem benefits and assist in the decision making process within the feasibility study.

This report contains the analysis, results, and documentation of the Rio Salado Oeste HGM assessment. An intensive Hydrogeomorphic Wetland Assessment (HGM) was undertaken to quantify benefits generated by proposed wetland ecosystem restoration alternatives for the Rio Salado Oeste, Phoenix, Arizona, Ecosystem Restoration Feasibility Study (Oeste). The Rio Salado Oeste study area lies within and along the Salt River between 19th and 83rd Avenues in Phoenix, Maricopa County, Arizona. The study area is approximately eight river miles in length and the 100 year floodplain is approximately 3,500 acres, of that 3,148 acres were mapped and evaluated in the functional assessment. The study area lies upstream of the Tres Rios Feasibility Study area, and downstream of the authorized Rio Salado project area. The non-federal sponsor for the feasibility phase of the study is the City of Phoenix.

The District requested the assistance of the U. S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC) to develop and evaluate a hydrogeomorphic wetland assessment (HGM)-based functional assessment methodology for use in Arizona restoration studies. Early in the evaluation process, an interagency Ecosystem Assessment Team (E-Team) was convened for the purpose of completing the field assessments. The E-team consisted of representatives from Planning Section C, the Los Angeles District technical sections, the U.S. Fish and Wildlife Service (USFWS), the Arizona Game and Fish Department (AZGFD), several environmental consulting firms, academia, and local and county governments. Each project team also included individuals responsible for project design and management. Together these individuals brought together the necessary technical expertise to support planning efforts requiring disciplines related to botany, soils, hydrology, hydraulics, geomorphology, and wildlife ecology.

Between 2002 and 2003, the E-Team completed intensive baseline habitat sampling activities at ten sites within the Gila River watershed. These sites consisted of the five feasibility study areas (including Rio Salado Oeste), and five "reference standard sites" for the calibration of the Functional Capacity Index (FCI) models. Based on the land uses present, the areas assessed were categorized into one of 19 cover types, or partial wetland assessment areas (PWAAs). Twenty-eight separate variables were measured for each PWAA in an attempt to develop a description of the baseline (2002) conditions at these sites. Ten FCI models were developed and used in the assessment to capture the functional capacity of the riparian habitats. These models focused on maintenance of characteristic channel dynamics, dynamic surface water storage and energy dissipation, long term surface water storage, dynamic subsurface water storage, nutrient cycling, removal and/or detention of imported elements, detention of particulates, maintenance of characteristic plant communities, maintain spatial structure of habitat, and the maintenance of corridors for interspersion and connectivity.

The specific, HGM-based functional assessment method resulting from these efforts is now known as the Arizona Riverine Assessment Tool (Functional Assessment Tool). The functional assessment was designed to evaluate the future changes in quantity (acres) and quality (functional capacity) of riverine, wetland and terrestrial riparian strand ecosystems. The model is described in its entirety in the following report, which is incorporated by reference.

Burks-Copes, K. A. and A. C. Webb. 2003. Tres Rios del Norte (Pima County, Arizona) Ecosystem Restoration Functional Assessment Using HGM: Analyses, Results and Documentation. Draft Report. U. S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS. 112 pp. + appendices.

Methods

The functional assessment tool utilized in this project is based upon a Habitat Evaluation Procedures-like approach to assessing the functional capacity of a wetland using standard wetland assessment protocols typically deployed in the regulatory arena (Smith et al. 1995). Referred to as the Hydrogeomorphic Approach or HGM, an assessment model is developed and serves as a simple representation of functions performed by a wetland ecosystem (Ainslie et al. 1999). The functional models developed in HGM define the relationships between one or more characteristics/processes of the wetland ecosystem (or surrounding landscape) and the functional capacity of a wetland ecosystem. Functional capacity is simply the ability of a wetland to perform a function as it compares to the level of performance in reference standard wetlands.

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 scores for each cover type. 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.

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.

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 or 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.

Applying Functional Assessment to the Rio Salado Oeste Study

Ten steps were completed in the assessment of Rio Salado Oeste's proposed ecosystem restoration designs using this functional assessment method. Briefly, they included:

1. Building a multi-disciplinary evaluation team (E-Team).
2. Defining the project.
3. Mapping the site's PWAAs.
4. The Arizona Riverine Functional Assessment Tool
5. Conducting field sampling.
6. Performing data management and statistical analyses.
7. Calculating baseline conditions.
8. Setting goals and objectives, and defining project life and Target Years (TYs).
9. Generating without-project conditions and calculating outputs.
10. Generating with-project conditions and calculating outputs.

Step 1: Ecosystem Evaluation Team (E-team)

In using functional assessment, an interagency, interdisciplinary team is formed to lead both the model selection/development phase of the project, and to establish the baseline and future conditions of the site(s). In this study scientists from the U. S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC) facilitated the model development and initial ecosystem evaluation efforts. The evaluation team also included members from the Los Angeles District, U.S. Fish and Wildlife Service (USFWS), the Arizona Game and Fish Department (AZGFD), several environmental consulting firms, and local and county agency personnel.

The multidisciplinary ecosystem evaluation team (E-Team) was convened early in June of 2002 to conduct without project assessments and again in 2004 to evaluate with project conditions. Members of the E-Team participating in the Rio Salado Oeste Feasibility Study are listed in Table 1. Note that due to the length of the study and staffing changes not all of those listed below participated in each portion of the evaluation.

Table 1 ***E-Team Members Participating in the Rio Salado Oeste Study***

NAME	ORGANIZATION/COMPANY	DISCIPLINE
Mr. Scott Estergard	USACE, Los Angeles District	Study Mgr/Biologist
Mr. Mike Fink	USACE, Los Angeles District	Biologist
Ms. Antisa Webb	ERDC-EL	Facilitator
Ms. Kelly Burks-Copes	ERDC-EL	Facilitator
Ms. Amy Lee	ERDC-EL	Ecologist
Ms. Karen Dada	City of Phoenix	Study Manager
Mr. Walt Kinsler	City of Phoenix	Landscape Architect
Mr. Mike Martinez	U.S. Fish and Wildlife Service	Biologist
Ms. Kathy Reichert	City of Phoenix	Parks and Recreation
Ms. Michele Waltz	Jones & Stokes	Project Manager
Mr. Bill Werner	Arizona Game & Fish	Ecologist
Ms. Karen Williams	City of Phoenix	Project Manager
Mr. Timothy Kennedy	USACE, Los Angeles District	Environmental Coordinator
Mr. Glenn Mashburn	USACE, Los Angeles District	Hydraulic Engineer
Mr. Michael Hrzic	USACE, Los Angeles District	Hydrologist/Hydraulic Engineer
Ms. Lois Goodman	USACE, Los Angeles District	Biologist

Step 2: Defining the Rio Salado Oeste Project

Geographic Location. The study area is located in the lower Sonoran Desert in the Salt River Watershed. The study area includes portions of the City of Phoenix, Maricopa County, and state and federal land. The study reach extends from the upstream limit of 19th Avenue down to the lower limit of 83rd Avenue – a distance of approximately eight miles. The downstream boundary of the study reach lies approximately 2.5 miles upstream of the confluence of the Salt and Gila Rivers. Figure 1 shows the location of the Rio Salado Oeste study area.

Hydrology and Geomorphology. Metropolitan Phoenix 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).

The Rio Salado Oeste study area lies within the lower Salt River valley near the center of the Gila River basin. The Salt River drains 14,500 square miles of mountainous terrain in central and eastern Arizona. By far, the largest tributary of the Salt River is the Verde River, which joins the Salt River approximately 30 miles upstream of 19th Avenue. The Salt River is the largest tributary to the Gila River. Annual average rainfall in the lower Salt River Valley is approximately 8 inches, while rainfall at the highest elevations of the watershed ranges up to 14 inches annually.

Within the study area, the Salt River flows through a major valley with a relatively flat floor of deep alluvium. Soils in the vicinity of the channel are well drained to excessively well drained on nearly level or gently sloping surfaces. They are often sandy to gravelly, but may include lenses of finer particles. These soils are often redistributed by water flows associated with nearby active channels.

Prior to the onset of European settlement, the Salt River was one of the few perennially watered riparian areas of the Sonoran Desert, supporting Native Americans, wildlife, and highly productive cottonwood, willow, and mesquite habitats. Flows in the river had a distinct seasonal pattern, with highest flows occurring in December and January and lowest flows in October. The river was a significant source of ground water recharge in some areas and a recipient of ground water discharge in other areas.

Beginning in the early 1900's, the historical conditions of the Salt River were altered by construction of dams on the Salt and Verde Rivers upstream of the study area. Due to dam construction, flow diversions and subsequent ground water withdrawal, perennial flows on the Salt River ceased. This 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, soil moisture in the riverbed was virtually eliminated, and the native cottonwoods, willows and riparian ecosystem rapidly died out. The river has been further impacted by construction of bridges and levees, and ongoing sand and gravel mining operations. Most areas of the Salt River are barren today. What little vegetation does exist is mostly limited to salt cedar, an exotic non-native species with little habitat value.

Soil moisture within close proximity to the surface (in the bed and banks of the channel) remains high in areas adjacent to wastewater treatment plant effluent discharges. However, this water is

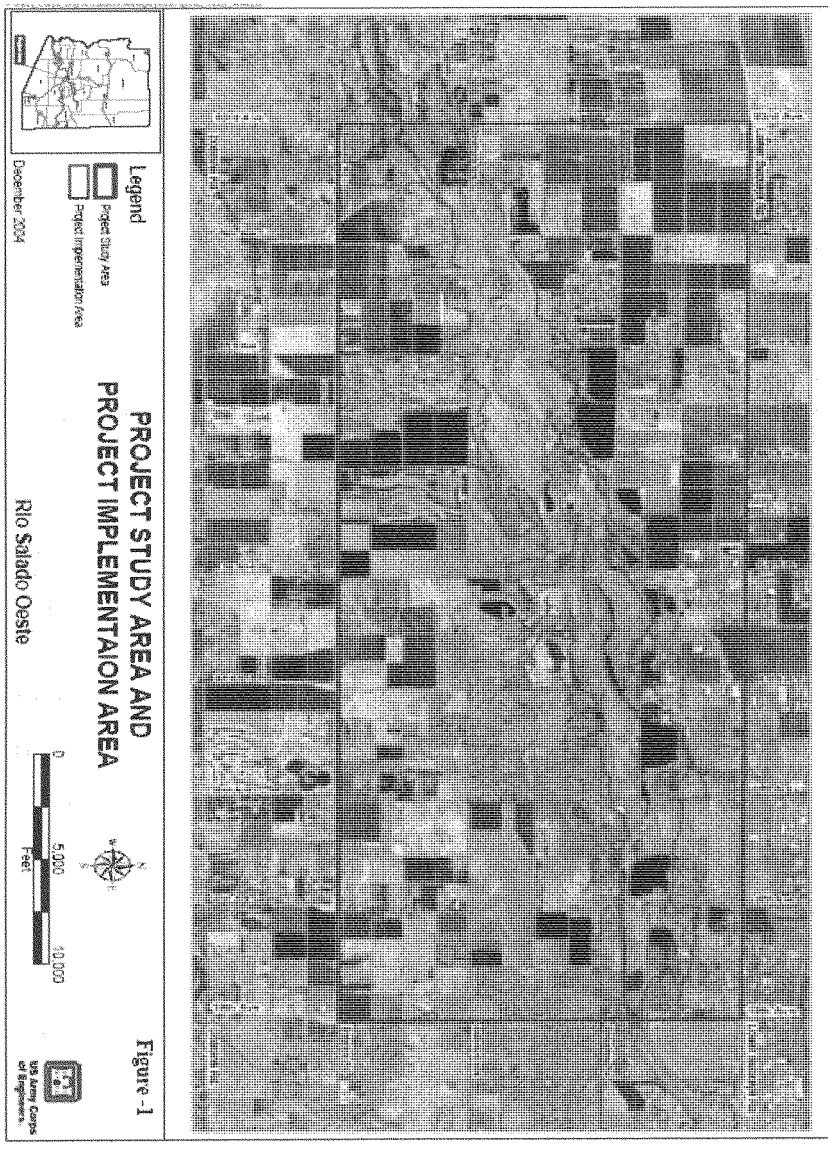

Figure 1Project Study Area

not available throughout the study area, nor is it available to support historical extent of riparian vegetation once associated with these reaches. Indeed, changes in water availability and extent have permanently impacted surface/groundwater interactions and sedimentation dynamics important in the sustenance and regeneration of riparian vegetation. While a significant portion of this effluent flow infiltrates into the bed of the channel, groundwater levels in the Rio Salado Oeste study area generally range from approximately 30 to 100 feet below the land surface. However, there is indication that there is shallow groundwater within 5 feet of the surface, most likely related to effluent discharges, in the eastern half of the study area. Those levels however, are not static and as stated above do not provide significant support of riparian vegetation.

As a direct results of the disconnection between surface and groundwater over the last century, the Salt River has changed from a braided and meandering streambed with a broad floodplain to a channel morphology shaped by sand and gravel mining, as well as uncharacteristic flood discharges that have scoured and incised the river.

Land Use Practices. Agriculture, urbanization and resource extraction have adversely affected the diversity and extent of the Salt River ecosystem. Historically, the perennial water source encouraged human settlement and agricultural practices that date back thousands of years. The Salt River also served as an important transportation route for Native Americans, missionaries, Spanish explorers, colonizers, miners, cattlemen, and settlers.

The water supply and hydropower benefits that the dams provided led to the economic development of the Phoenix metropolitan area. Phoenix grew from a settlement that supplied food and animal feed to the Army outposts and mines in the area to its current population of 3.2 million people. Agricultural land was rapidly being converted to urban uses to support this growth. Beginning in the late 1970s and early 1980s, sand and gravel mining operations were introduced. The demand for these construction and landscape materials is increasing along with the human population. Sand and gravel mining continues to this date along the Salt River within the study area. Today, the study area consists of a mixture of urban residential, commercial, industrial, agricultural, and open space land uses.

A rapid but declining rate of population growth is anticipated for the City of Phoenix and Maricopa County as a whole. Significant development of residential and non-residential land will be required to accommodate the projected growth. In the study area, existing land uses are primarily comprised of agriculture, industrial and low-density residential. It is anticipated that additional low-to-medium density residential development will take place due to the close proximity of the area to the city core. Existing vacant and agricultural land will likely be converted to residential uses.

Riparian Habitat. Like many rivers in the southwest, the Salt River once had a highly mobile channel that periodically changed location across a wide floodplain. Within this floodplain, the high water table supported extensive riparian forests of cottonwood, willow and mesquite. Subsurface flows and groundwater discharge supported biologically productive cienegas (seep marshlands). With the establishment and growth of the Phoenix metropolitan area, the Salt River has experienced severe and accelerated degradation and loss of riparian habitat. Upstream dams and increasing withdrawal of surface and groundwater flow (primarily attributed to a growing human population and agriculture) has changed the Salt River from a river with a highly available surface and subsurface flow to a primarily dry channel that flows only in response to

storm runoff. The lower Salt River within the study area has perennial flow only in association with wastewater discharges from the 23rd Avenue Wastewater treatment plant. As a result of the aforementioned hydrological alterations, stands of native riparian habitat are rare along the lower Salt River, particularly in the study area.

As land within the lower Salt River watershed has been converted to other uses, most of the biological resources and native habitat in the study area have been lost. Degradation of the river bottom, channel banks and adjacent overbank areas due to changing land uses has significantly impacted the once biologically rich and diverse habitat associated with the river. Biologically rich mesquite bosque habitats have largely disappeared. Sand and gravel extraction has removed large volumes of sediment, leaving open pits with very little resource value that function as sediment traps.

Project Evolution, Purpose, Ecosystem Approach. The study area is currently experiencing negative impacts due to the rapid shift of land uses within the watershed. Urban development has increased impervious cover, resulting in increased peaks and volumes of runoff entering tributaries and the Salt River itself. This has led to erosion of channel beds and banks and increased destruction of the vegetative resources. Conversion of open space has resulted in the loss of overbank storage during flood events. Where water once overflowed the banks of the river during floods, flood protection measures (meant to protect former floodplains) have caused increased volumes of flow to be held within the channel, necessitating bank protection and channelization. This in turn has led to accelerated loss of resources within the channel and in overbank areas. Urban development has also brought increased population pressure to the study area. The increased human presence has resulted in soil compaction, increased damage to the environment due to vehicle usage, and the introduction of large amounts of litter and debris. Demographic projections indicate a continued high rate of development in the study area over the 50-year planning horizon. This trend suggests that development of the floodplain and subsequent channelization and loss of associated resources would be the likely outcome in the absence of measures taken to restore and set aside both the land and its associated habitats. If restoration efforts are delayed, the land needed for effective projects may no longer be available.

Step 3: Mapping Partial Wetland Assessment Areas

To effectively evaluate the existing conditions, the study area was divided into manageable sections and quantified in terms of acres. This process, referred to as partial wetland assessment area (PWAA) mapping or "cover typing", required differentiation between vegetative covers (e.g., mesquite wetlands, shrub lands, open water, and river bottom streams, etc.), hydrology and soils characteristics, and clearly delineate these distinctions on a map. The final classification system, based primarily upon dominant vegetation cover, captured "natural" settings and common land-use practices in a specific and orderly fashion that accommodated the plan formulation process.

Cover types (PWAA) utilized in the model are listed and described in Table 2 below. Quantities of each, existing in the study area, are detailed later in this report.

Table 2 ***Cover Types Identified for the Arizona Riverine Functional Assessment Tool***

NO.	CODE	DESCRIPTION
1	AGCROP	Farms and Croplands - Dairy, Cotton, and Alfalfa
2	CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel
3	DESERT	Desert Areas – Bare Earth, Cacti, Rabbitbush, Acacia, Ironwood, Palo Verde
4	DITCHES	Existing Ditches
5	DRY RIVER BOTTOM	Existing Dry River Bottom Areas in the Active Channel - Largely Unvegetated
6	MESQUITE	Existing Mesquite Woodlands – on the Terraces and in the Active Channel, can and often does contain Palo Verde, Ironwood and Acacia within these woodlands.
7	NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel
8	NEWDRYRVRBOTTOM	Newly Developed Dry River Bottom Areas in the Active Channel - Largely Unvegetated
9	NEWMESQUIT	Newly Planted Mesquite Woodlands - on the Terraces and in the Active Channel, can and often does contain Palo Verde, Ironwood and Acacia within these woodlands.
10	NEWOPENWAT	Newly Developed Open Water Areas in the Active Channel
11	NEWSCRUB	Newly Planted Scrub – Shrub-lands in the Active Channel
12	NEWWETRVRBOTTOM	Newly Developed Wetted River Bottom Areas in the Active Channel – Primarily Emergent Vegetation
13	OPENWATER	Existing Open Water Areas in the Active Channel - Inactive Sand and Gravel Operations
14	PARKS	Parks and Recreation Areas
15	SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel
16	SCRUBSHRUB	Existing Scrub - Shrublands in the Active Channel – Rabbitbush, Quailbush, , and Saltbush
17	SOILCEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel
18	URBAN	Existing Residential, Industrial and Transportation Avenues
19	WETRVRBOTTOM	Existing Wetted River Bottom Areas in the Active Channel - Primarily Emergent Vegetation

Step 4: The Arizona Riverine Functional Assessment Tool

The final version of the model contains 10 discrete functions. It is important to note that the functions described here were selected on the basis of their representation of ongoing critical ecosystem processes within the wetland subclass. These functions, and the reasons supporting their inclusion in the characterization of arid riverine wetlands for the region, can be found in Table 3 below.

Table 3 ***Functions in the Arizona Riverine Functional Assessment Tool***

CODE	NAME	DESCRIPTION
CHANNELDYN	Function 1: Maintenance of Characteristic Channel Dynamics	Physical processes and structural attributes that maintain characteristic channel dynamics. These include flow characteristics, bedload, in-channel coarse woody debris, and potential coarse woody debris inputs, channel dimensions, and other physical features (e.g. bank vegetation, slope).
WATSTORENR	Function 2: Dynamic Surface Water Storage/Energy Dissipation	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.
WATSTORLNG	Function 3: Long Term Surface Water Storage	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.
WATSTORSUB	Function 4: Dynamic Subsurface Water Storage	Availability of water storage beneath the wetland surface. Storage capacity becomes available due to periodic drawdown of water table.
NUTRIENT	Function 5: Nutrient Cycling	Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.
ELEMENTS	Function 6: Detention of Imported Elements and Compounds	The detention of imported nutrients, contaminants, and other elements or compounds.
DETPARTICL	Function 7: Detention of Particles	Deposition and detention of inorganic and organic particulates (>0.45 um) from the water column, primarily through physical processes.
PLANTS	Function 8: Maintain Characteristic Plant Communities	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 TVVs, shrubs, seedlings, saplings, and herbs and by the physical characteristics of the vegetation.
HABSTRUCT	Function 9: Maintain Spatial Structure of Habitat	The capacity of a wetland to support animal populations and guilds by providing heterogeneous habitats.
INTERSPERS	Function 10: Maintain Interspersion and Connectivity	The capacity of the wetland to permit aquatic organisms to enter and leave the wetland via permanent of 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.

The first four functions (Channel Dynamics, Surface Water Storage, Long Term Surface Water Storage and Subsurface Water Storage) comprise the hydrologic components of the functional assessment model. The next three functions (Nutrient Cycling, Elements and Compound Importation, and Particulate Detention) are the biogeochemical components of the functional assessment model. The last three functions (Plants, Habitat and Insterspersion/Connectivity) together complete the biological components of the functional assessment model.

Variables Associated with the Arizona Riverine Functional Assessment Model. Within each function of the model, a series of variables have been defined, and are used to relate the value of the wetland to the reference standard condition. Of the 25 variables developed, 14 could be measured in the field using simple sampling protocols. The remaining 11 variables were obtained through searches of historical records and Geographic Information System (GIS) database exercises. Refer to Step 5: Field Sampling for the Rio Salado Oeste study below to review the overall field sampling process and data gathering methods used for the study in greater detail.

Table 4 ***Variable names and descriptions used in the 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.
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 Formulas in the Arizona Riverine HGM Model. Once the E-Team participants had addressed the critical components (e.g., variables) that capture the essence of wetland functionality for the model, they set out to combine these variables in a mathematical model. Each variable was weighted in terms of "importance" in characterizing the function, and standard mathematical logic was used to generate the formulas. Below, the functions are provided with their associated variable combinations.

Hydrology Functions

Function 1: Maintenance of Characteristic Channel Dynamics

$(V_Q + V_{FPA} + V_{SED})/3$

Function 2: Dynamic Surface Water Storage/Energy Dissipation

$(V_{FREQ}*(V_{FPA}+((V_{TOPO}+V_{TVV}+V_{CWD})/3)/2))^{1/2}$

Function 3: Long Term Surface Water Storage

$(((V_{TOPO}*V_{FREQ})^{1/2})*(((1 - V_{PORE})+V_{SUBIN})/2))^{1/2}$

Function 4: Dynamic Subsurface Water Storage

$(V_{DEPSATSED})$

Biogeochemistry Functions
Function 5: Nutrient Cycling

$((V_{TVV}+(3* V_{AGSA})/4)+((V_{DECAY}*((V_{LITTER}+ V_{FWD}+ V_{CWD})/3))^{1/2}))/2$

Function 6: Detention of Imported Elements and Compounds

$(((V_{FREQ}+V_{SURFIN}+V_{SUBIN})/3)+((V_{AGSA}+V_{LITTER}+(I-V_{PORE}))/3)+V_{TVV})/3$

Function 7: Detention of Particles
$((2*V_{FPA})+V_{TOPO}+((V_{CWD}+V_{FWD}+ V_{SED}+V_{TVV})/4))/4$

Habitat Functions

Function 8: Maintain Characteristic Plant Communities
Cottonwood-Willow and Mesquite Communities:

$(((((V_{SPECRICH}+V_{WIS}+V_{INVASIVES})/3)*((V_{CANHERB} + V_{CANSHRUB} + V_{CANTREE})/3))^{1/2})* V_{LANDBUFF})$
½

Scrub - Shrublands Communities:

$(((((V_{SPECRICH}+V_{WIS}+V_{INVASIVES})/3)*((V_{CANHERB} + V_{CANSHRUB})/2))^{1/2}) * V_{LANDBUFF})^{1/2}$

River Bottom Communities:

$(((((V_{SPECRICH} +V_{WIS}+V_{INVASIVES})/3)*(V_{CANHERB}))^{1/2}) * V_{LANDBUFF})^{1/2}$

Function 9: Maintain Spatial Structure of Habitat

$(((V_{VEGSTRATA} +((V_{CWD}+V_{FWD}+V_{LITTER})/3))/2) * V_{LANDBUFF})^{1/2}$

Function 10: Maintain Interspersion and Connectivity
$(((V_{FREQ}+ V_{TOPO}+ V_{CONTIG}+ V_{TRIB})/4) * V_{LANDBUFF})^{1/2}$

It is important to note that the E-Teams for the five feasibility studies adapted the original formulas provided by the workshop participants as planning constraints and data availability issues were encountered. It should also be noted that the E-Teams chose to tailor the formula for Function 8 to address functional capacity variations among cover types. Thus, the maintenance of characteristic plant communities in Scrub-Shrublands, Wet River Bottom Areas, and Dry River Bottom Areas did not include measures of tree canopy cover (or shrub canopy cover in the latter two cover types).

Reference Standards for the Arizona Riverine Functional Assessment Model. By definition, reference standard sites represent the highest level of functional capacity (highest, sustainable level of functioning) across the suite of functions performed by the regional wetland subclass (riverine overbank in this case). Because these wetland ecosystems exhibited a wide range of conditions as a result of natural processes and anthropogenic disturbance, and few undisturbed wetland ecosystems or landscapes were known to exist post-impoundment, the HGM approach established reference standards based on reference wetlands. Reference wetlands were actual wetland sites that represented the range of variability exhibited by regional wetlands as a result

of natural processes and anthropogenic disturbance. When the E-Team established reference standards for the five feasibility studies, the geographic area from which these reference wetlands were selected became the model's reference domain. For details regarding the Arizona Riverine Functional Assessment model reference domain and selection of reference wetlands, refer to Chapter 3 of Webb, Burks-Copes and Henderson 2003.

Step 5: Field Sampling for the Rio Salado Oeste Study

Basic site characterization and data collection are the first steps in inventorying an ecosystem restoration site (Fischenich 1999). Characterization for the subject study included gathering data on 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 was geographically-based and stored in a GIS database. As part of the basic site characterization, historical data on landscape-scale habitat conditions, land-use characteristics and ownership patterns was collected as well. Site- and landscape-level data were collected in the spring and fall of 2001. Historical data was obtained and reviewed during the winter of 2001. These datasets, in turn, were used to characterize the baseline conditions of the study area and the reference standard sites.

Several members of the E-Team participated in the field sampling efforts initiated in the early spring months of 2001. The 3-5 member field crews, facilitated by the ERDC, included members from 5 separate federal, state, and local agencies, as well as volunteers from the local community, and experts from nearby universities. For details regarding field sampling protocols, refer to Chapter 4 of Webb, Burks-Copes and Henderson 2003. The original field data is available in the Los Angeles District.

Step 6: Data Management and Statistical Analysis

Some limitations on the data collected during the functional assessment should be acknowledged. When data management problems arose, ERDC consulted with the E-Team prior to data handling, and solutions were devised with their knowledge and consent. This additional effort reduced the uncertainty in the findings, and allowed the E-Team to better delineate the wet and dry river bottom areas. Detailed notes and minutes were taken during these meetings to provide documentation for the assessment.

Step 7: Calculate Baseline Conditions

Once the baseline inventory was completed, the variable means/modes and the PWAA acreages were calculated, and the baseline conditions in terms of Functional Capacity Units (FCUs) were generated by multiplication. Strictly speaking, the means/mode values for each variable were applied to the Variable Subindex graphs (VSIs) as dictated by the model documentation (Webb, Burks-Copes, and Henderson, 2003). A new VSI graph was developed for each variable based on the reference standard and reference site findings. The means for each variable at the Rio Salado Oeste site were then "scored" on the VSI graphs – providing a comparison of the baseline conditions to that of reference. The basic mathematical premise is fairly straightforward and

easy to complete. For example, if the average percent of ground cover in the cottonwood-willow stands on-site was found to be 50 percent, the value "50" 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).

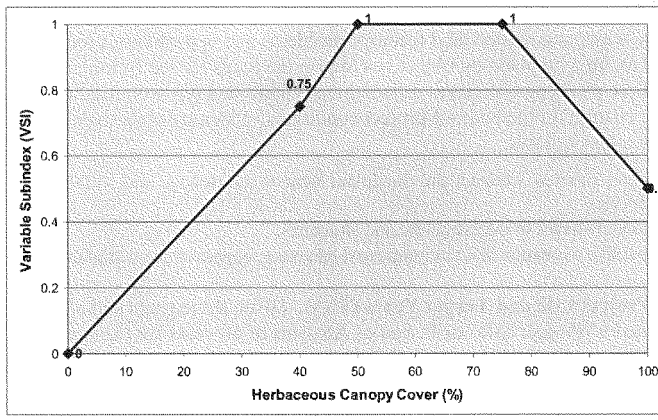

Figure 2 Example Variable Subindex (VSI) curve

The process was repeated for every variable in each PWAA for each of the 10 functional models. The individual VSI scores were entered into the FCI formula by PWAA, and individual cover type FCIs were generated. Each answer, referred to as the PWAA FCI, was then weighted by the relative area (RA)[1] of the PWAA, and combined with the answers from the remaining associated cover types in an additive fashion. The model's formula was considered to be the sum of the PWAA FCIs, arithmetically written as follows:

$$\text{FCI}_{\text{Subclass Model}} = \sum \left(\text{PWAA FCI} \times \text{RA}\right)_X$$

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 was to multiply the FCI result against the habitat acres (i.e., cover type acres associated with the model). The final results, referred to as FCUs, quantified the quality and quantity of the wetland conditions at the site for baseline. The details of this study's findings for baseline conditions are fully documented in Chapter 3 of this report.

[1] Relative Area: The relative area is a mathematical process used to "weight" the various applicable PWAAs on the basis of quantity. To derive the relative area of a model's PWAA for the study, the following equation was utilized: Relative Area = PWAA Area/Total Area where: PWAA Area = only those acres assigned to the PWAA of interest and Total Area = the sum of the acres utilized in the model

Step 8: Project Objectives, Project Life, and Target Years

In an attempt to generate quantifiable objectives for the study, the District set out specific ecosystem goals, and developed a series of performance measures to assess the success of the ecosystem restoration designs.

Project Objectives. The primary purpose of the Rio Salado Oeste feasibility study is ecosystem restoration. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without-project conditions. Planning objectives evaluated in this feasibility study are as follows:

- Restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish and wildlife species.
- Reduce flood damages to infrastructure and structures.
- Improve passive recreation and environmental education opportunities within the study area.

Selection of a Project Life and Target Years (TYs). Given these goals and objectives, the District designated a "Project Life" or Period of Analysis of 50 years for the study, and asked the E-Team to develop a series of TYs within this 50-year setting to guide the projections of both Without-Project and With-Project activities. Five TYs were defined by the E-Team:

1. TY = "0" refers to the baseline or existing condition.
2. TY = "1" refers to the first year of groundbreaking activities.
3. TY = "6" was chosen to capture 5 full years of vegetative growth under the proposed With-Project Conditions.
4. TY = "26" was selected to capture 25 full years of vegetative growth under the With-Project Conditions.
5. TY = "51" was chosen to capture 50 full years of vegetative growth under With-Project Conditions.

Step 9: Without-Project Conditions

To develop plans for a community or region, it becomes necessary to predict both the short-term and long-term future conditions of the environment. Forecasting, the process of developing these predictions, is undertaken to identify patterns in natural systems and human behavior, and to discover relationships among variables and systems, so that the timing, nature, and magnitude of change in future conditions can be estimated. Though many forecasting methods can be used in a standard assessment application such as functional assessment, 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, rate project performance, and determine many other important aspects of both Without- and With-Project conditions.

The Without-Project condition is universally regarded as a vital and important element of the evaluation. The future without-project condition is the same as the "no action" alternative, and describes what is expected to happen in the absence of federal or non-federal action. Under this alternative, the Corps of Engineers would take no action to provide ecosystem restoration within

the study area, nor to develop plans with potential incidental benefits associated with flood damage reduction, recreation, and water quality and supply. The no action alternative assumes the future will bring change, despite a lack of Corps participation. No single element is more critical to the planning process than the prediction of the most likely future conditions anticipated for the study area if no action is taken as a result of the study.

Most federal agencies use annualization as a means to display benefits and costs, and ecosystem restoration analyses should 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 that is referred to as the "period of analysis" and is defined as that period of time between a project becoming operational and the end of the analysis period as dictated by the 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, and/or other land-use impacts. Ecosystem restoration analyses incorporate these changes into their evaluations by using a "period of analysis" that includes pre-construction impacts. Functional Capacity Units (FCUs) are annualized by summing FCUs across all years in the period of analysis and dividing the total (cumulative FCU) by the number of years in the period of analysis. In this manner, pre-start changes can be considered in the analysis. The results of this calculation are referred to as Average Annual Functional Capacity Units (AAFCUs).

The assumptions that went into the projection of future conditions for the Rio Salado Oeste study area under the "No Action Alternative" are reported later in this report. Results, in terms of AAFCUs as well as expectations of change in terms of FCIs and acres for the study are fully documented therein.

Step 10: With-Project Scenarios

The E-team evaluated restoration alternatives and made assumptions pertaining to the outcomes and effects on each variable and function. From those assumptions and projections of future conditions the FCI and AAFCU's for each alternative were calculated and compared. Those results are reported later in this report.

Baseline Conditions

Baseline Acres

The study area comprises 3,148 acres (100 year floodplain) and is covered predominantly in scrub shrub (1,566 acres; 49.7%), sand and gravel operations (671 acres; 21.3%) and adjacent urban areas (327 acres; 10.4%). Although degraded, cottonwood willow and wetland areas do occur (142 acres), but comprise a minor portion of the study area. The majority of existing cover types have been degraded because of a lack of water or due to other anthropogenic activities. A complete listing of baseline cover types and their respective acreages is presented in Table 5.

Table 5 ***Baseline Acres and Cover Types for Rio Salado Oeste***

CODE	DESCRIPTION	BASELINE ACRES (TY 0)
AGCROP	Farms and Croplands in the Uplands – Dairy, Cotton, and Alfalfa	133
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112
DESERT	Desert or bare earth, Palo Verde, Ironwood, cacti	0
DITCHES	Ditches in the Uplands	3
DRY RIVER BOTTOM	Existing Dry River Bottom Areas in the Active Channel - Largely Unvegetated	66
MESQUITE	Existing Mesquite Woodlands - on the Terraces and in the Active Channel	0
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240
PARKS	Parks and Recreation Areas	0
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671
SCRUBSHRUB	Existing Scrub - Shrublands in the Active Channel - Rabbitbush, Quailbush, and Saltbush	1,566
SOIL CEMENT	Existing Soil Cement Areas on the Slopes of the Active Channel	0
WETRVRBOTTOM	Existing Wetted River Bottom Areas in the Active Channel - Primarily Emergent Vegetation	30
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327
TOTAL		3,148

Baseline Variable Values for Each Cover Type

Baseline field data was collected in the summer of 2002 to determine existing conditions for the site. Data for each variable per cover type (PWAA) was recorded, and the means/modes were calculated to generate baseline Functional Capacity Index (FCIs) per function in the functional assessment model. For detailed information regarding the field data collected by the Biological Team, please refer to Webb, A. C., K. A. Burks-Copes, and J. E. Henderson, 2003.

Baseline Functional Assessment Results

The results of the Rio Salado Oeste baseline functional assessment are summarized below. Functional capacity indices (FCIs) capture the quality of the acreage within the study area. Interpretations of these findings are generalized in Table 6. The FCI scores are multiplied by their respective PWAA acreages to determine the number of functional capacity units (i.e., FCUs). Both FCIs and FCUs are reported for each function included in the Functional Assessment Tool.

Table 6 ***Interpretation of FCI Scores Resulting From HGM Assessments***

FCI SCORE	INTERPRETATION
0.0	Non-functional – the wetland or PWAA does not perform to a measurable level and will not recover through natural processes
Above 0.0 to 0.19	Extremely low or very poor functional capacity - the wetland or PWAA's functional capacity can be measured, but it cannot be recovered through natural processes
0.2 to 0.29	Low or poorly functioning
0.3 to 0.39	Fair to moderately low functional capacity
0.4 to 0.49	Moderate functional capacity
0.5 to 0.59	Moderately high functional capacity
0.6 to 0.79	High or good functional capacity
0.8 to 0.99	Very high or excellent functional capacity
1.0	Optimum functional capacity - the wetland or PWAA performs function at highest the same level as reference standard settings

Table 7 below includes calculated values from the baseline conditions as well as a description of the problems and potential restoration options to recover that function. In most instances, the baseline FCI scores indicate either low/poor or fair to moderately low functional capacity. At baseline, 1,774 acres are associated with the model (e.g., this is the combination of existing cottonwood-willow forests, wet and dry river bottom areas, and scrub-shrublands). Given a maximum FCI of 1.0, and 1,774 acres of associated PWAAs within the study area at baseline, the highest possible FCU score is 1,774 units per function. The site is therefore operating at approximately one third of its potential functional capacity (i.e., average functional outputs ÷ possible outputs).

Table 7. Description of Existing Conditions in Terms of Ecological Processes, and Ecosystem Restoration Goals

Function Name	FCI	AAFCUs	Specific Problems	Description of Ecosystem Restoration Options and Goals
Function 1: Maintenance of Characteristic Channel Dynamics	0.23	41.4	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent. 2. Upstream dams, flow constrictions at bridges and sand/gravel mining have affected the historic topographic relief; deposition is occurring upstream of 35th Avenue while erosion is occurring downstream of 35th Avenue. 3. Sediment inputs have been artificially accelerated by adjacent land use practices.	To recover this function, flow patterns must be returned to simulate historic conditions, in-channel coarse woody debris inputs must be increased, and channel dimensions must be re-engineered.
Function 2: Dynamic Surface Water Storage/Energy Dissipation	0.42	74.9	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent. 2. Upstream dams, flow constrictions at bridges and sand/gravel mining have affected the historic topographic relief; deposition is occurring upstream of 35th Avenue while erosion is occurring downstream of 35th Avenue. 3. The removal of water and channelization has degraded the vegetative communities, which in turn has reduced the amount of coarse woody debris in the system.	To restore this function, channel widths and depths must be modified, roughness through the introduction of coarse woody debris and vegetation must be increased, and a connection between remnant wetlands, ponds, and secondary channels must be restored.
Function 3: Long Term Surface Water Storage	0.25	45.2	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent. 2. Upstream dams, flow constrictions at bridges and sand/gravel mining have affected the historic topographic relief; deposition is occurring upstream of 35th Avenue while erosion is occurring downstream of 35th Avenue. 3. The removal of water and channelization has degraded the vegetative communities, which in turn has reduced the amount of coarse woody debris in the system. 4. Lack of a restrictive layer to slow infiltration.	To recover this function, wetland areas that pond water over the short term must be created. Vegetation and restrictive layers are key to this recovery.
Function 4: Dynamic Subsurface Water Storage	0.44	78.3	The depth to groundwater is excessive in this setting.	To restore this function, additional water sources must be introduced and/or existing water sources must be committed to the system and, and an emphasis must be placed on improving infiltration rates in the system with the creation of a more extensive network of wetlands.

1124

Function Name	FCI	AAFCUs	Specific Problems	Description of Ecosystem Restoration Options and Goals
Function 6: Detention of Imported Elements and Compounds	0.38	66.9	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent. 2. The system lacks a restrictive soil layer. 3. The study area lacks organic sources.	To restore this function, perennial effluent flows must be better utilized to establish large quantities of vegetative stands.
Function 7: Detention of Particles	0.33	58.9	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent. 2. The system lacks a restrictive soil layer. 3. The study area lacks organic sources.	To recover this function, perennial effluents flows must be better utilized to establish large quantities of vegetative stands.
Function 8: Maintain Characteristic Plant Communities	0.42	74.8	The existing vegetated areas within the project boundaries show promise in terms of characteristic plant maintenance functionality. However, the communities are subject to restricted water availability in the near future that would result in reduced support for vegetative layer diversity and numbers.	To protect this function's high score, invasive plant species must be removed, water supply must be increased to remnant stands, and the aerial extent of native plant communities must be expanded.
Function 9: Maintain Spatial Structure of Habitat	0.30	53.1	The existing vegetated areas within the project boundaries show promise in terms of habitat structure. However, the communities are subject to high levels of invasive species and restricted water availability in the near future.	To protect and improve this function's output, water supply should be augmented for the remnant stands, and new species should be introduced to increase structural diversity.
Function 10: Maintain Interspersion and Connectivity	0.23	40.1	1. Diversion of surface water and groundwater to support increased range/agricultural demands has led to the disappearance of the perennial flow, except for reaches receiving effluent, which in turn has led to the reduction in contiguous communities linking river bottom areas to the uplands.	To restore this function, a connection between existing strands of riparian vegetation and newly planted wetlands should be created (e.g., create and improve aquatic and terrestrial corridors).
Avergage/Total	0.33	583		

1125

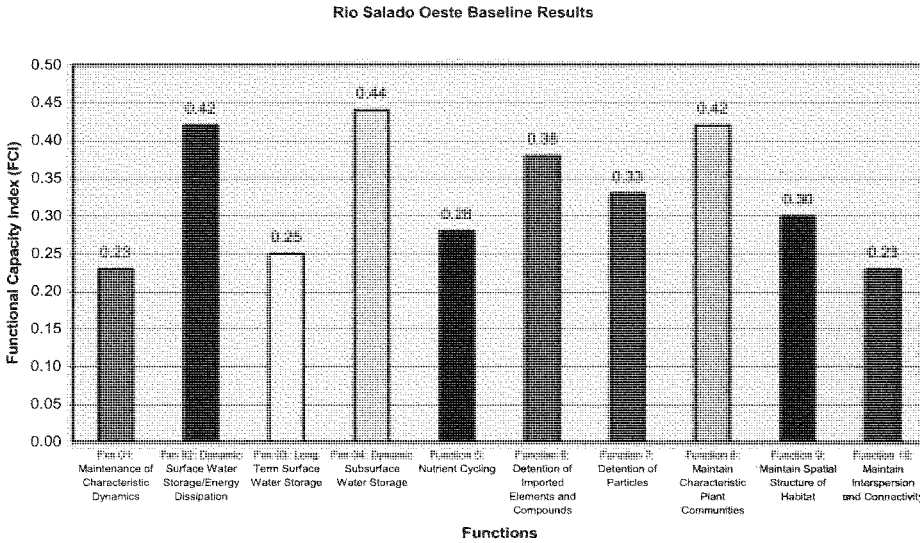

Figure 3 *FCI for the Rio Salado Oeste Study Area*

Figure 3 above displays graphically the baseline FCI values for each of the 10 functions. The highest functional score is found in Function 4, Dynamic Subsurface Water Storage (FCI = 0.44). The lowest functional scores are Functions 1, Maintenance of Characteristic Channel Dynamics and Function 10, Maintain Interspersion and Connectivity (FCI = 0.23 for both). The mean FCI across all ten functions is 0.33.

Without-Project Conditions

It was the general consensus of the E-Team that the future Without-Project conditions of the study area were certain to reflect a loss of agricultural land and most of the remaining cottonwood-willow forest, and a concurrent increase in urban areas, desert (bare earth), and scrubshrub. These changes were forecast based on existing trends, and the anticipated pressures of increasing population growth, coupled with further reductions in available water sources. The E-Team addressed these issues, and developed trends to capture both the losses of acreage and functionality to generate "No Action" scenario for the study. Numerous assumptions were used to support the projected values - these are presented below.

Acreage Losses in Future Without-Project Condition

Forecasting suggests that the already degraded ecosystem would continue to urbanize over the next 50 years. Agricultural lands within the study area are thought to be especially vulnerable to residential conversion over the next 50 years. In an effort to capture these significant land use changes with the Rio Salado Oeste study area, the E-Team developed a table projecting acreages per cover type on a Target Year basis (Table 8).

The FCI and AAFCU would appear to remain essentially the same in the Without-Project as a result of conversion from one cover type to cover types that are less valuable and provide fewer benefits. In general the higher value habitat, cottonwood-willow, open water and wet river bottom is being converted to desert, dry river bottom and scrub shrub.

The key assumptions made by the E team in estimating future conditions are as follow.

- All remaining agricultural land (133 acres) will be developed within five years.
- Remaining cottonwood willow forest will decrease from 112 acres to 25 acres over 50 years due to reduced water supply, increased urbanization and expansion of non-native salt cedar.
- Emergent wetlands will decrease slightly from 30 to 25 acres but will remain in areas of surface discharge and storm water outfalls. O&M activities at these outfall locations will disturb and result in periodic reductions in quantity and quality of the existing emergent wetland areas.
- The amount of dry river bottom is expected to increase from 66 acres to 71 acres as the wetlands are lost.
- The amount of open water will decrease from 240 to 80 acres as other uses for effluent and dewatering are established. Existing areas of open water will likely be converted to bare earth or support undesirable low value and/or non-native and invasive species, eventually converting to scrub shrub and desert wash cover. The amount of scrub shrub will increase from 1,566 to 1,653 acres.
- It is not possible to project acreage changes in sand and gravel operations but it is assumed that some operations will go out of operation while others start operating. In general these activities would migrate down stream, to the west end of the study area following the urban development.
- The reduction in water supply and decrease in surface flows will result in the reduction and/or elimination of one of the key mechanisms that drive many biochemical and biogeochemical processes that are associated with movement and cycling of nutrients.
- No establishment of new: cottonwood willow forest, wet river bottom, emergent wetlands, open water or mesquite woodlands or bosque is expected.
- There will be a decrease in the connectivity and spatial structure of the remnant high value cottonwood willow strands and a disconnect between the authorized Rio Salado Restoration and Tres Rios Demonstration projects.
- The biological diversity within the study area is expected to decrease with the reduction in high value cottonwood willow forest for cover, breeding, nesting, foraging and fledging activities. The reduction of open water and emergent wetland areas reduces and/or eliminates a key habitat or life history/cycle component for many native wildlife species and neo-tropical migratory songbirds and over-wintering waterfowl and wadding birds.
- The disturbance from unregulated recreation, off-highway vehicle traffic and "wildcat" dumping is expected to continue and potentially increase in some areas, further degrading the riparian system and remaining higher value remnant habitat it currently supports.

Table 8 ***Cover Types And Projected Acres Without Project***

DESCRIPTION	TY 0	TY 01	TY06	TY26	TY51
Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00
Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00
Existing ditches in the Uplands	3.00	3.00	3.00	3.00	3.00
Existing Emergent Wetlands in the Uplands - Cattails, Cienegas and Grasses	30.00	30.00	25.00	25.00	25.00
Existing Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00
Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00
Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00
Newly Developed Dry River Bottom Areas in the Active Chanel – Largely Unvegetated	0.00	0.00	0.00	0.00	0.00
Newly Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00
Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00
Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00
Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00
Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00
Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00
Desert or bare earth	0.00	0.00	72.00	122.00	160.00
Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00
TOTAL ACRES:	3148.00	3148.00	3148.00	3148.00	3148.00

Functional Losses in the Future Without-Project Condition

The Rio Salado Oeste study area has already been highly degraded and future channel characteristics along the Salt River channel are expected to remain similar to current conditions, though the location of active sand and gravel mining activities would change.

Changes in land use practices adjacent to the project area led the E-Team to predict considerable changes in contiguous habitat (CONTIG), which in turn will lead to severe deterioration of the remnant vegetative communities. Fragmentation will leave pockets of wetlands that are subject

to higher pressures from invasive species colonization (INVASIVES, WIS and SPECRICH). The overall structure of the forested communities is expected to decline or be eliminated entirely (VEGSTRATA, CANTREE, CANSHRUB and TVV) as water sources vanish as and remaining cottonwood-willow forest is replaced by salt cedar.

As can be seen in Figure 4 below, the AAFCU's decrease from 583 to 579 over the planning horizon. This seemingly minor change in AAFCU can be explained in two ways. The average FCI score across the 10 functions was 0.33, which indicates a fair to moderately low functioning wetland ecosystem at best. From one aspect the already low functioning ecosystem cannot decline much more. Another factor is that the existing habitat is so degraded that conversion of cottonwood-willow and wetland cover types to other cover types has little effect on the overall AAFCU's.

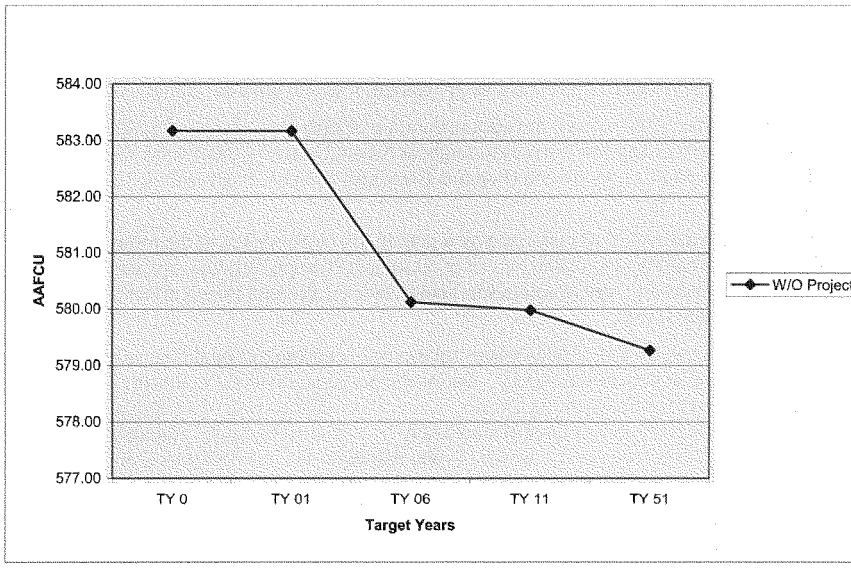

Figure 4 Future Without Project

With Project Conditions

Restoration Alternatives

Formulation of ecosystem restoration alternatives is described in detail within the feasibility report. Including No Action the team evaluated 7 alternatives with the functional assessment.

The final set of project alternatives and associated acreages of habitat are shown in Table 9 below. Measures common to the restoration alternatives include:

Channel Restoration: This measure provides a connection through the study reach and connects upstream and downstream projects. It will be accomplished by grading and terracing to restore an active channel through the entire reach.

Storm Water Outfalls: Existing outfalls would be modified to discharge to a concrete/stone channel through the river terrace and the water directed toward the low flow channel. Within that channel there would be a low weir to capture the low flows and allow floodwaters to pass. Although the wetland would in some cases be ephemeral, it would provide habitat value.

Cottonwood/Willow: This measure includes restoration of riparian cottonwood/willow stands adjacent to water sources and low terraces throughout the study area. Cottonwood-willow will be dominated by Fremont's cottonwood (Populus fremontii) and Gooding's willow (Salix gooddingii).

Mesquite: This habitat would be restored over a potentially large portion of the project area. Mesquite bosques would be dominated by velvet mesquite (Prosopis velutina) and some under story shrubs, such as desert thorn (Lycium spp.) palo verde (Cercidium floridum) and brittlebush (Encelia farinose), and forbes.

Wetland: Wetlands can consist of open water, submerged vegetation or mud flats, all requiring a high water table level at or near the surface. Due to the porous soils found in this project area, the site must be lined to maintain surface water. Excavation and layering of a silt/clay soil substrate approximately 12-inches thick is assumed to be sufficient to reduce permeability. Emergent wetlands contain primarily cattails (Typha domingensis), tule (Scirpus acutus), and sedges (Carex spp.).

Lakes: There are existing features created from aggregate mining operations at 27th and 37th Avenues that would require modification to implement lake restoration. These modifications are recommended to restore the floodplain landscape and improve the functionality of these features.

Invasive Control: Invasive species such as salt cedar (Tamarix spp.) and Arundo (Arundo donax) will require removal and management with project implementation. This will likely require physical removal and ongoing maintenance through the project life.

Water Supply: In addition to the storm water runoff that would be harvested with the storm water outfall measure, additional water supply will be required. Effluent from the 23rd Avenue Wastewater Treatment Plant is available for the restoration project.

Table 9 ***Final Array of Restoration Alternatives Evaluated***

Alternative	Cover Type	Acres
1. No Action No Federal Action to be conducted and no habitat restored. This is the future without project condition.		
2. Storm water and Channel This alternative includes the modification of existing storm-water outfall areas to improve retention and water spreading as well as increasing the existing habitat currently supported by these outfalls. It also includes modification and/or restructuring of the primary conveyance channel to a more natural state by grading and terracing the river corridor from 19th avenue to 83rd avenue. No additional water source is included in this alternative other than temporary irrigation to establish vegetation.	Channel	170
	In Channel Wetlands*	17
	Cottonwood/Willow	66
	Mesquite	43
	Wetlands	28
	Open Water	0
	Scrub Shrub	773
4. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent This alternative includes the features described in Alternative 2 and adds supplemental water supply in the form of effluent. It also includes restoration of emergent wetlands at the existing lake in the channel immediately downstream of 19th Avenue. At locations identified as suitable throughout the project area cottonwood/willow and mesquite cover types will be restored. This alternative would also address the management, control and removal of invasive species within the study area.	Channel	170
	In Channel Wetlands*	34
	Cottonwood/Willow	348
	Mesquite	409
	Wetlands	33
	Open Water	0
	Scrub Shrub	423
5. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake This alternative includes the features described in Alternative 4 and adds lake restoration at the existing gravel pits at 29th and 37th Avenues.	Channel	170
	In Channel Wetlands*	34
	Cottonwood/Willow	375
	Mesquite	417
	Wetlands	76
	Open Water	40
	Scrub Shrub	450
5A. Wetland/riparian restoration in lieu of permanent open water and lakes In lieu of lake restoration this alternative includes regrading the existing gravel pits to restore them to the floodplain and restoring emergent wetland and riparian areas.	Channel	170
	In Channel Wetlands*	34
	Cottonwood/Willow	375
	Mesquite	417
	Wetlands	156
	Open Water	0
	Scrub Shrub	410
5B. Hybrid of 5 and 5A This alternative includes restoration of one gravel pit to a wetland/riparian complex and the other to include the lake.	Channel	170
	In Channel Wetlands*	34
	Cottonwood/Willow	375
	Mesquite	417
	Wetlands	136
	Open Water	20
	Scrub Shrub	410

* Note that in channel wetland acreage is included in acres of channel restored

Environmental Benefits

Riparian ecosystems in the Southwest are invaluable. Although they represent less than 1% of the region's area (Knopf, F. L. 1989), a large proportion (75-80%) (Gillis 1991) of vertebrate wildlife species depends on riparian areas for food, water, cover, and migration routes. Riparian zones also improve water quality because they filter sediments and nutrients. Accumulated sediments in riparian zones store large amounts of water, which helps sustain stream flow during drier times.

Projection of Benefits

In April 2004, the E-Team consisting of members from USFWS, Arizona Game and Fish, City of Phoenix and Corps of Engineers met to review project alternatives and project benefits resulting from them. This included review of the future without project conditions and also resulted in the addition of two alternatives for analysis. Alternatives 5A and 5B were developed and benefits evaluated in this meeting. This included projections related to the acres of habitat to be restored and effects on each variable over the period of analysis. Those detailed results are not included in this report but are available upon request.

Key assumptions in projecting benefits are summarized below:

- Channel restoration will result in natural regeneration of emergent wetlands much like has been observed in Rio Salado. To estimate the acreage the team assumed that the low flow portion of that restored channel would include approximately 170 acres, of which 10% or 17 acres would develop into emergent wetland with alternative 2 and 20% with the other alternatives with additional water.
- Acres of floodplain that will be aggregate operations in the future are nearly impossible to project, assumed that general acreage will remain the same, although the locations will change.
- River bottom not being modified with the project will not change with project conditions.
- Contiguousness will improve in adjacent floodplain scrub shrub with restoration of other cover types.
- Planting densities and species were assumed to include the following species, although specifics will be determined during design.

  Mesquite bosques will be established within 5-20 feet above river channel with planting density of approximately 100- velvet mesquite, 10 screw bean mesquite, and 40 under story shrubs per acre. Under story forbs will also be planted using a seed mix. Container Plants will likely be utilized as 1-gallon to 5-gallon containers. Temporary irrigation (~ 5 yrs) will be required with flood or drip.

  Planting densities will be less in drier areas on higher terraces with approximately 25- velvet mesquite, 5 screw bean mesquite, and 10 under story shrubs per acre. Container plants will likely be utilized as 1-gallon to 5-gallon containers. Temporary irrigation (~ 5 yrs) will be required with flood or drip.

Cottonwood/Willow: The planting density of cottonwood-willow areas will be between 20 cottonwood trees, 40 willow, and 5 under story brush species per acre. Containers will be used for revegetation with 1-gallon to 5-gallon containers or pole plantings. Temporary irrigation (~5 yrs) will be required with flood or drip.

Acres Restored

In the future without project condition existing cottonwood/willow cover type was projected to decrease from 112 acres to 25 acres and existing wetland was projected to decrease from 30 to 25 acres as well. It is assumed that quality of that habitat would be low with high concentrations of invasive species such as salt cedar. Although there are scattered mesquite trees within the study area, none are dense enough to consider a mesquite cover type.

Alternative 2 relies mainly on restoration at storm water outfalls and restoration of the river channel itself without large amounts of restoration elsewhere. Alternatives 3 through 5A all maintain and improve the highly degraded 112 acres of cottonwood/willow and include restoration of mesquite and wetland habitats. Alternative 5A includes restoration of 375 acres of cottonwood/willow, 417 acres of mesquite and 190 acres of wetlands, including restoration of two large gravel pits within the floodplain. Also included in this alternative are 410 acres of scrub shrub and 170 acres river channel.

Results

Functional Capacity Index

Functional Capacity Index (FCI) describes the quality of the functional capacity of the habitat. Of the 10 functions evaluated in the without project conditions, all had low to moderate functional capacity. Implementation of project alternatives caused an increase in each FCI, with the average increasing by approximately 30% and into the ranges considered moderate to moderate-high functional capacity. The most improved functions included Function 1 (Maintenance of Characteristic Channel Dynamics), Function 7 (Detention of Particles), and Function 10 (Maintain Interspersion and Connectivity). Those functions showing the least improvement included Function 4 (Dynamic Subsurface Water Storage), Function 5 (Nutrient Cycling), and Function 6 (Detention of Imported Elements and Compounds). Table 10 below displays the FCI for the baseline condition as well as for each alternative.

Table 10 With Project Functional Capacity Indices (FCI)

Function Name	Existing	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B
Fxn 01: Maintenance of Characteristic Dynamics	0.23	0.27	0.4	0.39	0.4	0.39
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.42	0.45	0.57	0.57	0.57	0.57
Fxn 03: Long Term Surface Water Storage	0.25	0.27	0.34	0.33	0.34	0.34
Fxn 04: Dynamic Subsurface Water Storage	0.44	0.50	0.51	0.51	0.52	0.52
Function 5: Nutrient Cycling	0.28	0.28	0.33	0.33	0.34	0.33
Function 6: Detention of Imported Elements and Compounds	0.38	0.39	0.45	0.45	0.46	0.45
Function 7: Detention of Particles	0.33	0.36	0.48	0.47	0.48	0.48
Function 8: Maintain Characteristic Plant Communities	0.42	0.43	0.51	0.51	0.51	0.51
Function 9: Maintain Spatial Structure of Habitat	0.30	0.32	0.42	0.41	0.42	0.41
Function 10: Maintain Interspersion and Connectivity	0.23	0.29	0.33	0.34	0.34	0.34

Average Annual Functional Capacity Units (AAFCU)

Based upon the functional assessment completed for this study the number of acres and functional capacity indices were projected in order to derive with-project estimates of average annual functional capacity units (AAFCU). 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 AAFCU's for each alternative relative to without project conditions. As a reminder, the Functional Capacity Unit (FCU) represents the factor of habitat quality multiplied by quantity or FCI from above multiplied by acreage of habitat restored. Table 11 shows the results.

Table 11 With Project Average Annual Functional Capacity Units (AAFCUs)

Target Year	Without Project	Alt 2	Alt 4	Alt 5	Alt 5A	Alt 5B
T0	583	583	583	583	583	583
T1	580	619	691	766	791	778
T6	580	627	717	796	822	809
T26	579	635	755	828	857	842
T51	579	633	775	851	879	865
Average (T0-T51)	580	631	745	820	847	833

The proposed alternatives result in increased AAFCU's (relative to without project conditions) ranging from 51 for Alternative 2 to 267 for Alternative 5A. As can be seen in the table, the without project conditions change only slightly over 50 years and are not expected to change without some action. Each column numbered with different alternatives displays the number of FCU's that are expected in that year with the associated features of that alternative. Figure 5 below displays the various alternatives and changing outputs over the period of analysis.

Additional Alternatives

Four additional alternatives were developed to assure that the Cost Effectiveness and Incremental Cost Analysis provided an evaluation of a full range out output and cost. Those additional alternatives were refinements of the alternatives above. All assumptions previously utilized in forecasting benefits apply consistently with the refined alternatives.

Partial: This alternative restores only the portion of Salt River from 19th to 35th Avenues without any restoration of existing gravel pit lake. It includes capture of storm water from only 4 outfalls. Approximately 270 acres are required for this alternative and restored areas include 15 acres of emergent wetlands, 30 acres of cottonwood-willow, 30 acres of mesquite, and 75 acres of riparian scrub. In addition the low flow channel would encompass approximately 48 acres.

Refine 1: This alternative includes restoration of the river channel from 19th to 83rd Avenues, modification of existing storm water outfalls and restoration of associated habitats and restoration of the two existing gravel pit lakes. Approximately 1024 acres are required to implement this alternative. Acres restored with this alternative include: cottonwood-willow 210, mesquite 56, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 2: This refinement restores the river from 19th to 83rd Avenues and includes the same features as Alternative 5A but is scaled back to restore much less cottonwood-willow and mesquite habitats. Approximately 1300 acres are required to implement this alternative. Acres restored include: cottonwood-willow 204, mesquite 110, wetlands 140, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Refine 3: This refinement also restores the river from 19th to 83rd Avenues without restoration of the gravel pit lakes and less acreage of cottonwood-willow and mesquite. Approximately 1130 acres are required to implement this alternative. Acres restored include: cottonwood-

willow 169, mesquite 102, wetlands 92, low flow channel 170, riparian scrub 125 and the remaining areas would be scrub shrub.

Table 12 Functional Capacity Indices for Refined Alternatives

Function Name	Existing	Partial	Refine 1	Refine 2	Refine 3
Fxn 01: Maintenance of Characteristic Dynamics	0.23	0.25	0.27	0.28	0.27
Fxn 02: Dynamic Surface Water Storage/Energy Dissipation	0.42	0.45	0.49	0.50	0.49
Fxn 03: Long Term Surface Water Storage	0.25	0.27	0.29	0.30	0.29
Fxn 04: Dynamic Subsurface Water Storage	0.44	0.47	0.51	0.51	0.50
Function 5: Nutrient Cycling	0.28	0.27	0.29	0.28	0.27
Function 6: Detention of Imported Elements and Compounds	0.38	0.38	0.39	0.40	0.39
Function 7: Detention of Particles	0.33	0.34	0.38	0.39	0.38
Function 8: Maintain Characteristic Plant Communities	0.42	0.42	0.44	0.45	0.44
Function 9: Maintain Spatial Structure of Habitat	0.30	0.30	0.32	0.33	0.32
Function 10: Maintain Interspersion and Connectivity	0.23	0.25	0.28	0.28	0.28

Table 13 Refined Alternative Average Annual Functional Capacity Units (AAFCUs)

Target Year	Without Project	Partial	Refine 1	Refine 2	Refine 3
T0	583	583	583	583	583
T1	580	609	732	736	626
T6	580	611	749	754	649
T26	579	616	771	776	674
T51	579	612	779	785	682
Average (T0-T51)	580	613	764	768	667

Conclusion

The benefits above were utilized in performing Cost-effectiveness (CE) and incremental cost analyses (ICA. CE/ICA compares the costs and benefits of individual plans and identifies the least-costly solution for each level of output. Results of that evaluation are included in the main Feasibility Report and Economic Appendix.

Alternative 5A which produces 847 AAFCUs was determined to be the recommended alternative based upon both the amount of benefits produced and cost to accomplish those benefits.

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 (T2 -T1)[((A1 F1 +A2 F2) / 3) + ((A2 F1 +A1 F2) / 6)]
and where:

T1 = First Target Year time interval

T2 = Second Target Year time interval

A1 = Area of available wetland assessment area at beginning of T1

A2 = Area of available wetland assessment area at end of T2

F1 = FCI at beginning of T1

F2 = FCI at end of T2

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).

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.

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.

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 V1 * VSI V2) / 4, where:

VSI V1 is the Variable Subindex (VSI) for

variable 1;

VSI V2 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.

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.

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.

Target Year (TY)

A unit of time measurement used in Habitat Evaluation Procedures, that allows for projection of 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 = X2. TY1 is the first year land- and water-use conditions are expected to deviate from baseline conditions. TYX2 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.

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 alternative conditions, this is the condition of the site after an alternative or alternatives are 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.

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Summary Tables

AAFCU Summary tables including Acreages and AAFCU Calculations follow.

Rio Salado Oeste Baseline and Without Project

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93
1	6	0.23	0.23	1774	1774	2069.67
6	26	0.23	0.23	1774	1774	8278.67
26	51	0.23	0.23	1774	1774	10348.33
Without Project AAFCUs:						413.93

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64
1	6	0.42	0.42	1774	1774	3737.63
6	26	0.42	0.42	1774	1774	14902.49
26	51	0.42	0.42	1774	1774	18573.62
Without Project AAFCUs:						744.36

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12
1	6	0.25	0.25	1774	1774	2259.04
6	26	0.25	0.25	1774	1774	8798.88
26	51	0.25	0.25	1774	1774	10943.39
Without Project AAFCUs:						439.87

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00
1	6	0.44	0.45	1774	1774	3955.00
6	26	0.45	0.46	1774	1774	16139.00
26	51	0.46	0.47	1774	1774	20506.25
Without Project AAFCUs:						811.26

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52
1	6	0.28	0.27	1774	1774	2451.88
6	26	0.27	0.27	1774	1774	9576.43
26	51	0.27	0.26	1774	1774	11718.48
Without Project AAFCUs:						475.34

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88
1	6	0.38	0.37	1774	1774	3320.82
6	26	0.37	0.36	1774	1774	13065.78
26	51	0.36	0.36	1774	1774	16152.25
Without Project AAFCUs:						651.13

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51
1	6	0.33	0.33	1774	1774	2933.78
6	26	0.33	0.33	1774	1774	11653.36
26	51	0.33	0.33	1774	1774	14478.48
Without Project AAFCUs:						**581.45**

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35
1	6	0.42	0.42	1774	1774	3730.78
6	26	0.42	0.42	1774	1774	14839.73
26	51	0.42	0.42	1774	1774	18456.48
Without Project AAFCUs:						**740.69**

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41
1	6	0.30	0.30	1774	1774	2636.99
6	26	0.30	0.29	1774	1774	10376.28
26	51	0.29	0.29	1774	1774	12783.89
Without Project AAFCUs:						**516.25**

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30
1	6	0.23	0.23	1774	1774	2006.50
6	26	0.23	0.25	1774	1774	8387.75
26	51	0.25	0.25	1774	1774	10943.82
Without Project AAFCUs:						**426.26**

Project: Río Salado Oeste
Alternative: 2

Code	Description	Without Project					With Project				
		Target Year					Target Year				
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	80.00	50.00	25.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienegas and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	45.00	45.00	45.00	45.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	63.00	63.00	63.00	63.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00	48.00	48.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	38.00	5.00	5.00	5.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1438.00	1508.00	1538.00	1563.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	72.00	122.00	160.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 10% will be emergent wetland from Río Salado inflows, dry weather flows, and excess stormwater runoff.

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative 2

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	0	1	0.23	0.26	1774	1774	433.68
1	6	0.23	0.23	1774	1774	2069.67	1	6	0.26	0.25	1774	1774	2256.42
6	26	0.23	0.23	1774	1774	8278.67	6	26	0.25	0.28	1774	1774	9389.33
26	51	0.23	0.23	1774	1774	10348.33	26	51	0.28	0.27	1774	1774	12135.21
					Without Project AAFCUs:	413.93						With Project AAFCUs:	474.80
												Net AAFCUs:	60.86

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	0	1	0.42	0.46	1774	1774	784.51
1	6	0.42	0.42	1774	1774	3737.63	1	6	0.46	0.46	1774	1774	4094.70
6	26	0.42	0.42	1774	1774	14902.49	6	26	0.46	0.46	1774	1774	16271.33
26	51	0.42	0.42	1774	1774	18573.62	26	51	0.46	0.45	1774	1774	20152.34
					Without Project AAFCUs:	744.36						With Project AAFCUs:	809.86
												Net AAFCUs:	65.50

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	0	1	0.25	0.28	1774	1774	476.28
1	6	0.25	0.25	1774	1774	2239.04	1	6	0.28	0.28	1774	1774	2488.02
6	26	0.25	0.25	1774	1774	8798.88	6	26	0.28	0.28	1774	1774	9841.62
26	51	0.25	0.25	1774	1774	10943.39	26	51	0.28	0.27	1774	1774	12179.54
					Without Project AAFCUs:	439.87						With Project AAFCUs:	489.91
												Net AAFCUs:	50.04

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	0	1	0.44	0.49	1774	1774	829.25
1	6	0.44	0.45	1774	1774	3955.00	1	6	0.49	0.50	1774	1774	4425.00
6	26	0.45	0.46	1774	1774	16130.00	6	26	0.50	0.50	1774	1774	17890.00
26	51	0.46	0.47	1774	1774	20506.25	26	51	0.50	0.50	1774	1774	22362.50
					Without Project AAFCUs:	811.26						With Project AAFCUs:	892.29
												Net AAFCUs:	81.03

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	0	1	0.28	0.26	1774	1774	477.63
1	6	0.28	0.27	1774	1774	2451.88	1	6	0.26	0.27	1774	1774	2338.67
6	26	0.27	0.27	1774	1774	9576.43	6	26	0.27	0.27	1774	1774	9560.34
26	51	0.27	0.26	1774	1774	11718.48	26	51	0.27	0.28	1774	1774	12151.83
					Without Project AAFCUs:	475.34						With Project AAFCUs:	480.95
												Net AAFCUs:	5.61

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	0	1	0.38	0.38	1774	1774	672.49
1	6	0.38	0.37	1774	1774	3320.82	1	6	0.38	0.38	1774	1774	3395.14
6	26	0.37	0.36	1774	1774	13065.78	6	26	0.38	0.39	1774	1774	13719.86
26	51	0.36	0.36	1774	1774	16152.25	26	51	0.39	0.39	1774	1774	17238.39
Without Project AAFCUs:						651.13	With Project AAFCUs:						686.78
							Net AAFCUs:						35.65

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	0	1	0.33	0.37	1774	1774	620.85
1	6	0.33	0.33	1774	1774	2933.78	1	6	0.37	0.37	1774	1774	3261.77
6	26	0.33	0.33	1774	1774	11653.36	6	26	0.37	0.37	1774	1774	13026.35
26	51	0.33	0.33	1774	1774	14478.48	26	51	0.37	0.36	1774	1774	16187.00
Without Project AAFCUs:						581.45	With Project AAFCUs:						648.94
							Net AAFCUs:						67.49

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	0	1	0.42	0.43	1774	1774	759.25
1	6	0.42	0.42	1774	1774	3730.78	1	6	0.43	0.44	1774	1774	3867.49
6	26	0.42	0.42	1774	1774	14839.73	6	26	0.44	0.44	1774	1774	15489.64
26	51	0.42	0.42	1774	1774	18456.48	26	51	0.44	0.43	1774	1774	19273.68
Without Project AAFCUs:						740.69	With Project AAFCUs:						772.35
							Net AAFCUs:						31.66

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	0	1	0.30	0.31	1774	1774	538.71
1	6	0.30	0.30	1774	1774	2636.99	1	6	0.31	0.31	1774	1774	2753.50
6	26	0.30	0.29	1774	1774	10376.28	6	26	0.31	0.31	1774	1774	11135.79
26	51	0.29	0.29	1774	1774	12783.89	26	51	0.31	0.32	1774	1774	13970.81
Without Project AAFCUs:						516.25	With Project AAFCUs:						556.84
							Net AAFCUs:						40.59

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	0	1	0.23	0.25	1774	1774	419.15
1	6	0.23	0.23	1774	1774	2006.50	1	6	0.25	0.26	1774	1774	2266.95
6	26	0.23	0.25	1774	1774	8387.75	6	26	0.26	0.29	1774	1774	9869.40
26	51	0.25	0.25	1774	1774	10943.82	26	51	0.29	0.29	1774	1774	12901.29
Without Project AAFCUs:						426.26	With Project AAFCUs:						499.15
							Net AAFCUs:						72.89

Project: Rio Salado Oeste
Alternative: 3

		Without Project					With Project				
		Target Year					Target Year				
Code	Description	0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	62.00	62.00	62.00	62.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	228.00	228.00	228.00	228.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	409.00	409.00	409.00	409.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	933.00	933.00	950.00	950.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	77.00	110.00	148.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

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Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste *Alternative 3*

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	0	1	0.23	0.30	1774	1774	470.58
1	6	0.23	0.23	1774	1774	2069.67	1	6	0.30	0.30	1774	1769	2633.25
6	26	0.23	0.23	1774	1774	8278.67	6	26	0.30	0.40	1769	1786	12312.63
26	51	0.23	0.23	1774	1774	10348.33	26	51	0.40	0.40	1786	1786	17643.75
Without Project AAFCUs:						413.93	With Project AAFCUs:						648.24
							Net AAFCUs:						234.31

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	0	1	0.42	0.58	1774	1774	890.10
1	6	0.42	0.42	1774	1774	3737.63	1	6	0.58	0.59	1774	1769	5202.25
6	26	0.42	0.42	1774	1774	14902.49	6	26	0.59	0.56	1769	1786	20532.78
26	51	0.42	0.42	1774	1774	18573.62	26	51	0.56	0.57	1786	1786	25184.37
Without Project AAFCUs:						744.36	With Project AAFCUs:						1015.87
							Net AAFCUs:						271.51

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	0	1	0.25	0.35	1774	1774	535.66
1	6	0.25	0.25	1774	1774	2239.04	1	6	0.35	0.35	1774	1769	3092.85
6	26	0.25	0.25	1774	1774	8799.88	6	26	0.35	0.34	1769	1786	12190.36
26	51	0.25	0.25	1774	1774	10943.39	26	51	0.34	0.34	1786	1786	15025.80
Without Project AAFCUs:						439.87	With Project AAFCUs:						604.80
							Net AAFCUs:						164.93

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	0	1	0.44	0.51	1774	1774	843.00
1	6	0.44	0.45	1774	1774	3955.00	1	6	0.51	0.51	1774	1769	4515.01
6	26	0.45	0.46	1774	1774	16130.00	6	26	0.51	0.51	1769	1786	18145.01
26	51	0.46	0.47	1774	1774	20506.25	26	51	0.51	0.51	1786	1786	22787.50
Without Project AAFCUs:						811.26	With Project AAFCUs:						907.66
							Net AAFCUs:						96.40

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	0	1	0.28	0.22	1774	1774	442.39
1	6	0.28	0.27	1774	1774	2451.88	1	6	0.22	0.26	1774	1769	2131.67
6	26	0.27	0.27	1774	1774	9576.43	6	26	0.26	0.28	1769	1786	9690.39
26	51	0.27	0.26	1774	1774	11718.48	26	51	0.28	0.33	1786	1786	13599.35
Without Project AAFCUs:						475.34	With Project AAFCUs:						507.13
							Net AAFCUs:						31.79

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	0	1	0.38	0.39	1774	1774	677.68
1	6	0.38	0.37	1774	1774	3320.82	1	6	0.39	0.41	1774	1769	3529.07
6	26	0.37	0.36	1774	1774	13065.78	6	26	0.41	0.43	1769	1786	14953.24
26	51	0.36	0.36	1774	1774	16152.25	26	51	0.43	0.45	1786	1786	19743.59
Without Project AAFCUs:						651.13	With Project AAFCUs:						762.82
							Net AAFCUs:						111.68

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	0	1	0.33	0.44	1774	1774	683.91
1	6	0.33	0.33	1774	1774	2933.78	1	6	0.44	0.45	1774	1769	3936.83
6	26	0.33	0.33	1774	1774	11653.36	6	26	0.45	0.47	1769	1786	16324.77
26	51	0.33	0.33	1774	1774	14478.48	26	51	0.47	0.48	1786	1786	21094.81
Without Project AAFCUs:						581.45	With Project AAFCUs:						824.32
							Net AAFCUs:						242.87

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	0	1	0.42	0.46	1774	1774	781.96
1	6	0.42	0.42	1774	1774	3730.78	1	6	0.46	0.49	1774	1769	4223.09
6	26	0.42	0.42	1774	1774	14839.73	6	26	0.49	0.50	1769	1786	17715.52
26	51	0.42	0.42	1774	1774	18456.48	26	51	0.50	0.51	1786	1786	22618.52
Without Project AAFCUs:						740.69	With Project AAFCUs:						889.00
							Net AAFCUs:						148.31

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	0	1	0.30	0.35	1774	1774	573.68
1	6	0.30	0.30	1774	1774	2636.99	1	6	0.35	0.37	1774	1769	3159.37
6	26	0.30	0.29	1774	1774	10376.28	6	26	0.37	0.39	1769	1786	13395.51
26	51	0.29	0.29	1774	1774	12783.89	26	51	0.39	0.42	1786	1786	17931.25
Without Project AAFCUs:						516.25	With Project AAFCUs:						687.45
							Net AAFCUs:						171.20

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	0	1	0.23	0.30	1774	1774	464.00
1	6	0.23	0.23	1774	1774	2006.50	1	6	0.30	0.32	1774	1769	2710.26
6	26	0.23	0.25	1774	1774	8387.75	6	26	0.32	0.33	1769	1786	11441.05
26	51	0.25	0.25	1774	1774	10943.82	26	51	0.33	0.33	1786	1786	14670.08
Without Project AAFCUs:						426.26	With Project AAFCUs:						574.22
							Net AAFCUs:						147.96

Project: Rio Salado Oeste
Alternative: 4

Code	Description	Without Project					With Project				
		Target Year					Target Year				
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienegas and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	67.00	67.00	67.00	67.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	228.00	228.00	228.00	228.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	409.00	409.00	409.00	409.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	928.00	928.00	950.00	950.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	77.00	105.00	143.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste ***Alternative 4***

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	0	1	0.23	0.30	1774	1774	471.13
1	6	0.23	0.23	1774	1774	2069.67	1	6	0.30	0.30	1774	1769	2638.67
6	26	0.23	0.23	1774	1774	8278.67	6	26	0.30	0.40	1769	1791	12355.15
26	51	0.23	0.23	1774	1774	10348.33	26	51	0.40	0.40	1791	1791	17727.08
					Without Project AAFCUs:	413.93						With Project AAFCUs:	650.82
												Net AAFCUs:	236.89

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	0	1	0.42	0.58	1774	1774	891.56
1	6	0.42	0.42	1774	1774	3737.63	1	6	0.58	0.59	1774	1769	5216.80
6	26	0.42	0.42	1774	1774	14902.49	6	26	0.59	0.56	1769	1791	20612.42
26	51	0.42	0.42	1774	1774	18573.62	26	51	0.56	0.57	1791	1791	25309.36
					Without Project AAFCUs:	744.36						With Project AAFCUs:	1020.20
												Net AAFCUs:	275.84

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	0	1	0.25	0.35	1774	1774	536.28
1	6	0.25	0.25	1774	1774	2239.04	1	6	0.35	0.35	1774	1769	3099.01
6	26	0.25	0.25	1774	1774	8798.88	6	26	0.35	0.34	1769	1791	12228.01
26	51	0.25	0.25	1774	1774	10943.39	26	51	0.34	0.34	1791	1791	15088.50
					Without Project AAFCUs:	439.87						With Project AAFCUs:	606.90
												Net AAFCUs:	167.03

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	0	1	0.44	0.51	1774	1774	844.25
1	6	0.44	0.45	1774	1774	3955.00	1	6	0.51	0.51	1774	1769	4527.51
6	26	0.45	0.46	1774	1774	16130.00	6	26	0.51	0.51	1769	1791	18220.01
26	51	0.46	0.47	1774	1774	20506.25	26	51	0.51	0.51	1791	1791	22912.50
					Without Project AAFCUs:	811.26						With Project AAFCUs:	911.85
												Net AAFCUs:	100.59

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	0	1	0.28	0.22	1774	1774	443.33
1	6	0.28	0.27	1774	1774	2451.88	1	6	0.22	0.26	1774	1769	2142.28
6	26	0.27	0.27	1774	1774	9576.43	6	26	0.26	0.28	1769	1791	9753.30
26	51	0.27	0.26	1774	1774	11718.48	26	51	0.28	0.33	1791	1791	13699.92
					Without Project AAFCUs:	475.34						With Project AAFCUs:	510.57
												Net AAFCUs:	35.23

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	0	1	0.38	0.39	1774	1774	678.10
1	6	0.38	0.37	1774	1774	3320.82	1	6	0.39	0.41	1774	1769	3533.29
6	26	0.37	0.36	1774	1774	13065.78	6	26	0.41	0.43	1769	1791	14994.95
26	51	0.36	0.36	1774	1774	16152.25	26	51	0.43	0.45	1791	1791	19827.94
Without Project AAFCUs:						651.13	With Project AAFCUs:						765.38
							Net AAFCUs:						114.25

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	0	1	0.33	0.44	1774	1774	684.87
1	6	0.33	0.33	1774	1774	2933.78	1	6	0.44	0.45	1774	1769	3946.51
6	26	0.33	0.33	1774	1774	11653.36	6	26	0.45	0.47	1769	1791	16382.92
26	51	0.33	0.33	1774	1774	14478.48	26	51	0.47	0.48	1791	1791	21192.66
Without Project AAFCUs:						581.45	With Project AAFCUs:						827.59
							Net AAFCUs:						246.13

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	0	1	0.42	0.46	1774	1774	782.54
1	6	0.42	0.42	1774	1774	3730.78	1	6	0.46	0.49	1774	1769	4228.81
6	26	0.42	0.42	1774	1774	14839.73	6	26	0.49	0.50	1769	1791	17758.32
26	51	0.42	0.42	1774	1774	18456.48	26	51	0.50	0.51	1791	1791	22697.97
Without Project AAFCUs:						740.69	With Project AAFCUs:						891.52
							Net AAFCUs:						150.83

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	0	1	0.30	0.35	1774	1774	573.98
1	6	0.30	0.30	1774	1774	2636.99	1	6	0.35	0.37	1774	1769	3163.12
6	26	0.30	0.29	1774	1774	10376.28	6	26	0.37	0.39	1769	1791	13430.50
26	51	0.29	0.29	1774	1774	12783.89	26	51	0.39	0.42	1791	1791	17997.94
Without Project AAFCUs:						516.25	With Project AAFCUs:						689.52
							Net AAFCUs:						173.27

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	0	1	0.23	0.30	1774	1774	464.48
1	6	0.23	0.23	1774	1774	2036.50	1	6	0.30	0.32	1774	1769	2714.98
6	26	0.23	0.25	1774	1774	8387.75	6	26	0.32	0.33	1769	1791	11472.62
26	51	0.25	0.25	1774	1774	10943.82	26	51	0.33	0.33	1791	1791	14726.58
Without Project AAFCUs:						426.26	With Project AAFCUs:						576.05
							Net AAFCUs:						149.79

Project: Rio Salado Oeste
Alternative: 5

		Without Project					With Project				
		Target Year					Target Year				
Code	Description	0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	75.00	75.00	75.00	75.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	263.00	263.00	263.00	263.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	417.00	417.00	417.00	417.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	40.00	40.00	40.00	40.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1077.00	1082.00	1082.00	1082.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	0.00	0.00	0.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM
Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER
Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST
Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

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Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative 5

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	0	1	0.23	0.30	1774	1974	496.13
1	6	0.23	0.23	1774	1774	2069.67	1	6	0.30	0.30	1974	1974	2912.25
6	26	0.23	0.23	1774	1774	8278.67	6	26	0.30	0.39	1974	1974	13527.50
26	51	0.23	0.23	1774	1774	10348.33	26	51	0.39	0.39	1974	1974	19257.50
					Without Project AAFCUs:	413.93						With Project AAFCUs:	709.67
												Net AAFCUs:	295.74

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	0	1	0.42	0.58	1774	1974	939.55
1	6	0.42	0.42	1774	1774	3737.63	1	6	0.58	0.59	1974	1974	5758.34
6	26	0.42	0.42	1774	1774	14902.49	6	26	0.59	0.56	1974	1974	22716.70
26	51	0.42	0.42	1774	1774	18573.62	26	51	0.56	0.57	1974	1974	27825.15
					Without Project AAFCUs:	744.36						With Project AAFCUs:	1122.35
												Net AAFCUs:	377.99

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	0	1	0.25	0.35	1774	1974	564.49
1	6	0.25	0.25	1774	1774	2239.04	1	6	0.35	0.35	1974	1974	3414.67
6	26	0.25	0.25	1774	1774	8798.88	6	26	0.35	0.33	1974	1974	13442.22
26	51	0.25	0.25	1774	1774	10943.39	26	51	0.33	0.33	1974	1974	16532.18
					Without Project AAFCUs:	439.87						With Project AAFCUs:	665.76
												Net AAFCUs:	225.89

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	0	1	0.44	0.51	1774	1974	893.92
1	6	0.44	0.45	1774	1774	3955.00	1	6	0.51	0.51	1974	1974	5053.75
6	26	0.45	0.46	1774	1774	16136.00	6	26	0.51	0.51	1974	1974	20240.00
26	51	0.46	0.47	1774	1774	20506.25	26	51	0.51	0.51	1974	1974	25300.00
					Without Project AAFCUs:	811.26						With Project AAFCUs:	1009.56
												Net AAFCUs:	198.30

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	0	1	0.28	0.22	1774	1974	470.25
1	6	0.28	0.27	1774	1774	2451.88	1	6	0.22	0.27	1974	1974	2411.76
6	26	0.27	0.27	1774	1774	9576.43	6	26	0.27	0.29	1974	1974	10876.63
26	51	0.27	0.26	1774	1774	11718.48	26	51	0.29	0.33	1974	1974	15130.90
					Without Project AAFCUs:	475.34						With Project AAFCUs:	566.46
												Net AAFCUs:	91.12

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	0	1	0.38	0.39	1774	1974	717.48
1	6	0.38	0.37	1774	1774	3320.82	1	6	0.39	0.41	1974	1974	3941.78
6	26	0.37	0.36	1774	1774	13065.78	6	26	0.41	0.43	1974	1974	16623.30
26	51	0.36	0.36	1774	1774	16152.25	26	51	0.43	0.45	1974	1974	21806.85
Without Project AAFCUs:						651.13	With Project AAFCUs:						844.89
							Net AAFCUs:						193.76

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	0	1	0.33	0.44	1774	1974	721.27
1	6	0.33	0.33	1774	1774	2933.78	1	6	0.44	0.45	1974	1974	4353.26
6	26	0.33	0.33	1774	1774	11653.36	6	26	0.45	0.47	1974	1974	17993.46
26	51	0.33	0.33	1774	1774	14478.48	26	51	0.47	0.47	1974	1974	23149.03
Without Project AAFCUs:						581.45	With Project AAFCUs:						906.22
							Net AAFCUs:						324.76

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	0	1	0.42	0.46	1774	1974	826.33
1	6	0.42	0.42	1774	1774	3730.78	1	6	0.46	0.49	1974	1974	4690.63
6	26	0.42	0.42	1774	1774	14839.73	6	26	0.49	0.50	1974	1974	19564.58
26	51	0.42	0.42	1774	1774	18456.48	26	51	0.50	0.51	1974	1974	24856.04
Without Project AAFCUs:						740.69	With Project AAFCUs:						979.17
							Net AAFCUs:						238.48

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	0	1	0.30	0.35	1774	1974	605.00
1	6	0.30	0.30	1774	1774	2636.99	1	6	0.35	0.36	1974	1974	3500.42
6	26	0.30	0.29	1774	1774	10376.28	6	26	0.36	0.39	1974	1974	14793.09
26	51	0.29	0.29	1774	1774	12783.89	26	51	0.39	0.41	1974	1974	19692.45
Without Project AAFCUs:						516.25	With Project AAFCUs:						756.69
							Net AAFCUs:						240.44

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	0	1	0.23	0.29	1774	1974	489.23
1	6	0.23	0.23	1774	1774	2006.50	1	6	0.29	0.31	1974	1974	2998.27
6	26	0.23	0.25	1774	1774	8387.75	6	26	0.31	0.33	1974	1974	12654.31
26	51	0.25	0.25	1774	1774	10943.82	26	51	0.33	0.34	1974	1974	16376.89
Without Project AAFCUs:						426.26	With Project AAFCUs:						637.62
							Net AAFCUs:						211.36

Project: Rio Salado Oeste
Alternative: 5A

Code	Description	Without Project					With Project				
		Target Year					Target Year				
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienegas and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	115.00	115.00	115.00	115.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	263.00	263.00	263.00	263.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	417.00	417.00	417.00	417.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	0.00	0.00	0.00	0.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1077.00	1082.00	1082.00	1082.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	0.00	0.00	0.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM
Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER
Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST
Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

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Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative 5A

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.23	0.30	1774	2014	504.60
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.30	0.30	2014	2014	3002.25
6	26	0.23	0.25	1774	1774	8357.75	437.48	6	26	0.30	0.40	2014	2014	13974.17
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.40	0.40	2014	2014	19924.17
Without Project AAFCUs:						426.26		With Project AAFCUs:						733.43
Net AAFCUs:														307.17

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	748.64	0	1	0.42	0.59	1774	2014	958.18
1	6	0.42	0.42	1774	1774	3737.63	746.41	1	6	0.59	0.60	2014	2014	5958.34
6	26	0.42	0.42	1774	1774	14902.49	743.84	6	26	0.60	0.57	2014	2014	23516.70
26	51	0.42	0.42	1774	1774	18573.62	742.05	26	51	0.57	0.57	2014	2014	28825.14
Without Project AAFCUs:						744.36		With Project AAFCUs:						1161.93
Net AAFCUs:														417.57

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	452.12	0	1	0.25	0.35	1774	2014	573.79
1	6	0.25	0.25	1774	1774	2239.04	443.50	1	6	0.35	0.35	2014	2014	3514.99
6	26	0.25	0.25	1774	1774	8798.88	436.39	6	26	0.35	0.34	2014	2014	13843.47
26	51	0.25	0.25	1774	1774	10943.39	439.08	26	51	0.34	0.34	2014	2014	17033.74
Without Project AAFCUs:						439.87		With Project AAFCUs:						685.61
Net AAFCUs:														245.74

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	783.00	0	1	0.44	0.52	1774	2014	913.06
1	6	0.44	0.45	1774	1774	3955.00	799.00	1	6	0.52	0.52	2014	2014	5253.75
6	26	0.45	0.46	1774	1774	16130.00	814.00	6	26	0.52	0.52	2014	2014	21040.00
26	51	0.46	0.47	1774	1774	20506.25	826.50	26	51	0.52	0.52	2014	2014	26300.00
Without Project AAFCUs:						811.26		With Project AAFCUs:						1049.15
Net AAFCUs:														237.89

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	495.52	0	1	0.28	0.23	1774	2014	482.64
1	6	0.28	0.27	1774	1774	2451.88	485.23	1	6	0.23	0.27	2014	2014	2545.00
6	26	0.27	0.27	1774	1774	9576.43	472.41	6	26	0.27	0.30	2014	2014	11479.52
26	51	0.27	0.26	1774	1774	11718.48	465.06	26	51	0.30	0.34	2014	2014	15935.40
Without Project AAFCUs:						475.34		With Project AAFCUs:						596.91
Net AAFCUs:														121.57

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	668.88	0	1	0.38	0.39	1774	2014	727.94
1	6	0.38	0.37	1774	1774	3320.82	659.45	1	6	0.39	0.41	2014	2014	4048.62
6	26	0.37	0.36	1774	1774	13065.78	647.13	6	26	0.41	0.44	2014	2014	17106.08
26	51	0.36	0.36	1774	1774	16152.25	645.05	26	51	0.44	0.46	2014	2014	22481.67
					Without Project AAFCUs:	651.13							With Project AAFCUs:	869.89
													Net AAFCUs:	218.76

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	588.51	0	1	0.33	0.44	1774	2014	734.57
1	6	0.33	0.33	1774	1774	2933.78	585.00	1	6	0.44	0.45	2014	2014	4495.96
6	26	0.33	0.33	1774	1774	11653.36	580.33	6	26	0.45	0.47	2014	2014	18591.43
26	51	0.33	0.33	1774	1774	14478.48	577.94	26	51	0.47	0.48	2014	2014	23931.84
					Without Project AAFCUs:	581.45							With Project AAFCUs:	936.35
													Net AAFCUs:	354.90

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	748.35	0	1	0.42	0.46	1774	2014	838.86
1	6	0.42	0.42	1774	1774	3730.78	743.96	1	6	0.46	0.49	2014	2014	4818.88
6	26	0.42	0.42	1774	1774	14839.73	740.01	6	26	0.49	0.50	2014	2014	20073.12
26	51	0.42	0.42	1774	1774	18456.48	736.51	26	51	0.50	0.51	2014	2014	25491.71
					Without Project AAFCUs:	740.69							With Project AAFCUs:	1004.36
													Net AAFCUs:	263.67

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	531.41	0	1	0.30	0.35	1774	2014	612.73
1	6	0.30	0.30	1774	1774	2636.99	523.39	1	6	0.35	0.37	2014	2014	3587.41
6	26	0.30	0.29	1774	1774	10376.28	514.24	6	26	0.37	0.39	2014	2014	15189.66
26	51	0.29	0.29	1774	1774	12783.89	508.47	26	51	0.39	0.42	2014	2014	20225.97
					Without Project AAFCUs:	516.25							With Project AAFCUs:	776.78
													Net AAFCUs:	260.53

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.23	0.30	1774	2014	497.07
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.30	0.32	2014	2014	3083.45
6	26	0.23	0.25	1774	1774	8387.75	437.48	6	26	0.32	0.33	2014	2014	13007.95
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.33	0.34	2014	2014	16844.54
					Without Project AAFCUs:	426.26							With Project AAFCUs:	655.55
													Net AAFCUs:	229.29

Project: Rio Salado Oeste
Alternative: 5B

		Without Project					With Project				
		Target Year					Target Year				
Code	Description	0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega, and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	95.00	95.00	95.00	95.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	263.00	263.00	263.00	263.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	417.00	417.00	417.00	417.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	20.00	20.00	20.00	20.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1077.00	1082.00	1082.00	1082.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	0.00	0.00	0.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste *Alternative 5B*

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	0	1	0.23	0.30	1774	1994	500.37
1	6	0.23	0.23	1774	1774	2069.67	1	6	0.30	0.30	1994	1994	2957.25
6	26	0.23	0.23	1774	1774	8278.67	6	26	0.30	0.39	1994	1994	13750.83
26	51	0.23	0.23	1774	1774	10348.33	26	51	0.39	0.39	1994	1994	19590.83
					Without Project AAFCUs:	413.93						With Project AAFCUs:	721.55
												Net AAFCUs:	307.62

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	0	1	0.42	0.58	1774	1994	948.88
1	6	0.42	0.42	1774	1774	3737.63	1	6	0.58	0.59	1994	1994	5858.34
6	26	0.42	0.42	1774	1774	14902.49	6	26	0.59	0.57	1994	1994	23116.70
26	51	0.42	0.42	1774	1774	18573.62	26	51	0.57	0.57	1994	1994	28325.15
					Without Project AAFCUs:	744.36						With Project AAFCUs:	1142.14
												Net AAFCUs:	397.78

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	0	1	0.25	0.35	1774	1994	569.14
1	6	0.25	0.25	1774	1774	2239.04	1	6	0.35	0.35	1994	1994	3464.83
6	26	0.25	0.25	1774	1774	8798.88	6	26	0.35	0.34	1994	1994	13642.84
26	51	0.25	0.25	1774	1774	10943.39	26	51	0.34	0.34	1994	1994	16782.96
					Without Project AAFCUs:	439.87						With Project AAFCUs:	675.68
												Net AAFCUs:	235.81

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	0	1	0.44	0.52	1774	1994	903.50
1	6	0.44	0.45	1774	1774	3955.00	1	6	0.52	0.52	1994	1994	5153.75
6	26	0.45	0.46	1774	1774	16130.00	6	26	0.52	0.52	1994	1994	20640.00
26	51	0.46	0.47	1774	1774	20506.25	26	51	0.52	0.52	1994	1994	25800.00
					Without Project AAFCUs:	811.26						With Project AAFCUs:	1029.36
												Net AAFCUs:	218.10

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	0	1	0.28	0.23	1774	1994	476.46
1	6	0.28	0.27	1774	1774	2451.88	1	6	0.23	0.27	1994	1994	2478.38
6	26	0.27	0.27	1774	1774	9576.43	6	26	0.27	0.29	1994	1994	11178.08
26	51	0.27	0.26	1774	1774	11718.48	26	51	0.29	0.33	1994	1994	15533.15
					Without Project AAFCUs:	475.34						With Project AAFCUs:	581.69
												Net AAFCUs:	106.35

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	0	1	0.38	0.39	1774	1994	722.71
1	6	0.38	0.37	1774	1774	3320.82	1	6	0.39	0.41	1994	1994	3995.20
6	26	0.37	0.36	1774	1774	13065.78	6	26	0.41	0.43	1994	1994	16864.69
26	51	0.36	0.36	1774	1774	16152.25	26	51	0.43	0.45	1994	1994	22144.26
Without Project AAFCUs:						651.13	With Project AAFCUs:						857.39
							Net AAFCUs:						206.26

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	0	1	0.33	0.44	1774	1994	727.92
1	6	0.33	0.33	1774	1774	2933.78	1	6	0.44	0.45	1994	1994	4424.61
6	26	0.33	0.33	1774	1774	11653.36	6	26	0.45	0.47	1994	1994	18292.45
26	51	0.33	0.33	1774	1774	14478.48	26	51	0.47	0.48	1994	1994	23540.43
Without Project AAFCUs:						581.45	With Project AAFCUs:						921.28
							Net AAFCUs:						339.83

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	0	1	0.42	0.46	1774	1994	832.60
1	6	0.42	0.42	1774	1774	3730.78	1	6	0.46	0.49	1994	1994	4754.76
6	26	0.42	0.42	1774	1774	14839.73	6	26	0.49	0.50	1994	1994	19818.85
26	51	0.42	0.42	1774	1774	18456.48	26	51	0.50	0.51	1994	1994	25173.87
Without Project AAFCUs:						740.69	With Project AAFCUs:						991.77
							Net AAFCUs:						251.07

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	0	1	0.30	0.35	1774	1994	608.87
1	6	0.30	0.30	1774	1774	2636.99	1	6	0.35	0.37	1994	1994	3543.91
6	26	0.30	0.29	1774	1774	10376.28	6	26	0.37	0.39	1994	1994	14991.37
26	51	0.29	0.29	1774	1774	12783.89	26	51	0.39	0.41	1994	1994	19959.21
Without Project AAFCUs:						516.25	With Project AAFCUs:						766.73
							Net AAFCUs:						250.49

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project							With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs	TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	0	1	0.23	0.30	1774	1994	493.15
1	6	0.23	0.23	1774	1774	2006.50	1	6	0.30	0.31	1994	1994	3040.86
6	26	0.23	0.25	1774	1774	8387.75	6	26	0.31	0.33	1994	1994	12831.13
26	51	0.25	0.25	1774	1774	10943.82	26	51	0.33	0.34	1994	1994	16610.71
Without Project AAFCUs:						426.26	With Project AAFCUs:						646.59
							Net AAFCUs:						220.32

Project: Rio Salado Oeste
Alternative: Partial Alternative only restored acres between 19-35 Ave

Code	Description	Without Project Target Year 0	1	6	26	51	With Project Target Year 0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	80.00	50.00	25.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	15.00	15.00	15.00	15.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	30.00	30.00	30.00	30.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	30.00	30.00	30.00	30.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	66.00	66.00	66.00	66.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1491.00	1523.00	1575.00	1600.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	77.00	105.00	143.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM	Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM	NEWWETRVR 8 acres at storm water outfalls, plus 7 acres in low flow channel
OPENWATER	Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.	Reduced water in downstream reaches results in loss of CWFOREST and increased Desert, Dry River Bottom
CWWFOREST	Converts to scrub shrub as water decreases	

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative Partial

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	413.93	0	1	0.2333	0.24809	1774	1774	427.02
1	6	0.23	0.23	1774	1774	2069.67	413.93	1	6	0.2481	0.24572	1774	1769	2186.99
6	26	0.23	0.23	1774	1774	8278.67	413.93	6	26	0.2457	0.25846	1769	1791	8974.90
26	51	0.23	0.23	1774	1774	10348.33	413.93	26	51	0.2585	0.25357	1791	1791	11463.12
						Without Project AAFCUs:	413.93							With Project AAFCUs: 452.00
														Net AAFCUs: 38.07

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	748.64	0	1	0.422	0.46367	1774	1774	785.60
1	6	0.42	0.42	1774	1774	3737.63	746.41	1	6	0.4637	0.45859	1774	1769	4084.47
6	26	0.42	0.42	1774	1774	14902.49	743.84	6	26	0.4586	0.44777	1769	1791	16132.70
26	51	0.42	0.42	1774	1774	18573.62	742.05	26	51	0.4478	0.44088	1791	1791	19894.63
						Without Project AAFCUs:	744.36							With Project AAFCUs: 801.91
														Net AAFCUs: 57.55

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	452.12	0	1	0.2549	0.27854	1774	1774	473.12
1	6	0.25	0.25	1774	1774	2239.04	443.50	1	6	0.2785	0.27441	1774	1769	2448.85
6	26	0.25	0.25	1774	1774	8798.88	436.39	6	26	0.2744	0.26941	1769	1791	9679.67
26	51	0.25	0.25	1774	1774	10943.39	439.08	26	51	0.2694	0.26617	1791	1791	11990.15
						Without Project AAFCUs:	439.87							With Project AAFCUs: 482.19
														Net AAFCUs: 42.32

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	783.00	0	1	0.4414	0.47717	1774	1774	814.75
1	6	0.44	0.45	1774	1774	3955.00	799.00	1	6	0.4772	0.47852	1774	1769	4232.51
6	26	0.45	0.46	1774	1774	16130.00	814.00	6	26	0.4785	0.47878	1769	1791	17039.98
26	51	0.46	0.47	1774	1774	20506.25	826.50	26	51	0.4788	0.47878	1791	1791	21437.50
						Without Project AAFCUs:	811.26							With Project AAFCUs: 853.43
														Net AAFCUs: 42.17

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	495.52	0	1	0.2793	0.25955	1774	1774	477.99
1	6	0.28	0.27	1774	1774	2451.88	485.23	1	6	0.2596	0.26961	1774	1769	2343.50
6	26	0.27	0.27	1774	1774	9576.43	472.41	6	26	0.2696	0.26945	1769	1791	9595.16
26	51	0.27	0.26	1774	1774	11718.48	465.06	26	51	0.2694	0.27254	1791	1791	12133.79
						Without Project AAFCUs:	475.34							With Project AAFCUs: 481.38
														Net AAFCUs: 6.04

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	668.88	0	1	0.377	0.38042	1774	1774	671.87
1	6	0.38	0.37	1774	1774	3320.82	659.45	1	6	0.3804	0.38215	1774	1769	3377.23
6	26	0.37	0.36	1774	1774	13065.78	647.13	6	26	0.3821	0.38185	1769	1791	13599.15
26	51	0.36	0.36	1774	1774	16152.25	645.05	26	51	0.3819	0.37977	1791	1791	17050.81
					Without Project AAFCUs:	651.13							With Project AAFCUs:	680.37
													Net AAFCUs:	29.24

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	588.51	0	1	0.3317	0.35407	1774	1774	608.31
1	6	0.33	0.33	1774	1774	2933.78	585.00	1	6	0.3541	0.35185	1774	1769	3126.35
6	26	0.33	0.33	1774	1774	11653.36	580.33	6	26	0.3519	0.34909	1769	1791	12476.77
26	51	0.33	0.33	1774	1774	14478.48	577.94	26	51	0.3491	0.3448	1791	1791	15534.65
					Without Project AAFCUs:	581.45							With Project AAFCUs:	622.47
													Net AAFCUs:	41.02

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	748.35	0	1	0.4218	0.42809	1774	1774	753.89
1	6	0.42	0.42	1774	1774	3730.78	743.96	1	6	0.4281	0.43031	1774	1769	3801.64
6	26	0.42	0.42	1774	1774	14839.73	740.01	6	26	0.4303	0.4272	1769	1791	15263.55
26	51	0.42	0.42	1774	1774	18456.48	736.51	26	51	0.4272	0.42538	1791	1791	19087.10
					Without Project AAFCUs:	740.69							With Project AAFCUs:	762.87
													Net AAFCUs:	22.17

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	531.41	0	1	0.2996	0.30105	1774	1774	532.7352295
1	6	0.30	0.30	1774	1774	2636.99	523.39	1	6	0.3011	0.30345	1774	1769	2677.18335
6	26	0.30	0.29	1774	1774	10376.28	514.24	6	26	0.3035	0.30239	1769	1791	10783.99
26	51	0.29	0.29	1774	1774	12783.89	508.47	26	51	0.3024	0.30134	1791	1791	13516.08
					Without Project AAFCUs:	516.25							With Project AAFCUs:	539.41
													Net AAFCUs:	23.16

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.2262	0.24431	1774	1774	417.35
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.2443	0.26141	1774	1769	2239.66
6	26	0.23	0.25	1774	1774	8387.75	437.48	6	26	0.2614	0.25783	1769	1791	9242.29
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.2578	0.25547	1791	1791	11491.38
					Without Project AAFCUs:	426.26							With Project AAFCUs:	458.64
													Net AAFCUs:	32.38

5800.55

AAFCUs	6134.67
Total Gain	334.12

Project: Rio Salado Oeste
Alternative: (Refine 1)

Code	Description	Without Project					With Project				
		Target Year					Target Year				
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	115.00	115.00	115.00	115.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	98.00	98.00	98.00	98.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	56.00	56.00	56.00	56.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	0.00	0.00	0.00	0.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	38.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1565.00	1608.00	1608.00	1608.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	0.00	0.00	0.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 10% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

1165

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative Refine 1

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	413.93	0	1	0.2333	0.26332	1774	2014	470.93
1	6	0.23	0.23	1774	1774	2069.67	413.93	1	6	0.2633	0.26332	2014	2014	2651.58
6	26	0.23	0.23	1774	1774	8278.67	413.93	6	26	0.2633	0.3043	2014	2014	11431.83
26	51	0.23	0.23	1774	1774	10348.33	413.93	26	51	0.3043	0.3043	2014	2014	15321.67
					Without Project AAFCUs:	413.93							With Project AAFCUs:	585.80
													Net AAFCUs:	171.87

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	748.64	0	1	0.422	0.50594	1774	2014	880.45
1	6	0.42	0.42	1774	1774	3737.63	746.41	1	6	0.5059	0.5114	2014	2014	5122.31
6	26	0.42	0.42	1774	1774	14902.49	743.84	6	26	0.5114	0.50894	2014	2014	20549.54
26	51	0.42	0.42	1774	1774	18573.62	742.05	26	51	0.5089	0.51028	2014	2014	25658.77
					Without Project AAFCUs:	744.36							With Project AAFCUs:	1023.75
													Net AAFCUs:	279.39

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	452.12	0	1	0.2549	0.2981	1774	2014	524.52
1	6	0.25	0.25	1774	1774	2239.04	443.50	1	6	0.2981	0.2981	2014	2014	3001.89
6	26	0.25	0.25	1774	1774	8798.88	436.39	6	26	0.2981	0.29666	2014	2014	11978.51
26	51	0.25	0.25	1774	1774	10943.39	439.08	26	51	0.2967	0.29666	2014	2014	14936.79
					Without Project AAFCUs:	439.87							With Project AAFCUs:	596.90
													Net AAFCUs:	157.03

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	783.00	0	1	0.4414	0.51167	1774	2014	903.94
1	6	0.44	0.45	1774	1774	3955.00	799.00	1	6	0.5117	0.52234	2014	2014	5206.25
6	26	0.45	0.46	1774	1774	16130.00	814.00	6	26	0.5223	0.52234	2014	2014	21040.00
26	51	0.46	0.47	1774	1774	20506.25	826.50	26	51	0.5223	0.52234	2014	2014	26300.00
					Without Project AAFCUs:	811.26							With Project AAFCUs:	1048.04
													Net AAFCUs:	236.78

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	495.52	0	1	0.2793	0.26949	1774	2014	519.54
1	6	0.28	0.27	1774	1774	2451.88	485.23	1	6	0.2695	0.28537	2014	2014	2793.73
6	26	0.27	0.27	1774	1774	9576.43	472.41	6	26	0.2854	0.29407	2014	2014	11669.80
26	51	0.27	0.26	1774	1774	11718.48	465.06	26	51	0.2941	0.31197	2014	2014	15256.96
					Without Project AAFCUs:	475.34							With Project AAFCUs:	592.94
													Net AAFCUs:	117.60

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	668.88	0	1	0.377	0.39101	1774	2014	727.63
1	6	0.38	0.37	1774	1774	3320.82	659.45	1	6	0.391	0.39825	2014	2014	3973.91
6	26	0.37	0.36	1774	1774	13065.78	647.13	6	26	0.3982	0.41144	2014	2014	16307.15
26	51	0.36	0.36	1774	1774	16152.25	645.05	26	51	0.4114	0.41447	2014	2014	20792.27
					Without Project AAFCUs:	651.13							With Project AAFCUs:	819.63
													Net AAFCUs:	168.49

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	588.51	0	1	0.3317	0.38224	1774	2014	677.15
1	6	0.33	0.33	1774	1774	2933.78	585.00	1	6	0.3822	0.38757	2014	2014	3876.00
6	26	0.33	0.33	1774	1774	11653.36	580.33	6	26	0.3876	0.39633	2014	2014	15787.79
26	51	0.33	0.33	1774	1774	14478.48	577.94	26	51	0.3963	0.39845	2014	2014	20008.49
					Without Project AAFCUs:	581.45							With Project AAFCUs:	791.17
													Net AAFCUs:	209.71

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	748.35	0	1	0.4218	0.44341	1774	2014	819.82
1	6	0.42	0.42	1774	1774	3730.78	743.96	1	6	0.4434	0.45095	2014	2014	4503.06
6	26	0.42	0.42	1774	1774	14839.73	740.01	6	26	0.4509	0.4517	2014	2014	18179.38
26	51	0.42	0.42	1774	1774	18456.48	736.51	26	51	0.4517	0.45464	2014	2014	22817.18
					Without Project AAFCUs:	740.69							With Project AAFCUs:	908.22
													Net AAFCUs:	167.53

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	531.41	0	1	0.2996	0.31276	1774	2014	580.12
1	6	0.30	0.30	1774	1774	2636.99	523.39	1	6	0.3128	0.32518	2014	2014	3212.03
6	26	0.30	0.29	1774	1774	10376.28	514.24	6	26	0.3252	0.33524	2014	2014	13300.96
26	51	0.29	0.29	1774	1774	12783.89	508.47	26	51	0.3352	0.34517	2014	2014	17129.39
					Without Project AAFCUs:	516.25							With Project AAFCUs:	671.03
													Net AAFCUs:	154.78

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.2262	0.25945	1774	2014	460.58
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.2594	0.27964	2014	2014	2714.27
6	26	0.23	0.25	1774	1774	8387.75	437.48	6	26	0.2796	0.30841	2014	2014	11843.16
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.3084	0.31356	2014	2014	15657.93
					Without Project AAFCUs:	426.26							With Project AAFCUs:	601.49
													Net AAFCUs:	175.23

5800.55 AAFCUs 7638.97

Total Gain 1838.42

Project: Rio Salado Oeste
Alternative: (Refine 2)

Code	Description	Without Project					With Project				
		Target Year					Target Year				
		0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	115.00	115.00	115.00	115.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	92.00	92.00	92.00	92.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	110.00	110.00	110.00	110.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	0.00	0.00	0.00	0.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1555.00	1560.00	1560.00	1560.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	0.00	0.00	0.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste Alternative Refine 2

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	413.93	0	1	0.2333	0.26649	1774	2014	474.00
1	6	0.23	0.23	1774	1774	2069.67	413.93	1	6	0.2665	0.26649	2014	2014	2683.58
6	26	0.23	0.23	1774	1774	8278.67	413.93	6	26	0.2665	0.31264	2014	2014	11663.83
26	51	0.23	0.23	1774	1774	10348.33	413.93	26	51	0.3126	0.31264	2014	2014	15741.67
					Without Project AAFCUs:	413.93							With Project AAFCUs:	599.28
													Net AAFCUs:	185.34

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	748.64	0	1	0.422	0.51101	1774	2014	885.35
1	6	0.42	0.42	1774	1774	3737.63	746.41	1	6	0.511	0.5164	2014	2014	5173.00
6	26	0.42	0.42	1774	1774	14902.49	743.84	6	26	0.5164	0.51014	2014	2014	20674.40
26	51	0.42	0.42	1774	1774	18573.62	742.05	26	51	0.5101	0.51168	2014	2014	25724.36
					Without Project AAFCUs:	744.36							With Project AAFCUs:	1028.57
													Net AAFCUs:	284.21

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	452.12	0	1	0.2549	0.30219	1774	2014	528.47
1	6	0.25	0.25	1774	1774	2239.04	443.50	1	6	0.3022	0.30219	2014	2014	3043.03
6	26	0.25	0.25	1774	1774	8798.88	436.39	6	26	0.3022	0.29935	2014	2014	12115.03
26	51	0.25	0.25	1774	1774	10943.39	439.08	26	51	0.2994	0.29935	2014	2014	15072.40
					Without Project AAFCUs:	439.87							With Project AAFCUs:	603.12
													Net AAFCUs:	163.25

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	783.00	0	1	0.4414	0.5211	1774	2014	913.06
1	6	0.44	0.45	1774	1774	3955.00	799.00	1	6	0.5211	0.52234	2014	2014	5253.75
6	26	0.45	0.46	1774	1774	16130.00	814.00	6	26	0.5223	0.52234	2014	2014	21040.00
26	51	0.46	0.47	1774	1774	20506.25	826.50	26	51	0.5223	0.52234	2014	2014	26300.00
					Without Project AAFCUs:	811.26							With Project AAFCUs:	1049.15
													Net AAFCUs:	237.89

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	495.52	0	1	0.2793	0.25861	1774	2014	509.01
1	6	0.28	0.27	1774	1774	2451.88	485.23	1	6	0.2586	0.28131	2014	2014	2718.51
6	26	0.27	0.27	1774	1774	9576.43	472.41	6	26	0.2813	0.29157	2014	2014	11537.85
26	51	0.27	0.26	1774	1774	11718.48	465.06	26	51	0.2916	0.31084	2014	2014	15165.65
					Without Project AAFCUs:	475.34							With Project AAFCUs:	586.88
													Net AAFCUs:	111.54

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	668.88	0	1	0.377	0.38802	1774	2014	724.74
1	6	0.38	0.37	1774	1774	3320.82	659.45	1	6	0.388	0.397	2014	2014	3952.58
6	26	0.37	0.36	1774	1774	13065.78	647.13	6	26	0.397	0.41115	2014	2014	16276.23
26	51	0.36	0.36	1774	1774	16152.25	645.05	26	51	0.4112	0.41669	2014	2014	20840.97
Without Project AAFCUs:						651.13		With Project AAFCUs:						819.50
Net AAFCUs:								168.37						

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	588.51	0	1	0.3317	0.38716	1774	2014	681.91
1	6	0.33	0.33	1774	1774	2933.78	585.00	1	6	0.3872	0.39217	2014	2014	3923.96
6	26	0.33	0.33	1774	1774	11653.36	580.33	6	26	0.3922	0.40212	2014	2014	15996.97
26	51	0.33	0.33	1774	1774	14478.48	577.94	26	51	0.4021	0.40483	2014	2014	20314.78
Without Project AAFCUs:						581.45		With Project AAFCUs:						802.31
Net AAFCUs:								220.85						

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	748.35	0	1	0.4218	0.44385	1774	2014	820.25
1	6	0.42	0.42	1774	1774	3750.78	743.96	1	6	0.4438	0.45425	2014	2014	4521.93
6	26	0.42	0.42	1774	1774	14839.73	740.01	6	26	0.4543	0.45628	2014	2014	18338.23
26	51	0.42	0.42	1774	1774	18456.48	736.51	26	51	0.4563	0.45947	2014	2014	23054.19
Without Project AAFCUs:						740.69		With Project AAFCUs:						916.36
Net AAFCUs:								175.67						

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	531.41	0	1	0.2996	0.31533	1774	2014	582.61
1	6	0.30	0.30	1774	1774	2636.99	523.39	1	6	0.3153	0.3273	2014	2014	3235.61
6	26	0.30	0.29	1774	1774	10376.28	514.24	6	26	0.3273	0.33838	2014	2014	13406.64
26	51	0.29	0.29	1774	1774	12783.89	508.47	26	51	0.3384	0.3498	2014	2014	17324.89
Without Project AAFCUs:						516.25		With Project AAFCUs:						677.45
Net AAFCUs:								161.20						

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.2262	0.26237	1774	2014	463.41
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.2624	0.28239	2014	2014	2742.86
6	26	0.23	0.25	1774	1774	8387.75	437.48	6	26	0.2824	0.30935	2014	2014	11917.58
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.3094	0.31441	2014	2014	15703.13
Without Project AAFCUs:						426.26		With Project AAFCUs:						604.45
Net AAFCUs:								178.19						

5800.55 AAFCUs 7687.07

Total Gain 1886.52

Project: Rio Salado Oeste
Alternative: (Refine 3)

		Without Project					With Project				
		Target Year					Target Year				
Code	Description	0	1	6	26	51	0	1	6	26	51
AGCROP	Farms and Croplands in the Uplands - Dairy, Cotton, and Alfalfa	133.00	133.00	0.00	0.00	0.00	133.00	133.00	0.00	0.00	0.00
CWWFOREST	Existing Cottonwood-Willow Forests in the Active Channel	112.00	112.00	80.00	50.00	25.00	112.00	112.00	112.00	112.00	112.00
DITCHES	Ditches in the Uplands	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
WETRVRBOTTOM	Existing Emergent Wetlands in the Uplands - Cattails, Cienega and Grasses	30.00	30.00	25.00	25.00	25.00	30.00	30.00	25.00	25.00	25.00
MESQUITE	Existing 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
NEWWETRVRBOTTOM	Newly constructed river channel, includes emergent wetlands within the channel	0.00	0.00	0.00	0.00	0.00	0.00	67.00	67.00	67.00	67.00
NEWCWWFOR	Newly Planted Cottonwood-Willow Forests in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	57.00	57.00	57.00	57.00
NEWDRYRVRBOTTOM	Newly Planted Emergent Wetlands 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 Planted Mesquite Woodlands - on the Terraces and in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	102.00	102.00	102.00	102.00
NEWOPENWAT	Newly Developed Open Water in the Active Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPENWATER	Existing Open Water in the Active Channel - Inactive Sand and Gravel Operations	240.00	240.00	168.00	118.00	80.00	240.00	240.00	168.00	118.00	80.00
DRY RIVER BOTTOM	Existing River Bottom in the Active Channel - Largely Unvegetated	66.00	66.00	71.00	71.00	71.00	66.00	0.00	0.00	0.00	0.00
SCRUBSHRUB	Existing Scrub-Shrublands in the Active Channel - Rabbitbush, Quailbush, Ironwood, and Saltbush	1566.00	1566.00	1598.00	1628.00	1653.00	1566.00	1406.00	1406.00	1428.00	1428.00
SANDGRAVEL	Existing Sand and Gravel Operations/Extractions in the Active Channel	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00	671.00
DESERT	Desert or bare earth	0.00	0.00	72.00	122.00	160.00	0.00	0.00	77.00	105.00	143.00
URBAN	Existing Residential, Industrial and Transportation Avenues in the Uplands	327.00	327.00	460.00	460.00	460.00	327.00	327.00	460.00	460.00	460.00
	TOTALS:	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00

WETRVRBOTTOM Assume reduction in discharge at 43rd Ave, and less wet river bottom in that vicinity. 5 acres convert to DRYRVRBOTTOM

OPENWATER Assume less water discharged to the channel and filling the lakes. Dry lake beds classified as Desert or bare earth.

CWWFOREST Converts to scrub shrub as water decreases

NEWWETRVRBOTTOM
28 acres of stormwater wetlands

Channel Restoration is approximately 170 acres. Assume 20% will be emergent wetland from Rio Salado inflows, dry weather flows, and excess stormwater runoff.

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Arizona Rivers Ecosystem Restoration Studies

Rio Salado Oeste *Alternative Refine 3*

AAFCU Calculation Summary

Fxn 01: Maintenance of Characteristic Dynamics

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	413.93	413.93	0	1	0.2333	0.26188	1774	1774	439.26
1	6	0.23	0.23	1774	1774	2069.67	413.93	1	6	0.2619	0.26197	1774	1769	2320.00
6	26	0.23	0.23	1774	1774	8278.67	413.93	6	26	0.262	0.3025	1769	1791	10049.03
26	51	0.23	0.23	1774	1774	10348.33	413.93	26	51	0.3025	0.3025	1791	1791	13544.58
					Without Project AAFCUs:	413.93							With Project AAFCUs:	516.72
													Net AAFCUs:	102.79

AAFCU Calculation Summary

Fxn 02: Dynamic Surface Water Storage/Energy Dissipation

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.64	748.64	0	1	0.422	0.49763	1774	1774	815.71
1	6	0.42	0.42	1774	1774	3737.63	746.41	1	6	0.4976	0.50298	1774	1769	4431.43
6	26	0.42	0.42	1774	1774	14902.49	743.84	6	26	0.503	0.49526	1769	1791	17768.38
26	51	0.42	0.42	1774	1774	18573.62	742.05	26	51	0.4953	0.49675	1791	1791	22208.58
					Without Project AAFCUs:	744.36							With Project AAFCUs:	886.75
													Net AAFCUs:	142.39

AAFCU Calculation Summary

Fxn 03: Long Term Surface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.25	0.25	1774	1774	452.12	452.12	0	1	0.2549	0.29653	1774	1774	489.08
1	6	0.25	0.25	1774	1774	2239.04	443.50	1	6	0.2965	0.29665	1774	1769	2627.06
6	26	0.25	0.25	1774	1774	8798.88	436.39	6	26	0.2967	0.29318	1769	1791	10498.87
26	51	0.25	0.25	1774	1774	10943.39	439.08	26	51	0.2932	0.29318	1791	1791	13127.16
					Without Project AAFCUs:	439.87							With Project AAFCUs:	524.36
													Net AAFCUs:	84.49

AAFCU Calculation Summary

Fxn 04: Dynamic Subsurface Water Storage

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.44	0.44	1774	1774	783.00	783.00	0	1	0.4414	0.51043	1774	1774	844.25
1	6	0.44	0.45	1774	1774	3955.00	799.00	1	6	0.5104	0.51187	1774	1769	4527.51
6	26	0.45	0.46	1774	1774	16130.00	814.00	6	26	0.5119	0.51173	1769	1791	18220.01
26	51	0.46	0.47	1774	1774	20506.25	826.50	26	51	0.5117	0.51173	1791	1791	22912.50
					Without Project AAFCUs:	811.26							With Project AAFCUs:	911.85
													Net AAFCUs:	100.59

AAFCU Calculation Summary

Function 5: Nutrient Cycling

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.28	0.28	1774	1774	495.52	495.52	0	1	0.2793	0.25144	1774	1774	470.7937317
1	6	0.28	0.27	1774	1774	2451.88	485.23	1	6	0.2514	0.27144	1774	1769	2315.694824
6	26	0.27	0.27	1774	1774	9576.43	472.41	6	26	0.2714	0.27981	1769	1791	9812.58
26	51	0.27	0.26	1774	1774	11718.48	465.06	26	51	0.2798	0.29775	1791	1791	12930.17
					Without Project AAFCUs:	475.34							With Project AAFCUs:	500.57
													Net AAFCUs:	25.23

AAFCU Calculation Summary

Function 6: Detention of Imported Elements and Compounds

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.38	0.38	1774	1774	668.88	668.88	0	1	0.377	0.38368	1774	1774	674.77
1	6	0.38	0.37	1774	1774	3320.82	659.45	1	6	0.3837	0.39243	1774	1769	3437.19
6	26	0.37	0.36	1774	1774	13065.78	647.13	6	26	0.3924	0.40339	1769	1791	14165.89
26	51	0.36	0.36	1774	1774	16152.25	645.05	26	51	0.4034	0.409	1791	1791	18187.24
					Without Project AAFCUs:	651.13							With Project AAFCUs:	715.00
													Net AAFCUs:	63.87

AAFCU Calculation Summary

Function 7: Detention of Particles

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.33	0.33	1774	1774	588.51	588.51	0	1	0.3317	0.37856	1774	1774	630.04
1	6	0.33	0.33	1774	1774	2933.78	585.00	1	6	0.3786	0.3834	1774	1769	3374.49
6	26	0.33	0.33	1774	1774	11653.36	580.33	6	26	0.3834	0.39127	1769	1791	13789.26
26	51	0.33	0.33	1774	1774	14478.48	577.94	26	51	0.3913	0.3938	1791	1791	17575.61
					Without Project AAFCUs:	581.45							With Project AAFCUs:	693.52
													Net AAFCUs:	112.06

AAFCU Calculation Summary

Function 8: Maintain Characteristic Plant Communities

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.42	0.42	1774	1774	748.35	748.35	0	1	0.4218	0.43854	1774	1774	763.16
1	6	0.42	0.42	1774	1774	3730.78	743.96	1	6	0.4385	0.44925	1774	1769	3931.76
6	26	0.42	0.42	1774	1774	14839.73	740.01	6	26	0.4492	0.45097	1769	1791	16023.95
26	51	0.42	0.42	1774	1774	18456.48	736.51	26	51	0.451	0.45402	1791	1791	20260.45
					Without Project AAFCUs:	740.69							With Project AAFCUs:	803.52
													Net AAFCUs:	62.82

AAFCU Calculation Summary

Function 9: Maintain Spatial Structure of Habitat

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.30	0.30	1774	1774	531.41	531.41	0	1	0.2996	0.31218	1774	1774	542.61
1	6	0.30	0.30	1774	1774	2636.99	523.39	1	6	0.3122	0.3226	1774	1769	2811.29
6	26	0.30	0.29	1774	1774	10376.28	514.24	6	26	0.3226	0.33178	1769	1791	11648.36
26	51	0.29	0.29	1774	1774	12783.89	508.47	26	51	0.3318	0.34256	1791	1791	15096.86
					Without Project AAFCUs:	516.25							With Project AAFCUs:	590.18
													Net AAFCUs:	73.93

AAFCU Calculation Summary

Function 10: Maintain Interspersion and Connectivity

Without Project								With Project						
TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs		TY 1	TY 2	FCI 1	FCI 2	Area 1	Area 2	Cumulative FCUs
0	1	0.23	0.23	1774	1774	401.30	401.30	0	1	0.2262	0.25793	1774	1774	429.43
1	6	0.23	0.23	1774	1774	2006.50	401.30	1	6	0.2579	0.27821	1774	1769	2374.39
6	26	0.23	0.25	1774	1774	8387.75	437.48	6	26	0.2782	0.30495	1769	1791	10381.27
26	51	0.25	0.25	1774	1774	10943.82	438.03	26	51	0.3049	0.30495	1791	1791	13654.13
					Without Project AAFCUs:	426.26							With Project AAFCUs:	526.26
													Net AAFCUs:	100.00

5800.55

AAFCUs 6668.72
Total Gain 868.17

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Salt River-Phoenix, Arizona

Appendix J

Design

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

Appendix J
Design

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1.0 OBJECTIVE

The primary objective the Rio Salado Oeste project is to establish the feasibility of environmental restoration, flood damage reduction, and recreation along the Salt River in Phoenix, Arizona. 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 Rio Salado Oeste Salt River Restoration project is located along the Salt River, southwest of Phoenix, Arizona, within Maricopa County, between 19th and 83rd Avenues. The Salt River (Rio Salado in Spanish) 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. The study area is located between the authorized Rio Salado project area and the Tres Rios Feasibility Study area. The Oeste study area is approximately seven miles in length, averages 2 miles in width, and encompasses approximately 10,000 acres. However, the project area is a smaller extent including the 100-year floodplain, which is near an average of ¾ mile width and nearly 3200 acres.

3.0 DESIGN CRITERIA

3.1 Structural Requirements

The structural materials required for storm drain piping and outlet structures, involves reinforced concrete pipe (RCP), gravel, riprap, reinforce concrete, and grouted stone.

The structural material required for the drop structure at 35th Avenue involves roller compacted concrete (RCC) and compacted back fill. These are rigid materials that have been successfully used before on previous projects under these types of hydraulic conditions.

The structural requirements for the bank stabilization and concrete spillway include static and dynamic stability.

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 structure that discharge into the study reaches.

Evaluations of the hydraulic considerations of the low flow channel and drainage areas are discussed in the Hydraulic Appendix.

3.3 Geotechnical Requirements

River rock is readily available throughout the study are and has been used for construction of numerous features in the Rio Salado project upstream. It is assumed that the same materials will be suitable for construction on the Rio Salado Oeste project. Should additional materials be necessary, 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 the project. Two quarries have provided stone for previous Corps flood control projects.

3.4 Environmental Considerations

The project area includes approximately 8 miles of river channel and encompasses 3147 acres within the 100-year floodplain. Scattered remnants of natural vegetation remain, those cover types include cotton-willow forest, mesquite, scrub-shrub lands, and emergent wetlands. Of those cover types scrub-shrub lands are the most dominant in the study area covering approximately 1500 acres. The scarcest is cottonwood-willow forest extant within merely 112 acres of which salt cedar dominates.

3.5 Contaminants

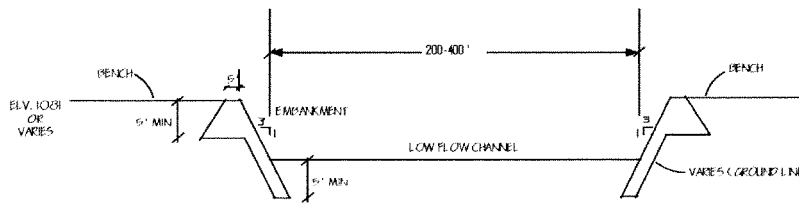
Sites identified with possible HTRW concerns are for the most part outside the 100 year floodplain and location where project features would be located. Project features are for the most part located within the 100 year floodplain and avoid the known HTRW sites. In accordance with Engineer Regulation 1165-2-132 the Corps will not participate in clean up of materials regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or by the Resource Conservation and Recovery Act (RCRA). Project cost estimates have included a percentage estimate for potential removal of inert debris not falling under CERCLA or RCRA should they be unearthed during construction. A remediation and management plan will need to be developed during design for unknown HTRW and other deleterious material should they be encountered during construction.

4.0 DESIGN FEATURES

4.1 Channel Restoration

Reshaping the Salt River riverbed is required through the entire project reach to restore a natural river channel. Channel restoration will be accomplished through grading and terracing of an area within the 10-year discharge area of inundation and following historic channel conditions. This includes a low flow channel design for the 5-year return period discharge (20,200 cfs) and is also assumed that the final channel may meander slightly and be braided as it was historically. This includes a total cutting and fill volume of approximately 660,000 cubic yards. It has been assumed that materials from reshaping will be disposed of onsite throughout the project area to form terraces and fill depressions and abandoned sand and gravel pits.

Liner materials will be investigated for use in wetlands and surface irrigation canals. An impermeable layer was added to surface irrigation canals in the Rio Salado project to reduce infiltratoin and increase efficiency. For estimating purposes in the feasibility study it was assumed that a 12 inch silt-clay soil substrate would be added to the stormwater wetlands to reduce permeability. Similar materials will be utilized to line surface irrigation canals in the water distribution system. Since the project area has extensive modification and existing aggregate mining operations throughout it is assumed that the soil-clay substrate is available onsite or near the project area. This may include fine materials discarded from aggregate operations and currently stockpiled at various locations.



TYPICAL LOW FLOW CHANNEL CROSS-SECTION

4.2 Wetland

Wetlands are restored throughout the project area with a total area of approximately 190 acres. Typical cross section of restored new wetland is shown in project plates.

4.3 Control Invasive Vegetation

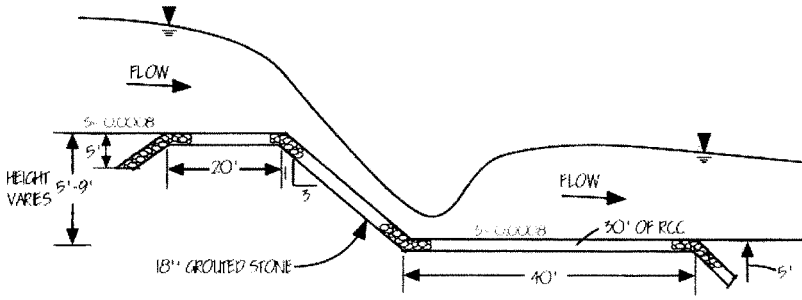
Control invasive vegetation is required in the vicinity of 37th Avenue where there is an existing stand of Salt Cedar and 43rd Avenue where there is a stand of Arundo with a total area of approximately 120 acres. The locations will be defined in the next phase of the study.

4.4 Planting

Planting includes approximately 375 acres of Cottonwood/ Willow and 417 acres of Mesquite. The locations of the plantings are shown on the project plates. Although detail design will be developed in the next project phase it was assumed that planting will include a combination of pole and containerized plants, as well as hydro seeding.

4.5 Drop Structure

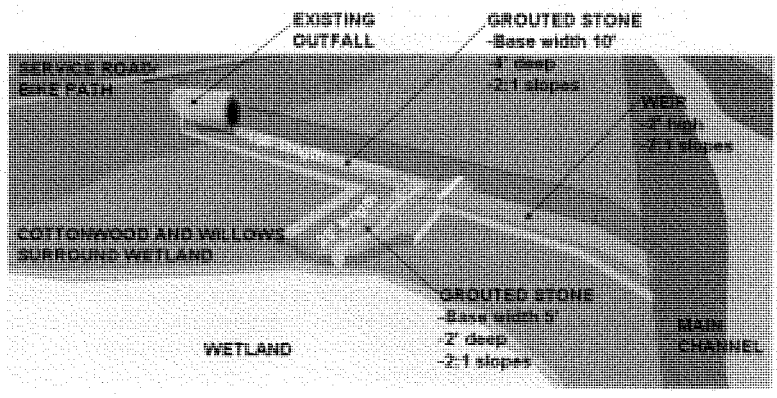
A drop structure will be constructed down stream of the 35th Avenue Bridge. This structure is design to protect the bridge abutments and footings from damage during a flood event. That drop structure follows the same design as those constructed for the Rio Salado Project upstream and is shown below.



DROP STRUCTURE DETAIL
not to scale

4.6 Grouted Rock Outfall

At eight locations within the project site, grouted rock outfalls will extend from the banks into the channel from existing pipe outfalls. The grouted rock will extend approximately 100 feet from the existing pipe outfall and vary from 2-4 feet in height. The required grout is approximately thirty percent of the needed rock. Each outfall will require 221 cubic yards of rock and 67 cubic yards of grout. An estimated 1 ft. of fill will be required under the grout layer. The eight outfall sites will require a total of 1768 cubic yards of rock and 536 cubic yards of grout. The following diagram represents the typical grouted rock outfall location although each channel will be designed specifically for the discharge of the pipe during design phase.



4.7 Water Supply and Distribution System

Description of the water supply and distribution system is attached at the end of this report. It provides detailed discussion of the proposed system provided by the project sponsor, City of Phoenix.

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 and 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 two years to develop healthy rootstock.

5.2 Access Roads

Recreational trails on both sides of the channel, and throughout will be used as access roads for operation and maintenance purposes. Specific alignment of access roads will be determined in the PED phase, but is anticipated to include underpasses at the major road crossings such as 19th, 35th, 51st, and 67th Avenues.

6.0 UTILITY RELOCATION

No utility relocation has been identified in the 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 RECOMMENDED PLAN

Construction time of the recommended plan is being estimated to be approximately 4 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 the 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. Up to 25% of vegetation may require replacement following a flood event at some time during the project life. (Extent of plant replacement will be strongly determined by size of event. Only in the case of catastrophic damage should the City consider an alternative to natural succession).

8.3 Invasive Species Control: Annual removal of exotic species was assumed to be necessary. This would include removal of non native species that threaten to overtake an area and become a monoculture. This wouldn't necessarily include removal of 100% of non natives through the project area.

8.4 Storm water wetlands: Regrading and excavation was assumed to be needed once every 10 years. It was assumed that 50% of the construction quantity would need to be regraded in this period.

8.5 Irrigation System: Maintenance of the irrigation infrastructure including replacement of infrastructure will occur annually. Costs were estimated on a per acre basis for those acres planted to vegetation.

8.6 Lakes/Wetlands: The restored wetlands at existing lakes (gravel pits) will require regrading and excavation once every 20 years of up to 1 foot of material over the 40 acres of wetlands.

8.7 Channel: The active channel will require regrading up to once every 20 years for up to 50% of the estimated construction quantity or 330,000 cy.

9.0 VALUE ENGINEERING

9.1 In accordance with CESPD-CM-P Memorandum Value Engineering Studies During Planning (September 30, 2003) a Value Engineering Study was conducted for the Rio Salado Oeste Feasibility Study. That VE study is dated December 2, 2004. Pertinent VE proposals were considered in plan formulation and all remaining proposals will be revisited during the design phase of the project.

PROPOSED ALTERNATIVES' DESIGN FEATURES

DESIGN FEATURES	ALTERNATIVES				
	2	4	5	5A	5B
1. Channel Restoration	X	X	X	X	X
2. Stormwater Outfall	X	X	X	X	X
3. Wetland Ponds	X	X	X	X	X
4. Clearing and Grubbing	X	X	X	X	X
5. Planting (including temporary irrigation)	X	X	X	X	X
6. Grade Control Structure	X	X	X	X	X
7. Debris Removal	X	X	X	X	X
8. Inspections and Surveys	X	X	X	X	X
9. Invasive Species Control	X	X	X	X	X
10. Wetlands	X	X	X	X	X
11. Channel	X	X	X	X	X
12. Water Supply		X	X	X	X
13. Additional Irrigation		X	X	X	X
14. Effluent Water		X	X	X	X
15. Emmergent Wetlands		X	X	X	X
16. Lake Restoration			X		
17. Restoration of Two Gravel Pit Lakes and Wetland/ Riparian				X	
18. Restoration of one Gravel Pit Lake and one Wetland/Riparian					X
19. Pump Station		X	X	X	X
20. Electronic Flow Regulated Valves		X	X	X	X
21. Reservoir		X	X	X	X
22. Ground Water Pond/Reservoir on Overbank		X	X	X	X
23. Waterline Pipes		X	X	X	X
24. Waterline Pipes Loops		X	X	X	X
25. Bridge Crossing		X	X	X	X
26. Terrace and LFC Canal Delivery Conveyance Channels		X	X	X	X
27. Overbank Canal Delivery Conveyance Channels		X	X	X	X
28. Waterfall to Move Water from Overbank to Terrace		X	X	X	X
29. Internal Drainage Conveyance Channels		X	X	X	X
30. Waste & Tire Removal		X	X	X	X
31. Supply Well		X	X	X	X
32. Monitoring Wells		X	X	X	X

10.0 WATER SUPPLY AND DISTRIBUTION SYSTEM (CITY OF PHOENIX)

Introduction:

Before the turn of the 20th century the Salt River was one of the few perennially watered riparian areas of the Sonoran desert with highly productive cottonwood, willow, and mesquite forest. These habitats were once rich in ecological diversity and supported a wide variety of wildlife species. Today, the River is in a state of environmental degradation from water projects constructed upstream. The River's hydrology has effectively been eliminated, taking with it the highly valued native riparian ecosystem. With virtually no flows in the river, except during storms and periodic upstream dam releases, a reliable water supply and distribution system is needed to support the Rio Salado Oeste Project (Oeste). The primary objective is to restore a portion of the Salt River riparian ecosystem.

At the time of this report, the United States Army Corps of Engineers (Corps of Engineers) and the City of Phoenix are developing the Rio Salado Environmental Restoration Project (Rio Salado) between 19th Avenue and 28th Street. The Tres Rios project which runs from 83rd Avenue to about 117th Avenue is soon to begin construction. Oeste, between 19th and 83ed Avenues, will employ many of the same environmental restoration principals that were developed for the Rio Salado and Tres Rios projects. The Rio Salado project employs ground water to sustain a variety of project habitat features, while Tres Rios, will be supported by reclaimed water from the City's 91st Avenue Water Reclamation Plant.

Water Supply Alternatives:

Three water source alternatives were evaluated for Oeste. The first was to maximize ground water pumping from the Rio Salado project wells and deliver by either pipe or open channels to Oeste. Rio Salado drilled five wells into the shallow aquifer and is currently evaluating wellhead treatment for at least two wells to remove volatile organic compounds (VOC). The upper aquifer lies close to the surface and is about 300-400 feet thick. This ground water is under utilized and according to the City's Water Services Department, is not suitable for urban water supplies. It contains varying concentrations of pollutants resulting from agricultural, urban, and adjacent landfill impacts making it available for environmental restoration purposes.

The Rio Salado wells can yield, if pumped 24 hours a day, 7 days a week, approximately 12.5 mgd. This could provide the Oeste Project with approximately 5.7 mgd to 8 mgd if piped or 4.5 mgd to 6.5 mgd if conveyed in open channels.

There are concerns however with using the Rio Salado supply wells. The main River channel or a low flow channel (LFC) could be used for conveyance reducing construction cost, but a substantial pump would be required in the River to move the water into Oeste's distribution system. Plus, if the water were to be conveyed through open channels, it is estimated that evaporation and percolation losses would be 20%-30% of the piped amount.

These losses could be reduced if the water was piped, but could double the conveyance cost of getting water from Rio Salado to Oeste compared to using an open channel delivery system. Trenching though the overbanks in the Rio Salado involves a high degree of waste removal, over excavation for structural stability, and more expensive construction methods to reduce impacts to existing landfills such as, double containment pipes to capture water that could result from a line break.

The cone of depression that could result and the impact to one of the contaminated groundwater plumes that exist within close proximity of the area is of critical concern. This would affect water quality and quantity for the current Rio Salado project and the future Oeste project. If this happened it could affect the Rio Salado wellhead treatment technology, possibly requiring a modification to respond to the introduction of new constituents. Legally there would be risks associated with drawing a contaminated groundwater plume into the area where it could affect the water quality of area wells.

The cone of depression concerns, conveyance costs, increases in Rio Salado pump maintenance costs (a 33% reduction in the pump's useful life expectancy due to the longer run times would increase replacement costs). Add to these the costs associated with the Rio Salado treatment operations, increase in hazardous material removal from the treatment facilities, and the potential water table drawdown concluded this alternative was too costly for further consideration.

The second alternative looked at duplicating what was done for the Rio Salado project and installing new supply wells for Oeste. The most critical issue with this alternative is the relationship Oeste's water supply would have with the City's conservation requirements.

The average daily demand for the Rio Salado is approximately 4.35 million gallons per day (mgd) with a peak demand of approximately 6.5 mgd.

State mandated conservation requirements, limits water use on a per capita basis and limits the total amount of groundwater available for the City's future use. Groundwater and most surface water use is calculated every year to evaluate compliance with the City's "gallons per capita per day" (GPCD) water use limitation. In 2003, the target water use rate for the City was 215 GPCD. This conservation requirement becomes progressively more restrictive in future years. The expected target GPCD will decrease from an estimated 209 GPCD in 2005, to 202 GPCD in 2010.

The City must also comply with groundwater use limitations that are part of the 100-year Assured Water Supply (AWS) Designation. The AWS designation quantifies a limited groundwater supply that is intended to serve as a "backup" water supply to offset reductions in surface water availability during times of drought. This backup groundwater supply equates to less than 10 percent of total water use annually.

The key concerns with pumped water are as follows:

- Any recovered effluent credits could potentially reduce the volume of water available for the Rio Salado project over the long-term. Availability of these credits is tied to the amount of effluent that the Roosevelt Irrigation District (RID), an agricultural area in southwest Phoenix, is willing to take each year based on an agricultural demand. RID has not yet demonstrated an ability to use enough effluent consistently to generate credits for both the Rio Salado and Oeste projects over a long period. It is estimated that Oeste's needs could result in a tripling of the demand for these credits.

- If groundwater is pumped (either in the form of incidental recharge credits or the allowance credit, this water will be charged against the GPCD conservation requirement as discussed above. The Oeste demand alone would increase the City of Phoenix's per-capita rate by 6 GPCD, which could create a compliance concern with the state limit.

- Recovered Central Arizona Project (CAP) credits were deemed impractical for Rio Salado, and the same applies to Oeste. This water, like groundwater, would be subject to the GPCD conservation requirements. In addition, the cost to the project in acquiring and storing this water would be substantial. Phoenix is relying on CAP supplies to meet future potable system demands that would be used more efficiently in other areas of the City.

To protect effluent and groundwater credits, and to avoid conservation compliance issues, the use of pumped groundwater for Oeste should be considered only for: 1) maintaining a certain water quality for selected project features; and 2) maintaining system redundancy (in the event of loss of direct effluent during an unplanned outage).

For the third alternative the City of Phoenix Water Services Department evaluated their 91st Avenue and 23rd Avenue Water Reclamation Plants for a sustainable water source. The City determined that 8 million gallons per day (mgd) could be directed to the Oeste project from the 23rd Avenue Water Reclamation Plant if certain conditions could be met. The 91st Avenue plant was determined to be too costly to deliver water up gradient to the far cast reaches of Oeste. Supplemental water could come from a variety of underground sources including: 1) effluent credits "recovered" (pumped) from within the area of hydrologic impact of the RID Groundwater Savings Facility; 2) incidental recharge credits associated with increased recharge from project implementation; 3) groundwater (based on the City's Assured Water Supply allowance); and 4) recovered credits for Central Arizona Project water (stored by the City). The use of pumped water (rather than direct effluent) has several limitations. One of these relates to the City's ability to comply with state mandated water conservation requirements. Storm water is also considered and may prove sufficient to support ephemeral wetlands or riparian habitat in portions of the project, but because it is not a reliable water source it is only identified as a supplement to the effluent.

The Selected Alternative:

The water supply and distribution system is critical to the success and sustainability of the Oeste Environmental Restoration Project. A sufficient quantity and adequate quality of water must be available to maintain the viability of the various habitat types that are being considered for Oeste. The primary water supply for the Oeste project is effluent obtained directly from the 23rd Avenue Water Reclamation Plant. Supplemental water could come from a variety of underground sources including: 1) effluent credits "recovered" (pumped) from within the area of hydrologic impact of the RID Groundwater Savings Facility; 2) incidental recharge credits associated with increased recharge from project implementation; 3) groundwater (based on the City's Assured Water Supply allowance); and 4) recovered credits for Central Arizona Project water (stored by the City).

Treated effluent from the City's 23rd Avenue Water Reclamation Plant and one ground water well have been identified as the primary water sources for Oeste. The use of pumped water (rather than direct effluent) has several limitations. One of these relates to the City's ability to comply with state mandated water conservation requirements as discussed above. Secondary influxes of dry weather flows and storm water flows from the network of storm drains that empty into the River, residual Rio Salado flows, and discharges east of 35th Avenue on the north bank from the 23rd Avenue Water Reclamation Plant and at 43rd Avenue on the north bank are also included.

The sustainable water supply and distribution system consists of the following features:

- (1) 20 MGD Pump Station
- (1) Supply well
- (2) Monitoring Wells
- (6) Electronic Flow Regulated Valves
- (5) Reservoirs
- (5) Pump stations
- Open channel canals
- Irrigation system
- Pressurized distribution piping

Design Assumptions:

The following design assumptions were made for the water supply and distribution system:
Project Water will be a combination of:

- 8 mgd (or 8,976 acre-feet per year) of reclaimed water from the 23rd Avenue Water Reclamation Plant.
- 1.85 mgd (or 2,075 acre-feet per year) from a ground water supply well. The well will be used for maintaining system redundancy in case of a direct lose of effluent during an unplanned outage and to provide water for the reservoir/urban fishing pond.

- 3.35 mgd (or 3,762 acre-feet per year) residual from Rio Salado when all wells are pumping to design capacity.
- 2 mgd (or 2,252 acre-feet per year) which is 50% of the storm water collection capacity.
- 7.1 mgd (or 7,966 acre-feet per year) as an average discharge from the 23rd Avenue Water Reclamation Plant to the River just east of 35th Ave. (This quantity is subject to diurnal variations. Historically, in fall and winter, has recorded peak flows over 50 mgd and on some days during the summer months as low as 0 mgd).
- The maximum velocity for all pressure and gravity pipelines will be 5 feet per second (fps); limiting the velocity in small pipes (<24 inches in diameter) to 5 fps is a commonly accepted engineering practice so as to reduce head loss and surge potential.
- The head requirements for the pump stations will be determined using the Hazen-Williams equation with a friction factor of 130. It is a commonly accepted engineering practice to accept this friction factor as a good average factor for the lifetime of most pipeline materials.
- Manning's equation will be used to calculate the capacity of all of the gravity pipelines using a friction factor of n=0.013. It is a commonly accepted engineering practice to accept this friction factor as a good average factor for the lifetime of most pipeline materials.
- Hydraulic Institute Standards will be met for the pump station configurations.

Water Supply for Each Reach:

The water distribution system will be a series of traditional and nontraditional irrigation methods. It is envisioned that water will be pumped from reservoirs along the banks into canals located on the banks or into a pressurized irrigation system. The canal water will move via gravity from along the over banks down spillways, waterfalls, channels, or piped to open ponds and wetlands along the terrace, then down to the perennial stream and ponds of the main river channel.

The wetlands, open ponds, and streams will be lined with either fine-grained soils or synthetic materials to reduce percolation and enhance horizontal migration of water to create a saturated soil profile. This wetted margin is needed to sustain riparian vegetation. Careful attention is needed to optimize plant densities to mitigate overcrowding, encroachment from exotics, and improved vector control. Design considerations will be made to control mosquito larva infestation by fluctuating water levels, increasing water movement, developing and managing appropriate planting densities and providing adequate access points for chemical applications.

The water distribution system should be designed to provide an uninterrupted supply of water to the open water features (reservoirs, ponds, wetlands, and canals) as well as meet the irrigation demands of the various habitat types throughout Oeste. To meet these goals, the water distribution system will have a built in redundant connection by discharge piping and isolation valves so that if any of the reservoirs are taken out of service, water can still be delivered to the various habitats. Based on this approach, a reservoir may provide a supply of water to any of the features and the pressurized irrigation system. The advantages of this system are as follows:

- Facilitates adding additional reservoirs if needed in the future.
- Facilitates delivery of water to all features if a reservoir is out of commission.

Generally, water will be delivered from the 23rd Avenue Water Reclamation Plant by a 20 mgd pump station conveyed through a pipe directly to Oeste's reservoirs. Electronically controlled flow regulated valves will adjust the flow of water from the plant to match the demand by the irrigation or the canal system.

Pump Station Requirements and Demand:

The pump station requirements are based on the available effluent that exists from the 23rd Avenue Water Reclamation Plant. A pipeline and reservoir network will be designed to provide a supply of water for the overall Project. The pump station will be equipped to vary the output of the reclaimed water to match the demand requirements. However, there will be a limit to the maximum supply that can be delivered based on plant output and City's prior water delivery commitments.

Supply Well Equipping:

The following assumptions are made for equipping the supply well:

- The well pump will be vertical turbine pump for cost efficiencies. Their life cycle cost are lowest based on installation, ease of operation and long-term maintenance. Similar pumps were installed in the Rio Salado providing familiarity for maintenance staff and an inventory of replacement parts.
- The supply well, associated appurtenant equipment and the electrical equipment will be located in a secured structure. The structure will have an open air roofing system that will protect the components from ultraviolet rays and vandalism. Individual climate control units will maintain the required operating temperatures of the electrical equipment.
- The well will include a flow meter and low-flow sampling port to monitor the quantity and quality of groundwater that is extracted because monitoring will be part of the City's Arizona Pollution Discharge Elimination System (AZPDES)

Supply Well Location:

The supply well location will depend upon available hydrology, real estate, utilities, access for installation, and maintenance of the well. Water quality and locating the well within the zone of influence must also be considered.

Hydrogeology:

The Rio Salado Project lies within the Salt River Valley (SRV) sub-basin of the Phoenix Active Management Area. The Project area is underlain by alluvium primarily consisting of unconsolidated to semi-consolidated clays, silts, sands, and gravels. The alluvium is subdivided into three major units: the upper alluvial unit (UAU), the middle alluvial unit (MAU), and the lower alluvial unit (LAU). These units vary in thickness across the SRV, with a general thickening toward the center of the SRV, northwest of the Project area. Depth to groundwater varies seasonally due to the effects of production and irrigation wells.

The UAU typically consists of unconsolidated coarser grained material providing unconfined groundwater conditions. Based on boring logs from wells within the Rio Salado study area between 19th Avenue and 28th Street, the UAU consists primarily of coarse sands, gravels, and boulders with interblended clay and silt. The MAU is characterized by generally finer grained sediments and a lack of gravel. The MAU is a semi confined aquifer. The contact between these two units ranges between 175 and 250 feet below ground surface within the Project area.

Groundwater Availability:

Groundwater from the UAU will be the primary source of water for Oeste's urban fishing pond and to maintain water quantity during unplanned water reclamation plant shut downs or diurnal fluctuations. The reliability of the quantity and quality of this water is critical to its success.

Currently, it is estimated the well will supply approximately 1.85 mgd. A series of pump test conducted by the Corps for the Rio Salado project indicate the UAU is showing a decrease in groundwater elevation and there is data indicating that over the past 25 years groundwater elevations within Rio Salado and Oeste areas have decreased approximately 15 to 20 feet. One well, for example, not far from the Rio Salado and Oeste projects has dropped about 4.5 feet per year between 1993 and 2000.

Groundwater Quality:

To a large extent, ground water sampling has shown in the Rio Salado project that the UAU is likely to be contaminated with many industrial compounds negatively impacting the aquifer. Groundwater quality in the eastern half of Oeste has been impacted by hydrocarbon releases and elevated concentrations of 1,1-DCE. The southwestern area of Oeste, indicate elevated concentrations of total dissolved solids and nitrates as concerns. A DCE plume from an unknown source is positioned along the south side of the River near the Del Rio Landfill, 8th Street to 14th Streets, and crosses over to the north side of the River near the 19th Avenue Landfill.

The UAU is highly impacted by contamination with fewer impacts on the MAU and the LAU. The main chemicals of concern (COC) are tetrachloroethene (PCE), trichloroethylene (TCE), 1,1-dichloroethene (DCE), and chromium. Other chemicals of less concern include nitrate and BTEX. Several sites near the Rio Salado Project area have been impacted by at least one of the COCs.

The Corps installed monitoring wells for the Rio Salado project in 1999 and 2001 to characterize the groundwater contamination near the production wells sites. Several of these have exceeded the state and federal water quality standards for volatile organic compound (VOC). Concentrations of DCE in some exceeded the Arizona Department of Environmental Quality (ADEQ) Fish Consumption (FC) standard. PCE has repeatedly been detected at concentrations exceeding the maximum concentration level (MCL) in monitoring wells located just north of Lower Buckeye Road and west of 7th Avenue. Chromium concentrations have also been reported to frequently exceed the MCL's.

Preliminary information on Oeste and the more extensive groundwater sampling program done for Rio Salado anticipate that some form of wellhead treatment may be required for

Oeste. An evaluation of the wellhead treatment cost must be weighted against acquiring real estate outside the immediate project boundaries, but within the cone of depression for a well installation, and the cost of a conveyance system to deliver the water to the project.

Access/Right-of-Way/Utility Constraints:

The well must be accessible to heavy equipment for well maintenance, rehabilitation, and replacement. The wellhead treatment compound, if needed must be accessible to heavy equipment to install, maintain, and supply the treatment units. The preferred well location would be within the Project area adjacent to a major arterial street down river of the ground water reservoir to capture water in the River. Electrical power is required at the well and all pump station locations but should not drastically affect the location.

Recommended Well Location:

It is probable that water from the proposed supply well will not meet the AZPDES water quality criteria used for permitting and may match the water quality seen in the Rio Salado project. With the UAU identified as the primary source of supply water for pond and make up water, some factors will impact the time it will take for the well to be affected. These factors include:

- Available real estate
- Access to install and maintain the well
- Water production of the well/flow rate
- Length of time the well will operate daily/annually
- Existing groundwater treatment and impacts on contamination
- Hydrologic properties of the upper alluvial unit
- Changes in water levels induced by Rio Salado water entering the Project and the pumping of the well

The driving forces in locating the well will be access, real estate availability, installation parameters, piping distance, and the potential for wellhead treatment system.

Until additional ground water test data is available, at this time the supply well location is uncertain, but near 35th Avenue is initially desired. Additional wells may be required beyond the one proposed due to limitations in the capacity of the well yield, operation criteria, and water quality constraints.

Water Quality Considerations:

The discharge of groundwater and effluent to the Oeste Project will be regulated by two sets of standards from the Arizona Administrative Code; Title 18, Chapter 11, Article 1 – Water Quality Standards for Surface Waters; and Title 18, chapter 11, Article 4 – Aquifer Water Quality Standards. The designated uses for this reach of the Salt River include aquatic and wildlife warm water, partial body contact, and fish consumption. The surface water quality standards that are applicable for these designated uses must be met at the point of discharge to the Salt River.

Water quality should be taken into account with regard to impacts on the plant life, water supply and distribution infrastructure. As an example, water with high total dissolved solids (TDS) may be deleterious to certain vegetative species as well as increase

maintenance and operations costs to the pipelines, pump stations, and other water delivery components.

Distribution System:

Reclaimed water and ground water will be held in reservoirs. The water will flow, by gravity, to an adjacent pump station. The pump stations will then pump water to the water supply systems along the overbank and terrace areas. Piping installed along the overbank area will distribute water across the Project site. At specific locations, surface or subsurface water turnout structures will deliver water to the terrace area. The pump station locations will be based on water demand zones and habitat needs, available real estate, piping distances, public and maintenance access. The preliminary locations are:

- North side 35th Avenue (ground water pond/reservoir)
- North side 51st Avenue
- North side 75th Avenue
- South side 35th Avenue
- South side 51st Avenue

There will be two sets of criteria for the pump stations: 1) pressure and flow requirements for a permanent drip irrigation system on the overbanks and a temporary system on the terrace, and 2) pressure and flow requirements for the supplemental water delivery system. During the startup period a large daily volume of water will be required to meet the plant establishment demand of the various habitat zones. Higher volumes and pressures will be required to water larger zones once plant maturity has occurred. The design elements that are part of the pressurized system include:

- Pipeline from the reservoir to the pump stations
- Pump stations
- Pressure distribution pipelines
- Turnout structures at the terrace area (surface and subsurface)
- Localized distribution system

Design Assumptions

The following design assumptions are made for the pressure distribution system:

- Pump intake design will be in accordance with the Hydraulic Institute standards, an accepted engineering standard for pump stations.
- Pumps will be vertical turbine type pumps because of ease of maintenance, and a preference by the City.
- A standby pump will be provided for each pump type; this is a commonly accepted engineering practice that allows for minimal down time during required maintenance. Use of a stand by pump is more cost effective than frequent switching between pumps because the latter requires additional instrumentation and control.
- Pump motors will be high-efficiency, 480-volt, three-phase and will be constant speed to reduce power costs and maintenance requirements.

- No backup power will be provided since power loss for a relatively short period of time (<24 hours) should not significantly impact the Project.

Water Distribution System:

Distribution piping will be installed in the overbank area for the entire reach of the Project. The piping will be designed to withstand a constant system pressure. Turnout structures, at strategic locations, will convey the water from the overbank to the terrace by surface or subsurface means. Automated Control Valves should be installed at turnouts to allow a supply of water to be delivered to individual areas from a remote location.

To maintain a level of system redundancy, pipes will be attached to the bridge structures at 35th Avenue, and 51st Avenue. This will interconnect reservoirs and pump stations on opposite sides of the river.

Several types of material for the distribution system piping will be considered. The potential piping materials are:

- Ductile iron pipe (DIP)
- High-density polyethylene (HDPE)
- Polyvinyl chloride pipe (PVC)

Pump Station Capacity:

The pump stations will be designed to meet the water demand requirements for the specific habitat zones they will be responsible for. The system should operate off of system pressure. A desired pressure in the system should be targeted. Once a system pressure drops below an acceptable value, the pumps should turn on to pressurize the system and turn off at a predetermined maximum pressure. The pump stations should be sized to meet the different pressure requirements of the temporary/establishment irrigation system and the longer-term supplemental water system. As a result of the different pressure requirements for these two systems, there should be two dedicated pumps, one for the temporary irrigation system and one for the supplemental water and permanent irrigation systems.

The pump stations are planned to be pre-engineered stations similar to stations that are in the Rio Salado project. Water will be conveyed from the reservoirs through a gravity pipeline to a wet well. The pumps will be installed above the wet well and will use adjustable-frequency-drive units. These stations will have local controls and will be housed outside. These stations will be located in similar enclosures as were used in the Rio Salado Project, with minor aesthetic changes to integrate the Oeste project design vernacular.

Pump Station Aesthetics:

The pump stations should be adjacent to the public staging areas and associated reservoirs. The functional nature of the enclosure requires close access to a stable road surface for routine maintenance with some screening of the equipment to improve aesthetics, reduce equipment noise, ultra violet ray damage and vandalism.

The aesthetic objectives for pump stations are as follows:

- Minimize straight lines and regular forms to increase shadow opportunities (thereby decreasing apparent mass) and to preventing a structured silhouette against the skyline. The overall aesthetic approach to these structures will be based on preserving the pretense of an existing natural environment separate from the built environment.
- Maximize landscape screening where practicable.
- Coordinate sitting issues to minimize adjacency to pedestrian elements and interpretive areas while also assuring the system can operate at peak efficiency.
- Investigate the use of recycled materials and/or green building technologies such as; reused river ruins, recycled steel, and tires.
- Maximize built shading opportunities and dark colors to better blend the structure with the natural environment.
- Maintain a rustic aesthetic consistent with the project objectives by using exposed weathered metal, and raw masonry elements, and/or natural stone.

Open Channel Distribution System:

Delivering water from the reservoirs along the overbank to the terrace and wetlands is proposed to be predominately with open canals. The canals will deliver water from the reservoirs using gravity flow whenever possible. Canals will be located where possible on the overbank and terrace levels to provide water to the wetlands and surface-irrigated vegetation in select habitats such as the cottonwood-willow and emergent zones adjacent to the wetlands. The canals and waterfalls can increase habitat value by adding movement to the water thus increasing the dissolved oxygen levels, cooling the water, and altering the adjacent microclimates by increasing humidity.

Design Assumptions:

The following criteria and assumptions will be used to design the canal system:

- As a safety measure, a minimum horizontal separation of 5-feet should be maintained between the maintenance road and all canals plus a maximum gradient of 20:1 should be provided at the edge or near the canal. Canals will be designed to meander where feasible for natural purposes. Other features, such as small waterfall-like drops, crossings, pools, etc., will be provided where reasonable as determined in the detail design phases. The canal cross section design should also maintain a minimum flow depth of approximately 6 inches, a velocity ranging between 2 fps and 6 fps, with the ability of providing occasional high-velocity zones to imitate the audio, visual, and functional effects of a natural stream. To replicate a natural stream bed and achieve the desired cross section, construction materials from the River that includes river rock, cobbles, and/or concrete river ruins should be employed.
- In the overbank areas, canals should be lined with an impermeable liner to prevent seepage. Maintaining the required water supply is crucial to the success of the Oeste Project and saturation of the soils behind the riverbanks could jeopardize bank stability in places. The canals should be located approximately 6 to 8 feet from the top of the riverbank slope. In areas that are identified to be more susceptible to

erosion from flood flows, the canals and other overbank facilities will be located as far away as possible from the top of the bank. Canals located between the maintenance road and the top of slope of the riverbank on the overbank level can also function as a barrier for safety purposes between pedestrians and the bank's slope.

- On the terrace level, all canals will be lined with a low permeable liner to prevent seepage, except reaches where a "leaky" canal is specifically desired for subsurface irrigation purposes. This may occur adjacent or near some wetlands to help saturate the soils in aquatic or emergent zone habitats. To improve protection of the canals, separation between the canals and flood conveyance features such as a low flow channel will be maintained. In most locations, the canals will be located on the outside edge of the terrace. Where canals are located adjacent to wetlands they should be located between the wetlands and the riverbank. This arrangement can help augment the gravity water flow delivery system to the wetlands.

Open Canal System:

Canals will typically be located along the overbank and terrace levels between 19th Avenue and 83rd Avenue. Further geotechnical investigations and project boundaries may provide information limiting the actual extent of the open canal system.

The canals located on the southern terraces and overbanks will be fed from two reservoirs located at 35th and 51st Avenues and the river. In general, west of 51st Avenue the existing grades in the overbank parallel the riverbed grades, sloping downward in a westerly direction. Preliminary investigation indicates that gravity flow is possible west of 51st Avenue. Where gravity flow is not possible a pump station could be installed to deliver water where needed.

The canals located on the northern terraces and overbanks will be fed by three reservoirs, located at 35th Avenue, 51st Avenue and 75th Avenue and the river. Gravity delivery of water from these reservoirs is possible west of 51st Avenue for the entire northern reach. As along the south reaches, in locations where gravity becomes an exception, a small pump station could be assigned to deliver the water.

From the standpoint of delivery, operation, and maintenance it is desirable to have consistent flow conditions throughout the open canal system. However, a uniform canal appearance is not generally acceptable for an environmental restoration project because it detracts from the natural stream effect. Desirable velocities will need to consider the require slopes and actual slope of the terrain. Velocities of 2 fps are permissible but flow velocities in excess of 3 fps are more desirable. Higher velocities are a deterrent to sediment buildup and to plant and algae growth. Fast moving, noisy, tumbling water also increases dissolved oxygen levels, cools the water and provides for better vector control. Oeste should optimize opportunities for high velocity small waterfalls to improve ecosystem restoration value, vector control, aesthetics, and maintenance. This may require the installation of some small pump stations. The location, quantity, practicality, and feasibility of these pumps, if they are necessary, will be determined during the design phase.

On the terrace level, the canals should complement the layout of the wetlands. The proposal for the wetland design will be to operate them in series such that the upstream

wetland pond overflows into the next lower elevated pond and so on. The concept for the canal is for them to feed the wetlands. To improved operations the canals may also be used as a bypass water source for each terrace wetland in case a given pond needs to be taken offline for maintenance or repairs. Drops and grade breaks in the vertical alignment should be incorporated to minimize grading and optimize the habitat value the canals offer.

It is unlikely the canals will flow continuously within the terrace and overbank levels from one end of the site to the other. Naturally undulating grades, waste pockets, and other constraints may limit the extent the canals can be located. The goal is to align the canals to follow the natural grades as much as possible and to limit the earthwork efforts. Typically, the terrace-level canals flow from east to west but anticipate there will be exceptions. The design grades for the gravity canals and pipeline system will not be determined until the project is in detailed design.

Canal Hydraulics

The canals will be designed to carry the peak demand for the proposed wetlands ponds for select habitats zones. At this conceptual phase, the minimum demand for a given reach is between 0.20 cubic feet per second (cfs) and the maximum demand of about 5.05 cfs. This results in canal top widths for a trapezoidal section ranging from 5 feet to 12 feet. The design velocity and flow-depth will be sized to prevent erosion from velocities over 6.0 fps, and prevent water quality and maintenance problems associated with velocities under 2.0 fps.

In areas where sufficient nuisance water exists, storm water nuisance flows will be captured in the canal system as an additional water source. Diversion weirs designed at the outfalls will help direct the water to these locations. Water delivered to the wetlands can be achieved through a system of diversion weirs.

To reduce percolation and potential structural problems to the overbank slopes it is proposed that all of the overbank canals and some of the terrace-level canals be lined with a low permeable lining system. Lining system alternatives will be selected to provide aesthetic enhancement and promote a natural system. Various alternatives should be investigated that will allow for river rock and sand (or other natural covering) to be placed over the liner to provide a solution that meets both the hydraulic, environmental, and aesthetic design criteria.

Overbank Canal:

The water supply and distribution system on the overbank areas will be composed of channels that vary in width and depth and make their way along the overbank areas. The canals may periodically cross underneath the maintenance road and trail system to allow the streams to be viewed, heard, studied, and experienced. This system is envisioned as a stream channel lined with river rock materials punctuated periodically by a large salvaged rock outcropping, boulder, and/or salvaged concrete river ruins set to mimic a natural boulder outcropping. The system may incorporate a variety of alternative uses for recycled concrete river ruins to create check dams, drop structures, and augment grade changes.

Overbank to Terrace Canal:

The water supply and distribution system transition from overbank to terrace level will capture the sound and visual effects of splashing water. These transitions will be strategically located to provide the necessary quantity of water to the terrace area delivery system and ultimately to the wetlands.

Both native stone and concrete river ruins that are discovered during the excavation of the wetland ponds and other construction activities should be incorporated to create the desired effects, reduce waste removal fees, and exhibit to visitors how recycled materials can be used effectively in the physical environment. These spillways are not envisioned to encroach into the river channel and should be designed to complement the natural grade and hydraulic flows against the embankment.

Terrace Canal:

The water supply and distribution system on the terrace areas will be composed of a wide variety of diverse delivery systems. The backbone of the delivery system will be very similar to that of the overbank area: meandering stream channels that vary in width and depth and snake their way along the terrace areas. The channel design on the terrace, like that of the overbank, is meant to reflect a naturally occurring babbling brook, creek or streambed.

This main system should be designed with river rock materials punctuated periodically by a large salvaged rock or concrete river ruin outcroppings, boulder, and/or salvaged concrete slabs set to appear as a naturally occurring boulder outcropping. It is envisioned that this system would use these same materials to create check dams, drop structures, spillways, and grade changes along the channel.

In addition to the main channel, the terrace delivery system will also consist of "rill irrigation". These rills would occur off the main channel and deliver water in a network of small cut, possibly braided channels that would feed the terrace areas. The main purpose of the rills is to help saturate soils beyond the reaches of the wetland pond areas. If manually controlled and operated, these features could produce a controlled flood through selected vegetation to assist in natural recruitment that depends on periodic flooding to reproduce.

Water Delivery:

Design Assumptions

The prevalent assumptions and approaches for Oeste's water delivery irrigation systems are:

1. Water for the Project's wetland features will be supplied from a ground water well reclaimed effluent from the 23rd Avenue Water Reclamation Plant, Rio Salado residual, storm outfall structures, and other discharges delivered by a surface (canal) and subsurface (pipe) delivery systems. This watering system can be used to irrigate specific habitat vegetation whenever the site and soil conditions are appropriate, both on the overbank as well as in the terrace areas.

2. Delivering water to the varies habitat zones may be accomplished through a variety of methods including flooding, rill ditches, constructed perched aquifers, and two different drip irrigation system concepts. The two drip systems include a long-lasting "hard pipe" drip irrigation system to irrigate the overbanks, and a temporary plant establishment irrigation system for irrigated species on the terrace and slope areas, composed primarily of PVC piping.

3. Both proposed drip irrigation systems will consist of a combination of methods and devices including pressure-compensating emitters, micro sprays, and pressure-compensating bubblers. The exact combination and use of these devices in each of the habitats will be determined during the systems' detailed design phase. The drip irrigation systems will be designed to meet City of Phoenix Parks and Recreation standards.

4. The main infrastructure (reservoirs, pump stations, transmission pipelines, etc.) will be sized to provide a sustainable water supply. The system will be configured to provide an appropriate level of redundancy to ensure water delivery in the event of equipment or well failures. The sustainable water supply is defined as the amount of water necessary to keep the vegetation living during the month of July

Specific recommendations for the methods and approach that will be followed during design will include the combination of the following techniques.

Overbank Areas

5. The overbank areas will be irrigated mostly with a combination of pressure-compensating emitters, bubblers, and micro sprays using the hard pipe (PVC pipe) irrigation concepts designed to City of Phoenix Parks and Recreation standards. A few focus areas on the overbanks could also be irrigated using the surface (canal, or rill) water supply system.

Terrace Areas:

The terrace area may use a combination of irrigation approaches:

- Temporary drip system for establishment of vegetation
- Subsurface liners to create an artificially perched aquifer
- Canal or Rill (ditch or flood)
- Water harvesting polymer or polymer type products

Temporary Drip System:
The intent is to build from the "backbone"; water source infrastructure, mainline, and control system of the overbank irrigation system, but to use small-diameter flexible polyethylene lateral pipe and drip emitters. It is intended to be in operation for about an 18 to 24-month establishment/growth period of the containerized plant materials. This approach is anticipated to be used on specific terrace areas to start plantings that need a reliable water source during establishment or they would likely parish. This was done on the Rio Salado to align with the Corp's policy guidance of minimizing and eventually eliminating the amount of irrigation on the terrace and the local sponsor's concern of high mortality during the first few years of establishment.

Perched Aquifer:
The perched aquifer system relies on the creation of a low permeable layer below the ground that will retain water at a certain level. The perched aquifer is created within the proposed wetland and extends beyond the edges of the wetland ponds. This aquifer is perched through the use of engineered liner systems consisting of geotextile fabrics, clay, and local soils or a combination of these materials to produce impervious and semi-impervious layers that lie below the surface creating the perched aquifer effect. This water system is highly desirable in maintaining the cottonwood-willow habitats associated with wetlands. The relatively shallow depth of the naturally occurring aquifer within the river channel also presents itself as a long-term potential water source for Oeste. As a design goal, the irrigation system will be selected on the ability to facilitate and encourage deep rooting by appropriate plant materials such that the existing and naturally occurring aquifer will sustain the desired project habitats. The water for these perched aquifers could be generated through the wetland water delivery system, and potentially augmented with dry-weather flows and storm water runoff in select locations and under appropriate conditions. These areas should comprise a mosaic of indigenous riparian vegetative types producing a cottonwood-willow gallery forest and open water wetland marsh habitats.

These perched aquifer areas will also serve as an incubator for seed germination by the cottonwood and willow over story through the man-made and controlled flooding that these areas should be designed to receive. This system should not be considered within 50 feet of an excavated channel if bank stability is an issue. These systems, as with the rill system, are in harms way and could experience catastrophic damage by flood events. A cost analysis should be conducted after further engineering data can be collected and evaluated to determine the practicality and life cycle cost..

Rill/Flooding:
Rill/flooding delivery consists of ditches that have been formed, or bladed, into the natural soil to channel water towards vegetation planted along the banks and within their wet zones. These natural ditches, or rills, may or may not be lined to contain and direct the flow of water. However, the system is envisioned as one that allows leakage and percolation of the water source to aid in feeding the surrounding plant materials and to create wet zones. The use of rills within the terrace areas and at existing storm water outfalls will be one of the water supply methods for these planting zones. It is envisioned that the method of diverting water into these rills will be controlled and regulated by check dams and diversion structures that force storm water or canal water into the rills to create the leaky canal system that make up the rill irrigation system. The rill technique should be designed to supply some water to those areas that lie outside of the lined wetland pond areas and to optimize the water coming out of the storm water outfalls. These systems may be severely impacted by significant flood events, but their low initial development cost, routing, and ease of recreating them allows for quick restoration or even to rerouted as Oeste's vegetation and habitats develop and matures.

Polymers:

A possible solution for areas that fall beyond the reaches of an irrigation system or possibly in lieu of a temporary establishment system is amend the planting mix with a

polymer or polymer type product. Polymers are tiny molecules strung in long repeating chains. These tiny pellets or sponges absorb water many times there their size then release it slowly to the plant material by means of soil capillary action and pressures. In the landscape industry these are typically synthetic, but there are also natural polymer type products that could be researched.

Driwater is a natural product that is placed around individual plants during the planting operation, in either a PVC tube that can be monitored and reloaded, or in a biodegradable quart carton. The unit and the plant are wetted to activate the product. it then releases absorbed water and the Driwater product biodegrades. Driwater was used fairly successfully along the Las Vegas Wash project without the need for a temporary irrigation system, but for a large planted area it has been reported to be expensive and highly labor intensive to maintain.

The Corp and City are currently evaluating several alternatives to irrigation on a demonstration project initiated in May 2004 between 18th and 20th Streets on the south bank of the Rio Salado project. Four different plant backfill material receipts were used on 350 1-gallon containerized trees. The alternatives included polymers, Driwater, fine grained soil with a polymer additive from a local sand and gravel operator, and native backfill. Over the next several years the Corps will monitor each tree and their selected backfill material to determine if a temporary irrigation system is needed through the plant establishment period.

Slope Areas:

Slope areas leading down to the terrace should be seeded with grasses and forbs to increase habitat values, assist in erosion control, and improved aesthetics. One alternative which is being implemented on Rio Salado and needs to be reviewed once activated is to supply water to a limited area of these seeded slopes using lower-pressure, shorter-radius rotor sprinklers on short risers located at the top of the over bank. The use of this method, as in the Rio Salado, should be very focused and selective. It is envisioned to be concentrated in areas composed of inert debris and other waste sites where removal of the material would be cost prohibitive or unwise and the area should be mitigated to visually mask undesirable views and potential erosion zones. This technique should be evaluated for it's relation to Oeste's overall restoration goals, project terrain, visibility, and the habitat zones.

Supervisory Control and Data Acquisition (SCADA):

Overview:

It is intended that the Rio Salado SCADA system will integrate with Oeste's water delivery system. The Rio Salado SCADA computer located in the Rio Salado Maintenance Facility monitors and provides supervisory control for remote sites, including the production well, reservoirs, irrigation pump stations, and canal transfer pump stations. Communication between each remote site and the SCADA computer may match the Rio Salado project using a spread-spectrum radio link, which does not require licensing, or possibly a telephone connection.

Design Assumptions:

It will need to be determined if radio or telephone is the most feasible communication link between the Supervisory Control and Data Acquisition (SCADA) computer, the central irrigation controller located at the Rio Salado Maintenance Facility, and the various remote sites in Oeste. This is verified by a radio survey and cost comparison for the telephone connection. The radio survey consists of two major tasks: (1) modeling each radio link to determine if it has adequate radio strength; and (2) verifying the model by field-measuring radio signal strength for each link. The telephone connection will be based on the City's ability to procure telephone communications into some of the more remote areas of Oeste and what these capital cost would be.

Dry Weather Flows:

The majority of the storm drain outfalls in Oeste have storm water discharge only after a rainfall event. However, regular discharges of a significant quantities, have been observed in dry weather conditions at the northeast side of 35th Avenue where the 23rd Avenue Water Reclamation Plant discharges and at 43rd Avenue where agricultural tail water discharges.

Reuse of a portion of the storm water flow poses some design challenges. These challenges include designing flow-splitting structures (splitter boxes), variable-flow-rate canals, and variable-flow-rate wetlands ponds. Splitter boxes are structures that allow small nuisance flows to be diverted from the storm water channel into the water supply canals while allowing larger damaging flows, such as storm runoff, to flow directly to the River without overloading the canals and endangering the integrity of the canals or wetlands. The design challenge is to optimize these available flows, when and where possible. The maximum peak startup canal flow is estimated to be only 5.0 cfs (3.2 mgd) and the maximum sustaining canal flow is only 3.0 cfs (1.9 mgd). Dry weather flows for some of the outfalls may exceed the total water demand for portions of Oeste.

Storm water Quality:

The majority of pollutants in storm water are contained in the first flush after runoff begins. First flush describes the washing action that storm water has on the watershed. Pollutants that are deposited on impervious surfaces during dry periods are transported by the initial runoff, creating a high-pollutant load at the early stages of runoff. After the first flush, the pollutant load decreases significantly for many of the pollutants, even if the flow rate increases. Capturing the first flush can treat the majority of pollutants i.e. petroleum compounds, metals, sediment, litter and trash. It should be noted that some pollutants behave differently than others and as such the first flush concept is applicable in varying degrees.

The concept of first flush is a highly variable, often misunderstood concept. The metropolitan Phoenix area does not have accepted guidelines that establish a recommended level of pollutants that should be removed during rainfall events. A commonly accepted threshold is to treat runoff from the 90th percentile storm to represent the first flush. A study was completed in 1997 for the Flood Control District of Maricopa County (FCDMC), in which 50 years of rainfall data was listed for the Phoenix

metropolitan area. The data reveals that 90 percent of all storms recorded during the period from 1945 to 1995 were less than or equal to 0.37 inches in depth.

Trash Removal:

Storm water generated from the upstream watershed will contain floating and suspended debris. Capturing a majority of this debris as it enters Oeste is desired for aesthetics, public health, maintenance, operations and hydraulic functions of the wetlands, and canals.

In the Rio Salado project some storm water outfalls were outfitted with trash removal structures. These structures were constructed from concrete River ruins salvaged from the site and have hidden screens and openings that let water pass through. The structures have a basin on the upstream side of the openings that collect floating and suspended debris. These features also provide a visually pleasing water feature during dry weather non-storm flows. Monitoring the Rio Salado trash removal structures over several years will provide historical data on the merits of their success and application for Oeste.

To concentrate the floating and suspended debris, the trash removal structures can also be used as a splitter-box type feature. A finite amount of water can be diverted through the trash removal structure, using a bypass weir system and spillway. These weirs divert a predetermined amount of the flows generated from the storm water outfalls through the trash removal system, but still allow large storm flows to pass through to the primary River channel. The amount of flow diverted is determined during the detailed design phase and will vary from outfall to outfall depending on its size and design discharge. Although the discharge volume has not yet been quantified, it is desired to be equivalent to the first flush or greater.

Operation and Maintenance:

Water Supply and Distribution System Operations/Maintenance

Operations and maintenance considerations for the water supply and distribution system are:

- Periodic maintenance will be required on the well submersible pumps. Periodically the pumps will need to be pulled from the wells and inspected. It is anticipated that this level of inspection would mirror Rio Salado and likely occur once every two years.
- If wellhead treatment is required, the required maintenance for this facility will increase significantly. It is anticipated the regime would be similar to the Rio Salado well head treatment facilities maintenance requirements and would include maintaining equipment, replacing filters, and daily facility monitoring.
- It is anticipated that required maintenance for the reservoirs themselves should be minimal. Additional upkeep and maintenance of the plant material will be ongoing and as monitoring and adaptive management principals are adapted could involve a variety of maintenance responsibilities. As the Rio Salado reservoir shells are monitored and the cost and functional operations of the liner material is further

evaluated, additional components like a leak detection monitoring system may be warranted for Oeste.

- The pump stations will require routine preventative maintenance including all the electrical and mechanical equipment. Maintenance should include exercising valves, lubricating pumps, and monitoring electrical devices for adequate power draws.

Canal Overbank: The use of the river rock in association with the channel will create pockets for dirt and debris to accumulate and may require periodic flushing/cleanings to minimize debris and potential odors.

The manually operated rill irrigation system will require periodic maintenance to ensure that it is operating effectively. The rill irrigation system is a dynamic system and has the propensity to meander in response to the flow of water pushed through the system. Because these systems would not typically be lined with a geotextile or liner material, when the river floods the terrace areas, the rills may need to be reestablished.

- Collection and removal of trapped debris from the basin floor and the debris screen.
- Inspection of debris screen for signs of corrosion, damage from high flows, or detachment from trash rack structure.
- Inspection of trash rack structure for indications of staining, damage from high flows, vandalism, or movement of concrete block/rock that might indicate a reduction in the stability of the structure.
- The trash rack aesthetic operations and maintenance issues will be in replacement of the screen and mesh once the metal screen has surpassed its submerged life cycle.
- The spillway should be monitored to ensure that undercutting by the channel is not eroding the stability of the structure.
- The headwall treatment should be monitored to ensure that undercutting by the flows that are coming out of the associated storm drains is not eroding the stability of the headwall treatment or the structure.
- The concrete spillway should be monitored to ensure stability of the structure(s).
- Rodent control and repair of rodent damage
- Vandalism control and repair of vandalism damage
- Water supply scheduling in accordance with local and real-time Et rates
- Filtration system and lateral flushing procedures
- Fertilizer injection if provided
- Chemical (chlorine) injection for emitter maintenance
- Emitter operational check procedures
- Sprinkler performance evaluation and sprinkler operation check procedures

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

Appendix K

Cost Estimates

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
LOS ANGELES, CALIFORNIA 90053-2325

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 Rio Salado Oeste Feasibility Study.

Where possible, unit cost information was established from actual cost data provided by manufacturers. Additional data and lessons learned were derived from the Rio Salado project currently under construction.

A. CONSTRUCTION COSTS

1. Excess Excavated Material: It is assumed that all excess material will be utilized on site throughout the project area for reshaping of the floodplain.

2. Contingency: A 20% contingency was included, in accordance with Corps of Engineers regulations for feasibility study construction cost estimates.

3. Planning, Engineering & Design (PED) and Engineering During Construction (EDC): The PED and EDC were 10% and 1%, respectively.

4. Supervision & Administration (S&A): A 7% 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 restoration is designed with the intent to restore ecosystem functions and be a self-sustaining natural riparian ecosystem. However, as in any manmade, controlled system, maintenance will be required.

1. Invasive Control: $60/acre as provided by invasive control companies. This applies for both Salt Cedar and Arundo.

Estimate based upon potential annual control of invasive species throughout the project area, calculation based upon acres planted to cottonwood/willow, mesquitc, wetlands although this will vary by year and could include the channel or adjacent riparian scrub.

$60 x 831 acres = $49,860

2. Restored Channel: Assumed grading once every 20 years a volume equal to ½ of the initial construction quantity or 330,000 c.y. Cost estimated at $4/c.y.

330,000 c.y. x $4 = $1,320,000 once every 20 years.

3. Storm water Wetlands: Regrading and excavation will be required once every 10 years.

Assume 50% of construction quantity or approximately 75,000 c.y.

75,000 c.y. x $7 = $525,000 once every 10 years

4. Irrigation System Maintenance: Assume $1000 per acre repair and replacement of irrigation infrastructure. Based upon City of Phoenix experience with maintenance at Rio Salado following construction.

5. Associated Cost, Water Supply: Assumed cost similar to that of Central Arizona Project water $106/acre-ft as recommended by City of Phoenix Water Services
6. Department.

7. Replanting and replacement cost: Assumed 25% of planting/irrigation will require replacement after a flood event. This is based upon modeled velocities and area of inundation with a 20 year frequency event and velocities of less than 7 cfs assumed to cause minimal or no damage to vegetation. Discharges of up to 39,000 cfs in 2005 while the Rio Salado Project was under construction confirmed that vegetation damage was minimal. Estimate that up to $2,767,222.50 for vegetation replacement will be required over the life of the project.

8. Lakes: Assume that excavation and regrading would be required once every 20 years, 40 acres at 1 ft depth.

65,000 cy x $7= $455,000 once ever 20 years.

9. Water Supply: Costs to operate and maintain the water supply/distribution were completed by the local sponsor, City of Phoenix. The following table displays that cost estimate.

DESCRIPTION	QTY.	UNIT COST	No. of Units per year	TOTAL
20 mgd Pump Station Materials/Supplies per year	1	$60.00/hr.	250 hrs.	$15,000 $7,500
Electronic Flow Regulated Valves to deliver water to Reservoirs Materials/Supplies per year	5	$60.00/hr.	300 hrs.	$18,000 $5,000
Pump Stations Materials/Supplies per year	5	$60.00/hr.	300 hrs.	$18,000 $20,000
Reservoirs Materials/Supplies per year	5	$60.00/hr.	125 hrs.	$7,500 $6,000
20" Waterline Pipe Materials/Supplies per year	18,500 l.f.	$40,00/hr.	80 hrs.	$3,200 $1,500
16" Waterline Pipe Materials/Supplies per year	26,500 l.f.	$40.00/hr.	120 hrs.	$4,800 $1,500
10" Waterline Pipe Loop Materials/Supplies per year	37,000 l.f.	$40.00/hr.	200 hrs.	$8,000 $3,000
Bridge crossing of 16" Waterline Materials/Supplies per year	1,800 l.f.	$40.00/hr.	25 hrs.	$1,000 $500
Bridge crossing of 10" Waterline Materials/Supplies per year	1,800 l.f.	$40.00/hr.	25 hrs.	$1,000 $500
Overbank Canal Delivery Conveyance Channels Materials/Supplies per year	25,000 l.f.	$40.00/hr.	200 hrs.	$8,000 $15,000
Terrace and LFC Canal Delivery Conveyance Channels Materials/Supplies per year	35,000 l.f.	$40.00/hr.	600 hrs.	$24,000 $20,000
Waterfalls Materials/Supplies per year	5	$40.00/hr.	200 hrs.	$8,000 $10,000
Supply Well Materials/Supplies per year	1	$60.00/hr.	100 hrs.	$6,000 $7,500
Monitoring Wells Materials/Supplies per year	2	$60.00/hr.	10	$600 $1,200
Water Sampling, Testing and Biomonitoring for Permits	L.S.	Varies	Varies	$250,000
Electrical Service Materials/Supplies per year	11	$50,000	11	$550,000 $25,000
Permitting CROA and AZPDES	Varies	$40.00/ hr	100 hrs.	$4,000
				$1,051,300

C. RECREATION COSTS

Estimates for the recreation features are based upon known costs for the Rio Salado project currently under construction.

Rio Salado Oeste MCACES Summary September 2006

5A. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake:

9/7/2006

Code	Cost Items	Quantity	UOM	MCACES Unit Cost	TOTALS	NOTES
01.	**Real Estate**					
	Flood Plain Project Land	1	Lump Sum		$43,920,000	
	Right of Way for Water Supply & Distribution	1	Lump Sum		$800,000	
	Subtotal Real Estate (w/o markups):				$44,720,000	1
			Contingency	25%	$11,180,000	
	Total of Real Estate:				**$55,900,000**	
06.03.00	**Mob/Demob**	1	Lump Sum	$764,000.00	**$764,000**	
06.03.01	**Clearing/grubbing** (trees, grasses etc.)	36	ACR	$4,400.00	**$158,400**	
06.03.01	**Invasive Removal**					
	Arundo Removal	10	ACR	$40,000.00	$400,000	
	Salt Cedar Removal	110	ACR	$6,700.00	$737,000	
	Subtotal Invasive Removal:				**$1,137,000**	2
06.03.09	**Channel Restoration**	660,000	CY	$4.25	**$2,805,000**	
06.03.09	**Grade Control Structure**					
	RCC (2400/structure from Rio Salado)	2,400	CY	$106.00	**$254,400**	
06.03.73	**Stormwater Outfall (8 ea)**					
	Grading/Excavation	3,312	CY	$6.10	$20,203	
	Concrete	416	CY	$226.00	$94,016	
	Cobble	22400	SF	$9.50	$212,800	
	Weir	16	CY	$226.00	$3,616	
	V-ditch	148	CY	$6.70	$992	
	Subtotal Stormwater Outfalls (8 ea):				**$331,627**	
06.03.73	**Wetland Ponds**					
	Grading/Excavation	149,890	CY	$5.50	$824,395	
	Liner (12" of fines)	45,128	CY	$4.30	$194,050	
	Hydroseeding	28	ACR	$2,680.00	$75,040	
	Subtotal Wetland Ponds:				**$1,093,485**	
06.03.73	**Emergent Wetlands**					
	Grading/Excavation	20,952	CY	$5.60	$117,331	
	Liner (12" of fines)	20,952	CY	$4.30	$90,094	
	Subtotal Emergent Wetlands:	13	ACR		**$207,425**	
06.03.73	**Cottonwood/willow (1 gal.)**					
	Planting	378	ACR	$1,600.00	$604,800	
	Irrigation	378	ACR	$11,800.00	$4,460,400	
	Maintenance of Plants and Irrigation during Plant Establishment Period	378	ACR	$134.00	$50,652	
	Subtotal Cottonwood/willow:				**$5,115,852**	
06.03.73	**Mesquite Bosque (1 gal.)**					
	Planting	244	ACR	$4,800.00	$1,171,200	
	Irrigation	244	ACR	$11,800.00	$2,879,200	
	Maintenance of Plants and Irrigation during Plant Establishment Period	244	ACR	$168.00	$40,992	
	Subtotal Mesquite Bosque (1 gal.):				**$4,091,392**	
06.03.73	**Mesquite Xeric**					
	Planting	168	ACR	$1,280.00	$215,040	
	Irrigation	168	ACR	$11,800.00	$1,982,400	
	Maintenance of Plants and Irrigation during Plant Establishment Period	168	ACR	$134.00	$22,512	
	Subtotal Mesquite Xeric :				**$2,219,952**	
06.03.73	**Lake Restoration**					
	Cut and Fill	3,000,000	CY	$5.00	$15,000,000	
	Emergent Wetlands					
	Liner (12" of fines)	64,469	CY	$4.30	$277,217	
	Hydroseeding	40	ACR	$2,680.00	$107,200	
	Plant Maintenance (1 year)	40	ACR	$30.00	$1,200	
	Subtotal Lake Restoration:				**$15,385,617**	
06.03.03	**Debris removal**	2.00%			**$764,000**	3
06.03.11	**Maintenance Structures**					
	Maintenance Facility	1	LS		$2,500,000	
	Maintenance Roads (Hard Surface)	16	miles		$3,019,000	
	Maintenance Roads and Trails (Soft Surface)	16	miles		$1,328,000	
	Maintenance Road Underpass @ 19th Ave (North Side)	1	LS		$1,337,000	
	Bridges and Culverts (medium) @ Stormwater Discharge	5	EA		$134,000	
	Project Signage	6	EA		$96,500	
	Subtotal Maintenance Structures:				**$8,414,500**	4
06.03.12	**Water Supply and Distribution**	1	LS		**$23,600,000**	5

5A. Storm water, Channel, Water Supply, Cottonwood, Mesquite, Invasive, Emergent, Lake:

9/7/2006

Code		Cost Items	Quantity	UOM	MCACES Unit Cost	TOTALS	NOTES
			Subtotal Construction Cost (w/o Real Estate):			**$66,342,650**	
			Contingency		20%	$13,268,530	
30.			Planning, Eng and Design		11%	$8,757,230	6
31.			Construction Management		6.5%	$5,743,947	
			Total Construction Cost (w/o Real Estate):			**$94,112,356**	
			Total Construction Cost (with Real Estate included):			**$150,912,356**	
06.03.99	**Adaptive Management**				3%	**$ 2,823,371**	
	Monitoring				1%	**$ 941,124**	
			Subtotal of Monitoring and Adaptive Management			**$ 3,764,494**	
			Total Construction Cost (w/o Recreation):			**$153,776,850**	
06.14.	**Recreation**						
	1.001	Site Preparation	1	LS		$925,000	
	1.002	Access and Circulation	1	LS		$1,947,000	
	1.003	Protection Access Control	1	LS		$1,275,500	
	1.004	Signage	1	LS		$166,000	
	1.005	Shelters	1	LS		$2,455,000	
	1.006	Utilities	1	LS		$640,000	
	1.007	Park Furniture	1	LS		$155,500	
	1.008	Interpretive Guidance Media	1	LS		$112,500	
			Subtotal Recreation (w/o markups):			**$7,876,500**	
			Contingency		20%	$1,575,300	
			Planning, Eng and Design		11%	$1,039,698	6
			Construction Management		6.5%	$681,947	
					Subtotal Recreation:	**$11,173,445**	
			Total Project Cost for Alternative 5A:			**$164,950,296**	

	Operation and Maintenance		**Cost**
06.03.99.	**Adaptive Management**	3%	**$ 2,823,371**
	Monitoring	1%	**$ 941,124**
	Total of Monitoring and Adaptive Management		**$ 3,764,494**
06.03.99.	**Replacement Cost** (assume 25% of planting/irriation) requiring replacment after flood		**$ 2,856,799.00**
06.03.99.	**Invasive Species Control**: Assume annual removal of exotic species. $60/acre		**$49,860** 831 acres
06.03.99.	**Wetlands**: Regrading and excavation required once every 10 yrs. Assume 50% of constructoin quantity. ~75,000 cy.		**$525,000**
06.03.99.	**Channel**: Assume regrading once every 20 years of 50% the original construction quantity or 330,000 cy.		**$ 1,320,000.00**
06.03.99.	**Water Supply**		**$ 1,051,300.00**
06.03.99	**Irrigation Maintenance:** Assume annually $1000 per acre repair and replacement of irrigation infrastructure		**$ 790,000.00** 790 acres
06.03.99.	**Lakes/Wetlands**: Assume excavation/regrading once every 20 years of 1 ft material from 40 acres of wetlands or 65,000 cy		**$455,000** 40 acres
	Acre Feet		
06.03.99.	**Water**	7709 106	**$ 817,154.00**

$106/acre foot CAP cost applied to effluent, as per Steve Rossi.

Construction Duration
1 year channel restoration simultaneous with water supply and distribution
1 year stormwater restoration
2 years lake restoration
18 months habitat restoration overlaps with lake restoretion
Total 4 years construction

Notes:
1 Real Estate costs are provided by the Gross Appraisal of City of Phoenix.
2 Invasive removal costs are historical costs after inflation adjustments.
3 Debris removal costs include the removal of concrete rubble, tires, and trash, etc.
4 The costs of Maintenance Structures are quoted from the historical bid tab of Rio Salado project.
5 The cost is quoted from a Black and Veatch document that the City of Phoenix Water Services uses for its water and sewer projects.
6 A small percentage (roughly 1.0%) of Engineering During Construction is included in Planning, Engineering, and Design.
7 Most of the unit costs are derived from MCACES cost estimating in compliance with ER 1110-2-1302, Civil Works Cost Engineering.

Oeste Feas. Study Cost Estimate

Phoenix, Az.
Feasibility Study Cost Estimate

Designed By: Los Angeles District, USACE.
Estimated By: Cost/Structural Engr'g Section

Prepared By: Phillip Eng
Cost/Structural Engr'g Section

Preparation Date: 09/06/06
Effective Date of Pricing: 09/06/06
Est Construction Time: 1440 Days

Sales Tax: 8.10%

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Release 1.2c

The project site of this feasibility study is located between the authorized Rio Salado project area (located upstream) and the Tres Rios Feasibility Study area (immediately downstream). The Oeste ("West" in Spanish) study area is approximately 8 river miles in length. The study area encompasses approximately 8 square miles.

The study area is located between S. 27th Ave. and S. 83rd Ave. along the Salt River. It includes portions of the City of Phoenix, Maricopa County, as well as state and federal land.

The purpose of the study is to develop alternatives and recommend an implementable solution to the identified water resources problems including native riparian ecosystem restoration, flood damage reduction, storm water retention, water conservation and supply, and the recreational needs of the Rio Salado Oeste study area.

Construction Duration:
1 year channel restoration simultaneously with water supply and distribution
1 year stormwater restoration
2 years lake restoration
18 months habitat restoration with lake restoration
Total = 4 years of construction = 1440 days

Arizona Business Transaction Privilege Tax for Construction:
State = 5.6%
Maricopa County = 0.7%
City of Phoenix = 1.6%

Total = 8.1% [Source: Arizona Dept. of Revenue, www.azdor.gov, www.revenue.state.az.us, (800) 634-6494, (602) 255-2060]

Monitoring and Adaptive Managment Cost is computed separately in the attached Excel Spreadsheet.

** PROJECT SETTINGS **

ESTIMATE TYPE : A-Crews with Auto Reprice

SALES TAX : 8.10%

DATE OF ESCALATION SCHEDULE : 09/06/06

PROJECT DIRECT COST COLUMNS

Col Type	H	L	E	M	U
Rep Width	8	9	9	9	8
Title	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER

PROJECT INDIRECT COST COLUMNS

Col Type	O	U	P	B	X
Rep Width	12	12	12	12	0
Title	OVERHEAD	HOME OFC	PROFIT	BOND	(Unused)

PROJECT OWNER COST COLUMNS

Col Type	C	U	U	X	X
Rep Width	12	12	12	0	0
Title	CONTINGN	PE&D+edc	S&A	(Unused)	(Unused)

PROJECT BREAKDOWN

PROJECT ID	Length	Trail Sep	Level Title	2nd View Order
Level 1 ID :	2	.	Scope	1
Level 2 ID :	3	.	Facility	2
Level 3 ID :	3	.	System	3
Level 4 ID :	3	.	Subsystm	0
Level 5 ID :	3	.	Assm Cat	0
Level 6 ID :	2	.	Assembly	0

Owner Cost Level : 1

** PROJECT SETTINGS **

2ND VIEW COLUMNS

Quantity Column Width : 10

Col Type	X	X	X	X	X
Rep Width	0	0	0	0	0
Title	(Unused)	(Unused)	(Unused)	(Unused)	(Unused)
Shadow	X	X	X	X	X

DETAIL REPORT FORMATTING

PAGE OPTIONS
Page Break Levels : 2
Table of Contents Levels : 2

0 1 2 3 4 5 6 7

ROW OPTIONS
Print Titles at Levels : Y Y Y Y Y Y
Print Totals at Levels : Y Y Y Y Y Y
Print Notes at Levels : Y Y Y Y Y Y Y Y
Print Unit Cost Row : Y
Print Page Footer : Y
Show Cost Codes : Y

COLUMNS OPTIONS
Print Crew Id : Y
Crew Output : Y
Unit Cost : Y

UPB TITLES
No. of Levels to Print : 0
Bracket Titles With : N N
Include titles Notes : N

** PROJECT SETTINGS **

OTHER REPORT FORMATTING

COLUMN TITLES FOR SUMMARY REPORTS

```
  Column 1 OVERHEAD : OVERHEAD (10.0%)
  Column 2 HOME OFC : HOME OFC (8.0%)
  Column 3 PROFIT   : PROFIT (12.0%)
  Column 4 BOND     : BOND (0.72%)
  Column 5 (Unused) : (Unused)

  Column 1 CONTINGN : CONTINGENCY
  Column 2 PE&D+edc : PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)
  Column 3 S&A      : CONTN MANAGEMENT (Acct. 31)
  Column 4 (Unused) :
  Column 5 (Unused) :
```

```
STANDARD COLUMN WIDTHS          SUMMARY FEATURES

   Quantity Columns : 10    Round Totals Column : N-None
 Total cost Columns : 12       Contingency Notes : No
  Unit Cost Columns : 10    Show Project Totals : Yes
```

SPECIAL REPORT FORMATTING OPTIONS

```
                First Alternate ID : (None)
               Show Markup at Level : 0
 Display Indirect/Owner Markup as : A - Unit Costs Only
                 CSI Sort at Level : (None)
```

** PROJECT SETTINGS **

REPORT SELECTION

Project Settings :	Y	Profit Guidelines :	N
Contractor Settings :	N		
Link Listing :	N	Measurement Units :	U.S.

	REPORT FORMAT TYPE			FOR LEVEL (S)
	Direct	Indirect	Owner	0 1 2 3 4 5 6
Detail :	Y			
Project :	Y	Y	Y	Y Y Y Y Y Y
Contractor :	N	N		N N N N N N N
Division :	N	N	N	N N N N N N N
System :	N	N	N	N N N N N N N
2nd View :	N			
Crew :	Y			Y N N N N N N
Labor :	Y			
Equipment :	Y			
Prime Labor Cost Level :	0			

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

			AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
01 LERRD's								
	CONTINGENCY	P		0.00				
	PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	P		0.00				
	CONTN MANAGEMENT (Acct. 31)	P		0.00				
01.001 Flood Plain Project Land								
	CONTINGENCY	P		25.00				
	PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	O						
	CONTN MANAGEMENT (Acct. 31)	O						
01.002 ROW for Water Supply & Distribu-								
	CONTINGENCY	P		25.00				
	PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	O						
	CONTN MANAGEMENT (Acct. 31)	O						
06 Wetland Restoration								
	CONTINGENCY	P		20.00				
	PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	P		11.00				
	CONTN MANAGEMENT (Acct. 31)	P		6.50				
99 Monitoring & Adaptive Mangement								
	CONTINGENCY	P		0.00				
	PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	P		0.00				
	CONTN MANAGEMENT (Acct. 31)	P		0.00				

01.001. Flood Plain Project Land	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST

01. LERRD's
Costs are obtained from the Gross Appraisal Estimate of the City of Phoenix.

01.001. Flood Plain Project Land
A 25% contingency will be added to this cost of $39,588,000.
The estimated Flood Plain Project Land area is 1500 acres.

TOTAL Flood Plain Project Land					0	0	0	0	43900000	43,900,000	

01.002. ROW for Water Supply & Distribu-	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01.002. ROW for Water Supply & Distribution											
A 25% contingency will be added to the direct cost of $800,000. The estimated area of this ROW is 20 acres.											
TOTAL ROW for Water Supply & Distribu-					0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00	EA			0	0	0	0	44700000	44,700,000	44700000

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. Wetland Restoration											
06. 03. Wetland Restoration											
06. 03. 00. Mob/Demob											
TOTAL Equipment (major and heavy)	50.00	EA			0	0	0	0	50,000	50,000	1000.00
TOTAL Setup and Dismantling	50.00	EA			0	0	0	0	100,000	100,000	2000.00
TOTAL Replacement of worn-out quipment	10.00	EA			0	0	0	0	20,000	20,000	2000.00
TOTAL Setup & Dismantling of cranes	4.00	EA			0	0	0	0	100,000	100,000	25000.00
TOTAL Move & transport around job site	50.00	EA			0	0	0	0	100,000	100,000	2000.00
TOTAL Miscellaneous	1.00	EA			0	0	0	0	200,000	200,000	200000.00
TOTAL Mob/Demob	1.00	EA			0	0	0	0	570,000	570,000	570000.00
06. 03. 01. Clearing and Grubbing											
This revised cost item is for clearing/grubbing/removing some small trees (assume 10 trees/acre), low brushes, grasses, and a few scattered palm trees.											
RSM GP <02109 3000 > Clear & grub, chipping stumps,					0.40	12.77	6.69	0.00	0.00	19.45	
to 18" deep, 12" dia	360.00	EA	COMCB86	2.50	144	4,596	2,407	0	0	7,003	19.45
AF GP <02109 9100 > Clear & grub, grub stumps, w/335					0.03	0.85	1.99	0.00	0.00	2.84	
HP dozer, to 6" dia	200.00	EA	CODTB10M	50.00	6	169	399	0	0	568	2.84
AF GP <02109 0375 > Clear & grub, grub & stack, 160					0.06	1.63	3.11	0.00	0.00	4.73	
HP track loader	360.00	CY	CODFB10P	26.00	21	585	1,118	0	0	1,703	4.73
Assume 10 cy/acre											
MIL GP <02109 0010 > Clear & grub, cut & chip light					48.00	1090.11	884.40	0.00	0.00	1974.51	
trees to 6" dia	36.00	ACR	CODFB7	0.13	1,728	39,244	31,839	0	0	71,082	1974.51
AF GP <02112 0600 > Felling trees & piling,					21.33	484.41	393.00	0.00	0.00	877.41	
chipping, light brush	36.00	ACR	CODFB7	0.28	768	17,439	14,148	0	0	31,587	877.41
USR GP < > Hauling and Disposal Cost					0.00	0.00	0.00	0.00	10.00	10.00	
This cost includes transportation cost and disposal fee of the cleared materials.	500.00	CY	N/A	0.00	0	0	0	0	5,000	5,000	10.00
Assume that the disposal site is 5-mile radius from the project area.											

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Clearing and Grubbing	36.00	ACR			2,667	62,032	49,910	0	5,000	116,942	3248.40
06. 03. 02. Invasive Removal											
10 acres (Arundo donax) + 110 acres (Saltcedar) = 120 acres											
Saltcedar is near the lake. The invasive plant of Arundo donax growth covers an area of 10 acres.											
TOTAL Arundo Removal	10.00	ACR			0	0	0	0	300,000	300,000	30000.00
TOTAL Salt Cedar Removal	110.00	ACR			0	0	0	0	550,000	550,000	5000.00
TOTAL Invasive Removal	120.00	ACR			0	0	0	0	850,000	850,000	7083.33
06. 03. 03. Debris Removal											
This cost item is for assuming to remove a combination of inert debris in the area, ie. concrete, rubble, tires, and trash, etc.											
A 2% of the total construction cost is applied here.											
TOTAL Debris Removal	1.00	EA			0	0	0	0	555,000	555,000	555000.00
06. 03. 09. Channel Restoration Excavation											
06. 03. 09.001. Excavation											
06. 03. 09.001.001. Excavation											
CIV GP <02224 3510 > Excavating, bulk, medium matl, dozer, 150' push, open site, 120 HP					0.03	0.94	0.66	0.00	0.00	1.60	
	660000	CY	CODTB10W	45.00	21,978	619,674	437,448	0	0	1,057,122	1.60
TOTAL Excavation	660000	CY			21,978	619,674	437,448	0	0	1,057,122	1.60
06. 03. 09.001.002. Backfill											
AF GP <02215 2500 > Backfill (Reuse for Lake Restoration)					0.01	0.28	0.25	0.00	0.00	0.53	
	726000	CY	CODFB10N	150.00	7,260	204,514	180,048	0	0	384,562	0.53
TOTAL Backfill	660000	CY			7,260	204,514	180,048	0	0	384,562	0.58
06. 03. 09.001.003. Hauling											
MIL GP <02234 2200 > Hauling, off hwy haulers, 26 CY, 1 mile RT @ 20 mph (4.2 cyc/hr)					0.01	0.26	0.61	0.00	0.00	0.87	
	726000	CY	CTDHB34F	96.25	7,550	191,809	442,424	0	0	634,234	0.87
This hauling cost is for moving											

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
excavated material around before finally backfilling.											
TOTAL Hauling	660000	CY			7,550	191,809	442,424	0	0	634,234	0.96
TOTAL Excavation	660000	CY			36,788	1015997	1059920	0	0	2,075,918	3.15
TOTAL Channel Restoration Excavation	660000	CY			36,788	1015997	1059920	0	0	2,075,918	3.15
06. 03. 10. Grade Control Structure (1 ea)											
For this GCS, we need to develop the costs of											
(1) RCC = 2340 cy											
(2) Portland Cement = 285 ton (Assume RCC:Cement = 8.22 cy/ton)											
(3) Pozzolan (Fly Ash) = 109 ton (Assume RCC:Fly Ash = 21.48 cy/ton)											
TOTAL RCC	2400.00	CY			0	0	0	0	84,000	84,000	35.00
TOTAL Portland Cement	285.00	TON			0	0	0	0	31,350	31,350	110.00
TOTAL Pozzolan (Fly Ash)	109.00	TON			0	0	0	0	4,905	4,905	45.00
06. 03. 10.004. Gabion Weirs and Water "V" Ditch "Grade Control Structures"											
MIL GP <02228 0342 > Excavate trench, mdm soil,					0.01	0.26	0.25	0.00	0.00	0.51	
6'-10' D, 1.5 CY excavator	520.00	CY	CODEB12B	231.00	5	134	132	0	0	266	0.51
(5'x2'x800' "V" Ditch)											
5'x2'x800' = 300 cy											
M RSM GP <02240 0020 > Fill, borrow, for embankments,					0.02	0.62	1.08	5.50	0.00	7.20	
load, 1 mile haul, spread w/dozer	520.00	CY	CODTB15	150.00	12	323	561	2,861	0	3,745	7.20
MIL GP <02220 8900 > Compaction, structural/trench,					0.07	1.49	0.17	0.00	0.00	1.66	
by hand w/air tamp, 6" lift	260.00	CY	ULABB9	70.00	19	388	44	0	0	432	1.66
M MIL GP <02220 9000 > Compaction, water, truck, 3000					0.01	0.24	0.24	0.22	0.00	0.70	
gal, 3 mile haul	260.00	CY	COKBB45	236.00	2	63	64	56	0	183	0.70
M MIL GP <02270 0400 > Rip-rap, gabions, 6" deep, galv					0.28	6.56	3.79	18.20	0.00	28.55	
steel mesh mats, stone filled	350.00	SY	CLABB13	25.00	98	2,295	1,325	6,371	0	9,992	28.55
B MIL GP <03330 3620 > Concrete in place,dir chute,					12.00	294.64	0.00	162.15	0.00	456.79	
3000psi, incl forms,reinf, flexural on grade	50.00	CY	ULABC8A	0.50	600	14,732	0	8,108	0	22,839	456.79

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
B MIL GP <05150 8450 > Structural steel members, comb					1.00	40.80	11.83	108.10	0.00	160.73	
sections, channel/angle, 0-30 PLF	10.00	EA	SIWSE21	8.00	10	408	118	1,081	0	1,607	160.73
M RSM GP <02270 0100 > Rip-rap, random, machine placed					0.26	7.69	5.26	26.99	0.00	39.94	
for slope protection. Placed with clamshell.	700.00	CY	UOEHB12G	7.75	181	5,382	3,679	18,895	0	27,956	39.94
M MIL GP <02270 1000 > Rip-rap, random pieces, dumped					0.51	11.99	6.02	33.13	0.00	51.15	
from truck, 3/8 - 1/4 CY	35.00	CY	CODEB3A	9.75	18	420	211	1,160	0	1,790	51.15
TOTAL Gabion Weirs and Water "V" Ditch	1.00	EA			944	24,144	6,135	38,532	0	68,811	68810.58
TOTAL Grade Control Structure (1 ea)	2400.00	CY			944	24,144	6,135	38,532	120,255	189,066	78.78
06. 03. 11. Maintainence Structures											
The one lump-sum cost items are quoted from City of Phoenix, and the remaining cost items are quoted from the previous project of Rio Salado Water Supply and Distribution.											
TOTAL Maintenance Facility					0	0	0	0	1990000	1,990,000	
06. 03. 11.002. Maintenance Roads (hard surface)											
The hard-surface road is 12' wide, and the quoted/historical cost from Rio Salado Water Supply and Distribution project is $25/sy (markups already included). Withont markups, the unit cost should be around $20/sy.											
Originally the quantity was 5.0 mile, and we increased the length of the road to 16 miles = 84,480 lf. Then, 84,480' (L) x 12' (W) = 1,013,760 sf = 112,640 sy. Then, 112,640 sy x $20/sy = $2,252,800. Then, $2,252,800 / 16 miles = $140,800/mile. The indirect markup percentage will be added and appear in the Indirect Summary Pages later. (09/06/2006)											
TOTAL Maintenance Roads (hard surface)	16.00	MI			0	0	0	0	2252800	2,252,800	140800.00
06. 03. 11.003. Maintenance Roads & Trails (soft surface)											
The Maintenance Roads and Trails is 12' wide, and the quoted/historical cost from Rio Salado Water Supply and Distribution project is $11/sy, which includes markups already.											
The original quantity was 10 miles, and we increased the length to 16 miles. (09/06/2006)											
TOTAL Maintenance Roads & Trails (soft	16.00	MI			0	0	0	0	991,232	991,232	61952.00

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 11.004. Maintenance Road Underpass @19th Avenue (north side)											
TOTAL Maintenance Road Underpass @19th					0	0	0	0	997,300	997,300	
06. 03. 11.005. Bridges & Culverts (med) @Storm water Discharge											
TOTAL Bridges & Culverts (med) @Storm	5.00	EA			0	0	0	0	100,000	100,000	20000.00
TOTAL Project Signage	6.00	EA			0	0	0	0	72,000	72,000	12000.00
TOTAL Maintainence Structures					0	0	0	0	6403332	6,403,332	

06. 03. 12. Water Supply & Distribution

Source: A document from Black & Veatch that City of Phoenix Water Services uses to estimate costs for water and sewer projects.

The costs entered here are the dirsct costs without markups of 25.65%, whereas we believe that the A/E document already included markups in its breakdowns.

Assumptions:
(1) 8 mgd from the 23rd Ave. WWTP
(2) Gravity flows (canals & pipes) west of +/- 51st Avenue
(3) 8 outfalls to receive supplemental water
(4) Redundant connections to all reservoirs via 10" loop line
(5) Waste removals for water distribution infrastructure and reservoirs only

06. 03. 12.001. 20 mgd pump station, (incl. mechanical, electrical, enclosure and site work)											
TOTAL 20 mgd pump station,					0	0	0	0	2390000	2,390,000	
06. 03. 12.002. Electronic Flow Regulated Valve to deliver water to Peterson's Farm (incl. mechanical, electrical, concrete, valve and site work)											
TOTAL Electronic Flow Regulated Valve					0	0	0	0	40,000	40,000	
06. 03. 12.003. Electronic Flow Regulated Valves to deliver water to Reservoirs (incl. mechanical, electrical, concrete, valve, and site work)											
TOTAL Electronic Flow Regulated Valves					0	0	0	0	200,000	200,000	

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 12.004. Pump Station (incl. mechanical, electrical, enclosures, and site work)											
TOTAL Pump Station (incl. mechanical,					0	0	0	0	2000000	2,000,000	
06. 03. 12.005. Reservoir (incl. excavation, sub base, liner, trench wall and edge treatment)											
TOTAL Reservoir (incl. excavation, sub					0	0	0	0	1120000	1,120,000	
06. 03. 12.006. Ground Water Pond/Reservoir on Overbank (incl. excavation, sub base, liner, trench wall, and edge treatment)											
TOTAL Ground Water Pond/Reservoir on					0	0	0	0	280,000	280,000	
06. 03. 12.007. 20" Waterline Pipe (incl. trench -ing, shading, valves, joints, backfill and compaction)											
TOTAL 20" Waterline Pipe (incl. trench	13200	LF			0	0	0	0	1584000	1,584,000	120.00
06. 03. 12.008. 16" Waterline Pipe (incl. trench -ing, shading, valves, joints, backfill and compaction)											
TOTAL 16" Waterline Pipe (incl. trench	26500	LF			0	0	0	0	2650000	2,650,000	100.00
06. 03. 12.009. 10" Waterline Pipe Loop (incl. trenching, shading, valves, joints, backfill and compaction)											
TOTAL 10" Waterline Pipe Loop (incl.	37000	LF			0	0	0	0	2664000	2,664,000	72.00
06. 03. 12.010. Bridge crossing of 16" Waterline (incl. waterline, and attachements)											
TOTAL Bridge crossing of 16" Waterline					0	0	0	0	480,000	480,000	
06. 03. 12.011. Bridge crossing of 10" Waterline (incl. waterline and attachements)											
TOTAL Bridge crossing of 10" Waterline					0	0	0	0	320,000	320,000	
06. 03. 12.012. 8" Waterline Pipe to existing outfall structures to supplement current conditions (incl. trenching, shading, valves, backfill and compaction)											
TOTAL 8" Waterline Pipe to existing	5000.00	LF			0	0	0	0	300,000	300,000	60.00

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 12.013. Overbank Canal Delivery Convey- ance Channels (incl. trenching, sub base, soil liner, and edge treatment)											
TOTAL Overbank Canal Delivery Convey-	25000	LF			0	0	0	0	700,000	700,000	28.00
06. 03. 12.014. Terrace and LFC Canal Delivery Conveyance Channels (incl. trenching, sub base, soil liner, and edge treatment)											
TOTAL Terrace and LFC Canal Delivery	35000	LF			0	0	0	0	560,000	560,000	16.00
06. 03. 12.015. Waterfal to Move Water from Overbank to Terrace and/or Terrace to LFC (incl. excavation, sub base, liner, concrete river ruins used for waterfalls and weirs)											
TOTAL Waterfal to Move Water from					0	0	0	0	300,000	300,000	
06. 03. 12.016. Internal Drainage Conveyance Channels in response to Full-scale project Development (incl. excavation, concrete ruin riprap, pipes, and headwalls)											
TOTAL Internal Drainage Conveyance	30.00	EA			0	0	0	0	358,200	358,200	11940.00
06. 03. 12.017. Waste and Tire Removal (incl. over excavation, cleaning/cutting, segregation, soil processing, and hauling waste to landfills)											
TOTAL Waste and Tire Removal (incl.					0	0	0	0	1190000	1,190,000	
06. 03. 12.018. Supply Well (incl. pump, mechan- ical, electrical, concrete, valves, enclosures, and site work)											
TOTAL Supply Well (incl. pump, mechan-	1.00	EA			0	0	0	0	398,000	398,000	398000.00
06. 03. 12.019. Monitoring Well (incl. pump, concrete, and site work)											
TOTAL Monitoring Well (incl. pump,	2.00	EA			0	0	0	0	71,640	71,640	35820.00
TOTAL Water Supply & Distribution					0	0	0	017605840		17,605,840	
06. 03. 73. Stormwater Outfall											
06. 03. 73.001. Grading/Excavation 414 cy x 8 = 3312 cy											
MIL GP <02226 4000 > Excavation, bulk, semi-grade, 2					0.67	17.53	11.77	0.00	0.00	29.30	
passes w/grader	50.00	CSY	COFGB11L	3.00	33	876	589	0	0	1,465	29.30
Assume dimension: 100 yard x 50 yard = 50 CSY											

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CIV GP <02224 1010 > Excavating, bulk; medium matl, 150' push, dozer, open site, 65 HP	3312.00	CY	CODTB10L	25.00	0.06 199	1.69 5,597	1.10 3,647	0.00 0	0.00 0	2.79 9,244	2.79
MIL GP <02234 0610 > Hauling, hwy haulers, 16.5 CY, 1 mile round trip @ 20 MPH (4.2 cyc/hr)	3312.00	CY	CTDHB34C	57.50	0.02 58	0.44 1,465	0.88 2,913	0.00 0	0.00 0	1.32 4,377	1.32
This cost is for hauling, unloading, and piling around the excavation site.											
TOTAL Grading/Excavation	3312.00	CY			290	7,938	7,149	0	0	15,087	4.56
06. 03. 73.002. Concrete 52 cy x 8 = 416 cy											
MIL GP <03372 2000 > Placing conc, footings, shallow, continuous, w/crane & bucket	416.00	CY	ULABC7	11.25	0.71 296	16.78 6,980	9.11 3,792	0.00 0	0.00 0	25.89 10,771	25.89
M RSM GP <03326 0150 > Concrete ready mix, regular weight, 3000 psi	457.60	CY	N/A	0.00	0.00 0	0.00 0	0.00 0	129.72 59,360	0.00 0	129.72 59,360	129.72
TOTAL Concrete	416.00	CY			296	6,980	3,792	59,360	0	70,131	168.59
06. 03. 73.003. Cobble 2800 sf x 8 = 22400 sf Cost is quoted by Pam Conrad from a previous cost estimate and bid abstract, "Tempe"											
TOTAL Cobble	22400	SF			0	0	0	0	156,800	156,800	7.00
06. 03. 73.004. Weir, concrete 2 cy x 8 = 16 CY											
MIL GP <03372 2000 > Placing conc, footings, shallow, continuous, w/crane & bucket	16.00	CY	ULABC7	11.25	0.71 11	16.78 268	9.11 146	0.00 0	0.00 0	25.89 414	25.89
M RSM GP <03326 0150 > Concrete ready mix, regular weight, 3000 psi	17.60	CY	N/A	0.00	0.00 0	0.00 0	0.00 0	129.72 2,283	0.00 0	129.72 2,283	129.72
TOTAL Weir, concrete	16.00	CY			11	268	146	2,283	0	2,697	168.59

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 73.005. V-Ditch Excavation 18.5 cy x 8 = 148 cy											
TOTAL V-Ditch Excavation	148.00	CY			0	444	296	0	0	740	5.00
TOTAL Stormwater Outfall	8.00	EA			597	15,630	11,382	61,643	156,800	245,456	30681.95
06. 03. 74. Wetland Ponds											
06. 03. 74.001. Grading/Excavation											
MIL GP <02226 4000 > Excavation, bulk, semi-grade, 2 passes w/grader	50.00	CSY	COFGB11L	3.00	0.67 33	17.53 876	11.77 589	0.00 0	0.00 0	29.30 1,465	29.30
Assume dimension: 100 yard x 50 yard = 50 CSY											
CIV GP <02224 1010 > Excavating, bulk, medium matl, 150' push, dozer, open site, 65 HP	149890	CY	CODTB10L	25.00	0.06 8,993	1.69 253,314	1.10 165,059	0.00 0	0.00 0	2.79 418,373	2.79
MIL GP <02234 0610 > Hauling, hwy haulers, 16.5 CY, 1 mile round trip @ 20 MPH (4.2 cyc/hr)	149890	CY	CTDHB34C	57.50	0.02 2,608	0.44 66,281	0.88 131,828	0.00 0	0.00 0	1.32 198,110	1.32
This cost is for hauling, unloading, and piling around the excavation site.											
TOTAL Grading/Excavation	149890	CY			11,635	320,472	297,476	0	0	617,948	4.12
06. 03. 74.002. Liner, 12" fines, 3:1 slope, distance of hauling: 4 miles (assumption).											
The unit cost will include hauling, placing, spreading, and roller-compacting, plus material cost of water.											
Material cost of the "fines" is not needed here, because they are readily available at the job site, per Scott Estergard.											
MIL GP <02232 0260 > Excavate & load, wheeled loader, 5 CY, light matl	49641	CY	CODFB10U	207.50	0.01 357	0.20 10,107	0.39 19,256	0.00 0	0.00 0	0.59 29,363	0.59
MIL GP <02234 2210 > Hauling, off hwy haulers, 26 CY, 3 mile RT @ 30 mph (2.9 cyc/hr)	49641	CY	CTDHB34F	71.88	0.01 690	0.35 17,563	0.82 40,507	0.00 0	0.00 0	1.17 58,070	1.17
MIL GP <02239 0110 > Spread/compact, 200 HP dozer w/sheepsfoot roller, 6" lift, embankment	49641	CY	COFCB32E	468.75	0.01 298	0.16 7,858	0.30 14,828	0.00 0	0.00 0	0.46 22,686	0.46

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL GP <02220 9000 > Compaction, water, truck, 3000 gal, 3 mile haul					0.01	0.24	0.24	0.22	0.00	0.70	
	49641	CY	COKBB45	236.00	422	12,063	12,157	10,732	0	34,952	0.70
TOTAL Liner, 12" fines, 3:1 slope,	45128	CY			1,767	47,591	86,747	10,732	0	145,070	3.21
TOTAL Hydroseeding	28.00	ACR			0	0	0	0	56,000	56,000	2000.00
TOTAL Wetland Ponds	28.00	ACR			13,402	368,063	384,223	10,732	56,000	819,018	29250.63
06. 03. 75. Emergent Wetlands											
06. 03. 75.001. Grading/Excavation											
MIL GP <02226 4000 > Excavation, bulk, semi-grade, 2 passes w/grader					0.67	17.53	11.77	0.00	0.00	29.30	
	50.00	CSY	COPGB11L	3.00	33	876	589	0	0	1,465	29.30
Assume dimension: 100 yard x 50 yard = 50 CSY											
CIV GP <02224 1010 > Excavating, bulk, medium matl, 150' push, dozer, open site, 65 HP					0.06	1.69	1.10	0.00	0.00	2.79	
	20952	CY	CODTB10L	25.00	1,257	35,409	23,072	0	0	58,481	2.79
MIL GP <02234 0610 > Hauling, hwy haulers, 16.5 CY, 1 mile round trip @ 20 MPH (4.2 cyc/hr)					0.02	0.44	0.88	0.00	0.00	1.32	
	20952	CY	CTDHB34C	57.50	365	9,265	18,427	0	0	27,692	1.32
This cost is for hauling, unloading, and piling around the excavation site.											
TOTAL Grading/Excavation	20952	CY			1,655	45,550	42,088	0	0	87,638	4.18
06. 03. 75.002. Liner, 12" fines, 3:1 slope, distance of hauling: 4 miles (assumption).											
The unit cost will include hauling, placing, spreading, and roller-compacting, plus material cost of water.											
Material cost of the "fines" is not needed here, because they are readily available at the job site, per Scott Estergard.											
MIL GP <02232 0260 > Excavate & load, wheeled loader, 5 CY, light matl					0.01	0.20	0.39	0.00	0.00	0.59	
	23047	CY	CODFB10U	207.50	166	4,692	8,940	0	0	13,632	0.59
MIL GP <02234 2210 > Hauling, off hwy haulers, 26 CY, 3 mile RT @ 30 mph (2.9 cyc/hr)					0.01	0.35	0.82	0.00	0.00	1.17	
	23047	CY	CTDHB34F	71.88	320	8,154	18,807	0	0	26,961	1.17

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL GP <02239 0110 > Spread/compact, 200 HP dozer					0.01	0.16	0.30	0.00	0.00	0.46	
w/sheepsfoot roller, 6" lift, embankment	23047	CY	COFCB32E	468.75	138	3,648	6,884	0	0	10,533	0.46
M MIL GP <02220 9000 > Compaction, water, truck, 3000					0.01	0.24	0.24	0.22	0.00	0.70	
gal, 3 mile haul	23047	CY	COKBB45	236.00	196	5,600	5,644	4,983	0	16,228	0.70
TOTAL Liner, 12" fines, 3:1 slope,	20952	CY			820	22,095	40,275	4,983	0	67,353	3.21
TOTAL Emergent Wetlands	13.00	ACR			2,476	67,646	82,363	4,983	0	154,992	11922.43
06. 03. 76. Cottonwood/willow (1 gal)											
06. 03. 76.001. Planting											
Source: see "Planting" tab in Excel spreadsheet.											
TOTAL Planting	378.00	ACR			0	0	0	0	451,710	451,710	1195.00
TOTAL Irrigation	378.00	ACR			0	0	0	0	3326400	3,326,400	8800.00
06. 03. 76.003. Maintenance of Plants & Irrigat-											
ion System During Plant Establishment Period of 1 year. Assume plant growth will be stabilized after one-year period.											
Cost is quoted and estimated roughly from another project of Rio Salado, Phoenix. Estimate is taken as 1% of the cost of planting and irrigation system.											
TOTAL Maintenance of Plants & Irrigat-	378.00	ACR			0	0	0	0	37,800	37,800	100.00
TOTAL Cottonwood/willow (1 gal)	378.00	ACR			0	0	0	0	3815910	3,815,910	10095.00
06. 03. 77. Mesquite Bosque (1 gal)											
06. 03. 77.001. Planting											
Source: see "Planting" tab in the Excel spreadsheet.											
TOTAL Planting	244.00	ACR			0	0	0	0	874,008	874,008	3582.00
TOTAL Irrigation	244.00	ACR			0	0	0	0	2147200	2,147,200	8800.00
06. 03. 77.003. Maintenance of Plants and Irrig-											
ation System During Plant Establishment Period of 1 year.											
See notes at the previous cost item.											
TOTAL Maintenance of Plants and Irrig-	244.00	ACR			0	0	0	0	30,500	30,500	125.00

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Mesquite Bosque (1 gal)	244.00	ACR			0	0	0	0	3051708	3,051,708	12507.00
06. 03. 78. Mesquite Xeric											
06. 03. 78.001. Planting											
Source: see "Planting" tab in Excel spreadsheet.											
TOTAL Planting	168.00	ACR			0	0	0	0	160,440	160,440	955.00
TOTAL Irrigation	168.00	ACR			0	0	0	0	1478400	1,478,400	8800.00
06. 03. 78.003. Maintenance of Plants and Irrig-											
ation System During Plant Establishment of 1 year.											
See notes at the previous cost item.											
TOTAL Maintenance of Plants and Irrig-	168.00	ACR			0	0	0	0	16,800	16,800	100.00
TOTAL Mesquite Xeric	168.00	ACR			0	0	0	0	1655640	1,655,640	9855.00
06. 03. 79. Lake Restoration											
06. 03. 79.001. Lake Restoration (2 lakes)											
This cost item is the construction of a 20-acre lake at 39th Avenue by backfilling 68 acres of water surrounding the quadrant. The depth of the lake is 20ft.											
68 acres x 43,560 sf/acre = 2,962,080 sf											
2,962,080 sf x 20' depth = 2,194,133 cy											
**********											
The above information is replaced by the following information. (06/14/04)											
Construction of two lakes, one at 29th Avenue (needs 20 acres of lake lining), and the other at 37th Avenue.											
Quantity = 2 lakes x 1,346,018 cy = 2,692,036 cy (see e-mails dated 06/14/04). The volume of backfill material to create the two lakes are readily available nearby, and no need for cost of borrow material to be included. Use the quantity 3,000,000 cy.											
MIL GP <02226 3120 > Excavation, bulk, 6 cycle/hr,					0.02	0.69	1.77	0.00	0.00	2.46	
push loaded self prop scraper, 16 BCY	3000000	CY	CODSB33D	75.00	72,000	2073000	5318400	0	0	7,391,400	2.46
MIL GP <02232 0245 > Excavate & load, wheeled loader,					0.01	0.31	0.38	0.00	0.00	0.68	
3 CY, medium matl	3000000	CY	CODFB10T	137.50	32,700	921,900	1127400	0	0	2,049,300	0.68

06. 03. Wetland Restoration	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
RSM GP <02216 2000 > Backfill, strl, sand & gravel,					0.01	0.31	0.20	0.00	0.00	0.51	
no cmpct, 75 HP dozer, 50' haul	3300000	CY	CODTB10L	137.50	35,970	1014090	660,660	0	0	1,674,750	0.51
TOTAL Lake Restoration (2 lakes)	3000000	CY			140,670	4008990	7106460	0	0	11,115,450	3.71

06. 03. 79.002. Emergent Wetlands (2 lakes)
This cost item is tied to "002: Lake Restoration (2 lakes)" in the above.

06. 03. 79.002.001. Emergent Wetlands

06. 03. 79.002.001. 1. Liner, 12" fines, 3:1 slope,
distance of hauling: 4 miles (assumption).

The unit cost will include hauling, placing, spreading, and roller-compacting, plus material cost of water.

Material cost of the "fines" is not needed here, because they are readily available at the job site, per Scott Estergard.

MIL GP <02232 0260 > Excavate & load, wheeled loader,					0.01	0.20	0.39	0.00	0.00	0.59	
5 CY, light matl	70916	CY	CODFB10U	207.50	511	14,438	27,508	0	0	41,947	0.59
MIL GP <02234 2210 > Hauling, off hwy haulers, 26 CY,					0.01	0.35	0.82	0.00	0.00	1.17	
3 mile RT @ 30 mph (2.9 cyc/hr)	70916	CY	CTDHB34F	71.88	986	25,090	57,867	0	0	82,957	1.17
MIL GP <02239 0110 > Spread/compact, 200 HP dozer					0.01	0.16	0.30	0.00	0.00	0.46	
w/sheepsfoot roller, 6" lift, embankment	70916	CY	COFCB32E	468.75	425	11,226	21,183	0	0	32,409	0.46
M MIL GP <02220 9000 > Compaction, water, truck, 3000					0.01	0.24	0.24	0.22	0.00	0.70	
gal, 3 mile haul	70916	CY	COKBB45	236.00	603	17,233	17,367	15,332	0	49,932	0.70
TOTAL Liner, 12" fines, 3:1 slope,	64469	CY			2,525	67,987	123,926	15,332	0	207,245	3.21
TOTAL Emergent Wetlands	64469	CY			2,525	67,987	123,926	15,332	0	207,245	3.21
TOTAL Hydroseeding	40.00	ACR			0	0	0	0	80,000	80,000	2000.00
TOTAL Plant Maintenance (1 year)	40.00	ACR			0	0	0	0	800	800	20.00
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR			2,525	67,987	123,926	15,332	80,800	288,045	7201.12
TOTAL Lake Restoration	2.00	EA			143,195	4076977	7230386	15,332	80,800	11,403,495	5701747
TOTAL Wetland Restoration	1.00	EA			200,068	5630490	8824319	131,22234926285		49,512,315	49512315

06. 14. Recreation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 14. Recreation ALL THE FOLLOWING QUANTITIES AND UNIT COSTS ARE PROVIDED BY THE CITY OF PHOENIX.											
06. 14.002. Access Points 5 drive-ins (35th N&S, 51st N&S, 75th), and 5 walk-ins (23rd, 43rd, 75th, 83rd)											
06. 14.002.001. Site Preparation Including clearing, grubbing, and grading											
USR < > Site Prep, incl. clearing, grubbing, and grading	9.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	28000 252,000	28000.00 252,000	28000.00
USR < > Vegetative restoration (drive in access)	4.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	150000 600,000	150000.00 600,000	150000.00
USR < > Vegetative restoration (walk	5.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	15000 75,000	15000.00 75,000	15000.00
TOTAL Site Preparation	1.00	EA			0	0	0	0	927,000	927,000	927000.00
06. 14.002.002. Access and Circulation											
USR < > Entry road w/turnaround to incl. curb, gutter, driveway, and road	4.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	150000 600,000	150000.00 600,000	150000.00
USR < > Parking Lot	500.00	SP		0.00	0.00 0	0.00 0	0.00 0	0.00 0	1500.00 750,000	1500.00 750,000	1500.00
USR < > Sidewalks and rampa	40000	SF		0.00	0.00 0	0.00 0	0.00 0	0.00 0	6.00 240,000	6.00 240,000	6.00
USR < > Multi-use trails (16 mile * 5280 * 5 ft = 46,933 sy)	47000	SY		0.00	0.00 0	0.00 0	0.00 0	0.00 0	6.00 282,000	6.00 282,000	6.00
USR < > Bridges and Culverts (small) at canals, and localized drainage areas	10.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	7500.00 75,000	7500.00 75,000	7500.00
TOTAL Access and Circulation	1.00	EA			0	0	0	0	1947000	1,947,000	1947000

1234

06. 14. Recreation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 14.002.003. Protection Access Control											
USR < > Access Control Gates (vehicular)					0.00	0.00	0.00	0.00	7500.00	7500.00	
	10.00	EA		0.00	0	0	0	0	75,000	75,000	7500.00
USR < > Access Control Gates (pedestrian					0.00	0.00	0.00	0.00	3500.00	3500.00	
	18.00	EA		0.00	0	0	0	0	63,000	63,000	3500.00
USR < > Handrails					0.00	0.00	0.00	0.00	50.00	50.00	
	5000.00	LF		0.00	0	0	0	0	250,000	250,000	50.00
USR < > Guardrails					0.00	0.00	0.00	0.00	50.00	50.00	
	3000.00	LF		0.00	0	0	0	0	150,000	150,000	50.00
USR < > Fencing					0.00	0.00	0.00	0.00	30.00	30.00	
	5000.00	LF		0.00	0	0	0	0	150,000	150,000	30.00
USR < > Walls					0.00	0.00	0.00	0.00	125.00	125.00	
	1500.00	LF		0.00	0	0	0	0	187,500	187,500	125.00
USR < > Security Lights					0.00	0.00	0.00	0.00	4000.00	4000.00	
	100.00	EA		0.00	0	0	0	0	400,000	400,000	4000.00
TOTAL Protection Access Control	1.00	EA			0	0	0	0	1275500	1,275,500	1275500
06. 14.002.004. Signage											
USR < > Entrance identification signage					0.00	0.00	0.00	0.00	15000	15000.00	
	8.00	EA		0.00	0	0	0	0	120,000	120,000	15000.00
USR < > Traffic Control (vehicular)					0.00	0.00	0.00	0.00	500.00	500.00	
	20.00	EA		0.00	0	0	0	0	10,000	10,000	500.00
USR < > Traffic Control (pedestrians)					0.00	0.00	0.00	0.00	500.00	500.00	
	27.00	EA		0.00	0	0	0	0	13,500	13,500	500.00
USR < > Instructional/Directional					0.00	0.00	0.00	0.00	500.00	500.00	
	45.00	EA		0.00	0	0	0	0	22,500	22,500	500.00
TOTAL Signage	1.00	EA			0	0	0	0	166,000	166,000	166000.00
06. 14.002.005. Shelters											
USR < > Picnic (large)					0.00	0.00	0.00	0.00	60000	60000.00	
	5.00	EA		0.00	0	0	0	0	300,000	300,000	60000.00
USR < > Picnic (small)					0.00	0.00	0.00	0.00	25000	25000.00	
	5.00	EA		0.00	0	0	0	0	125,000	125,000	25000.00

06. 14. Recreation			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR	<	> Restroom Facility/Comfort Stat.					0.00	0.00	0.00	0.00	250000	250000.00	
			5.00	EA		0.00	0	0	0	0	1250000	1,250,000	250000.00
USR	<	> Shelter w/Bulletin Boards					0.00	0.00	0.00	0.00	25000	25000.00	
			4.00	EA		0.00	0	0	0	0	100,000	100,000	25000.00
USR	<	> Trail Shelter w/Railing (large)					0.00	0.00	0.00	0.00	40000	40000.00	
			9.00	EA		0.00	0	0	0	0	360,000	360,000	40000.00
USR	<	> Trail Shelter w/Railing (medium)					0.00	0.00	0.00	0.00	30000	30000.00	
			4.00	EA		0.00	0	0	0	0	120,000	120,000	30000.00
USR	<	> Trail Shelter w/Railing (small)					0.00	0.00	0.00	0.00	20000	20000.00	
			10.00	EA		0.00	0	0	0	0	200,000	200,000	20000.00
		TOTAL Shelters	1.00	EA			0	0	0	0	2455000	2,455,000	2455000
06. 14.002.006. Utilities													
USR	<	> Municipal Water Supply & Wastewater Disposal					0.00	0.00	0.00	0.00	100000	100000.00	
			5.00	LS		0.00	0	0	0	0	500,000	500,000	100000.00
USR	<	> Storm Drainage					0.00	0.00	0.00	0.00	20000	20000.00	
			4.00	LS		0.00	0	0	0	0	80,000	80,000	20000.00
USR	<	> Drinking Fountain w/Chiller					0.00	0.00	0.00	0.00	5000.00	5000.00	
			12.00	EA		0.00	0	0	0	0	60,000	60,000	5000.00
USR	<	> Electrical					0.00	0.00	0.00	0.00	50000	50000.00	
			4.00	EA		0.00	0	0	0	0	200,000	200,000	50000.00
		TOTAL Utilities	1.00	EA			0	0	0	0	840,000	840,000	840000.00
06. 14.002.007. Park Furniture													
USR	<	> Benches					0.00	0.00	0.00	0.00	1500.00	1500.00	
			14.00	EA		0.00	0	0	0	0	21,000	21,000	1500.00
USR	<	> Benches (off-the-shelf)					0.00	0.00	0.00	0.00	800.00	800.00	
			40.00	EA		0.00	0	0	0	0	32,000	32,000	800.00
USR	<	> Benches (recycled/custom)					0.00	0.00	0.00	0.00	500.00	500.00	
			50.00	EA		0.00	0	0	0	0	25,000	25,000	500.00
USR	<	> Picnic Tables					0.00	0.00	0.00	0.00	1000.00	1000.00	
			40.00	EA		0.00	0	0	0	0	40,000	40,000	1000.00

06. 14. Recreation	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR < > Trash Receptacles					0.00	0.00	0.00	0.00	500.00	500.00	
	75.00	EA		0.00	0	0	0	0	37,500	37,500	500.00
TOTAL Park Furniture	1.00	EA			0	0	0	0	155,500	155,500	155500.00
06. 14.002.008. Interpretive Guidance Media											
USR < > Display Boards					0.00	0.00	0.00	0.00	600.00	600.00	
	50.00	EA		0.00	0	0	0	0	30,000	30,000	600.00
USR < > Interpretive Markers					0.00	0.00	0.00	0.00	600.00	600.00	
	100.00	EA		0.00	0	0	0	0	60,000	60,000	600.00
USR < > Bulletin Boards					0.00	0.00	0.00	0.00	2500.00	2500.00	
	9.00	EA		0.00	0	0	0	0	22,500	22,500	2500.00
TOTAL Interpretive Guidance Media	1.00	EA			0	0	0	0	112,500	112,500	112500.00
TOTAL Access Points	1.00	EA			0	0	0	0	7878500	7,878,500	7878500
TOTAL Recreation	1.00	EA			0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA			200,068	5630490	8824319	131,22242804785		57,390,815	57390815

	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
99. Monitoring & Adaptive Mangement											
TOTAL Monitoring & Adaptive Mangement	1.00	EA			0	0	0	0	0	0	0.00
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA			200,068	5630490	8824319	131,22287504785		102,090,815	102090815

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's	1.00	EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration	1.00	EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement								
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land			43,900,000	10,975,000	0	0	54,875,000	
01.002 ROW for Water Supply & Distribu-			800,000	200,000	0	0	1,000,000	
TOTAL LERRD's	1.00	EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration								
06. 03 Wetland Restoration	1.00	EA	66,355,552	13,271,110	8,758,933	5,745,064	94,130,659	94130659
06. 14 Recreation	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Wetland Restoration	1.00	EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement								
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's							
01.001 Flood Plain Project Land		43,900,000	10,975,000	0	0	54,875,000	
01.002 ROW for Water Supply & Distribu-		800,000	200,000	0	0	1,000,000	
TOTAL LERRD's	1.00 EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration							
06. 03 Wetland Restoration							
06. 03. 00 Mob/Demob	1.00 EA	763,904	152,781	100,835	66,139	1,083,659	1083659
06. 03. 01 Clearing and Grubbing	36.00 ACR	156,724	31,345	20,688	13,569	222,326	6175.72
06. 03. 02 Invasive Removal	120.00 ACR	1,139,155	227,831	150,369	98,628	1,615,983	13466.53
06. 03. 03 Debris Removal	1.00 EA	743,801	148,760	98,182	64,398	1,055,142	1055142
06. 03. 09 Channel Restoration Excavation	660000.00 CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
06. 03. 10 Grade Control Structure (1 ea)	2400.00 CY	253,382	50,676	33,446	21,938	359,443	149.77
06. 03. 11 Maintainence Structures		8,581,635	1,716,327	1,132,776	742,998	12,173,736	
06. 03. 12 Water Supply & Distribution		23,595,043	4,719,009	3,114,546	2,042,859	33,471,457	
06. 03. 73 Stormwater Outfall	8.00 EA	328,955	65,791	43,422	28,481	466,649	58331.18
06. 03. 74 Wetland Ponds	28.00 ACR	1,097,634	219,527	144,888	95,033	1,557,081	55610.03
06. 03. 75 Emergent Wetlands	13.00 ACR	207,717	41,543	27,419	17,984	294,663	22666.40
06. 03. 76 Cottonwood/willow (1 gal)	378.00 ACR	5,114,017	1,022,803	675,050	442,772	7,254,642	19192.17
06. 03. 77 Mesquite Bosque (1 gal)	244.00 ACR	4,089,846	817,969	539,860	354,099	5,801,774	23777.76
06. 03. 78 Mesquite Xeric	168.00 ACR	2,218,860	443,772	292,890	192,109	3,147,631	18735.90
06. 03. 79 Lake Restoration	2.00 EA	15,282,767	3,056,553	2,017,325	1,323,182	21,679,828	10839914
TOTAL Wetland Restoration	1.00 EA	66,355,552	13,271,110	8,758,933	5,745,064	94,130,659	94130659
06. 14 Recreation							
06. 14.002 Access Points	1.00 EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Recreation	1.00 EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Wetland Restoration	1.00 EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement							
TOTAL Oeste Feas. Study Cost Estimate	1.00 EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land			43,900,000	10,975,000	0	0	54,875,000	
01.002 ROW for Water Supply & Distribu-			800,000	200,000	0	0	1,000,000	
TOTAL LERRD's	1.00	EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00	EA	67,009	13,402	8,845	5,802	95,058	1901.16
06. 03. 00.002 Setup and Dismantling	50.00	EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.003 Replacement of worn-out quipment	10.00	EA	26,804	5,361	3,538	2,321	38,023	3802.31
06. 03. 00.004 Setup & Dismantling of cranes	4.00	EA	134,018	26,804	17,690	11,603	190,116	47528.91
06. 03. 00.005 Move & transport around job site	50.00	EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.006 Miscellaneous	1.00	EA	268,037	53,607	35,381	23,207	380,231	380231.30
TOTAL Mob/Demob	1.00	EA	763,904	152,781	100,835	66,139	1,083,659	1083659
06. 03. 01 Clearing and Grubbing	36.00	ACR	156,724	31,345	20,688	13,569	222,326	6175.72
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00	ACR	402,055	80,411	53,071	34,810	570,347	57034.69
06. 03. 02.002 Salt Cedar Removal	110.00	ACR	737,101	147,420	97,297	63,818	1,045,636	9505.78
TOTAL Invasive Removal	120.00	ACR	1,139,155	227,831	150,369	98,628	1,615,983	13466.53
06. 03. 03 Debris Removal	1.00	EA	743,801	148,760	98,182	64,398	1,055,142	1055142
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation	660000.00	CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
TOTAL Channel Restoration Excavation	660000.00	CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00	CY	112,575	22,515	14,860	9,747	159,697	66.54
06. 03. 10.002 Portland Cement	285.00	TON	42,015	8,403	5,546	3,638	59,601	209.13
06. 03. 10.003 Pozzolan (Fly Ash)	109.00	TON	6,574	1,315	868	569	9,325	85.55
06. 03. 10.004 Gabion Weirs and Water "V" Ditch	1.00	EA	92,219	18,444	12,173	7,984	130,820	130819.68
TOTAL Grade Control Structure (1 ea)	2400.00	CY	253,382	50,676	33,446	21,938	359,443	149.77

		QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 11	Maintainence Structures								
06. 03. 11.001	Maintenance Facility			2,666,964	533,393	352,039	230,906	3,783,301	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	3,019,164	603,833	398,530	261,399	4,282,925	267682.83
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	1,328,432	265,686	175,353	115,016	1,884,487	117780.45
06. 03. 11.004	Maintenance Road Underpass @19th			1,336,564	267,313	176,426	115,720	1,896,023	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	134,018	26,804	17,690	11,603	190,116	38023.13
06. 03. 11.006	Project Signage	6.00	EA	96,493	19,299	12,737	8,354	136,883	22813.88
	TOTAL Maintainence Structures			8,581,635	1,716,327	1,132,776	742,998	12,173,736	
06. 03. 12	Water Supply & Distribution								
06. 03. 12.001	20 mgd pump station,			3,203,037	640,607	422,801	277,319	4,543,764	
06. 03. 12.002	Electronic Flow Regulated Valve			53,607	10,721	7,076	4,641	76,046	
06. 03. 12.003	Electronic Flow Regulated Valves			268,037	53,607	35,381	23,207	380,231	
06. 03. 12.004	Pump Station (incl. mechanical,			2,680,366	536,073	353,808	232,066	3,802,313	
06. 03. 12.005	Reservoir (incl. excavation, sub			1,501,005	300,201	198,133	129,957	2,129,295	
06. 03. 12.006	Ground Water Pond/Reservoir on			375,251	75,050	49,533	32,489	532,324	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	2,122,850	424,570	280,216	183,796	3,011,432	228.14
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	3,551,484	710,297	468,796	307,488	5,038,065	190.12
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	3,570,247	714,049	471,273	309,112	5,064,681	136.88
06. 03. 12.010	Bridge crossing of 16" Waterline			643,288	128,658	84,914	55,696	912,555	
06. 03. 12.011	Bridge crossing of 10" Waterline			428,858	85,772	56,609	37,131	608,370	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	402,055	80,411	53,071	34,810	570,347	114.07
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	938,128	187,626	123,833	81,223	1,330,810	53.23
06. 03. 12.014	Terrace and LPC Canal Delivery	35000.00	LF	750,502	150,100	99,066	64,978	1,064,648	30.42
06. 03. 12.015	Waterfal to Move Water from			402,055	80,411	53,071	34,810	570,347	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	480,053	96,011	63,367	41,563	680,994	22699.81
06. 03. 12.017	Waste and Tire Removal (incl.			1,594,818	318,964	210,516	138,079	2,262,376	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	533,393	106,679	70,408	46,181	756,660	756660.28
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	96,011	19,202	12,673	8,313	136,199	68099.43
	TOTAL Water Supply & Distribution			23,595,043	4,719,009	3,114,546	2,042,859	33,471,457	
06. 03. 73	Stormwater Outfall								
06. 03. 73.001	Grading/Excavation	3312.00	CY	20,219	4,044	2,669	1,751	28,682	8.66
06. 03. 73.002	Concrete	416.00	CY	93,989	18,798	12,407	8,138	133,331	320.51
06. 03. 73.003	Cobble	22400.00	SF	210,141	42,028	27,739	18,194	298,101	13.31
06. 03. 73.004	Weir, concrete	16.00	CY	3,615	723	477	313	5,128	320.51
06. 03. 73.005	V-Ditch Excavation	148.00	CY	992	198	131	86	1,407	9.51
	TOTAL Stormwater Outfall	8.00	EA	328,955	65,791	43,422	28,481	466,649	58331.18
06. 03. 74	Wetland Ponds								
06. 03. 74.001	Grading/Excavation	149890.00	CY	828,163	165,633	109,317	71,702	1,174,815	7.84

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00	CY	194,421	38,884	25,664	16,833	275,801	6.11
06. 03. 74.003 Hydroseeding	28.00	ACR	75,050	15,010	9,907	6,498	106,465	3802.31
TOTAL Wetland Ponds	28.00	ACR	1,097,634	219,527	144,888	95,033	1,557,081	55610.03
06. 03. 75 Emergent Wetlands								
06. 03. 75.001 Grading/Excavation	20952.00	CY	117,451	23,490	15,504	10,169	166,614	7.95
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00	CY	90,266	18,053	11,915	7,815	128,049	6.11
TOTAL Emergent Wetlands	13.00	ACR	207,717	41,543	27,419	17,984	294,663	22666.40
06. 03. 76 Cottonwood/willow (1 gal)								
06. 03. 76.001 Planting	378.00	ACR	605,374	121,075	79,909	52,413	858,771	2271.88
06. 03. 76.002 Irrigation	378.00	ACR	4,457,984	891,597	588,454	385,972	6,324,007	16730.18
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00	ACR	50,659	10,132	6,687	4,386	71,864	190.12
TOTAL Cottonwood/willow (1 gal)	378.00	ACR	5,114,017	1,022,803	675,050	442,772	7,254,642	19192.17
06. 03. 77 Mesquite Bosque (1 gal)								
06. 03. 77.001 Planting	244.00	ACR	1,171,330	234,266	154,616	101,414	1,661,626	6809.94
06. 03. 77.002 Irrigation	244.00	ACR	2,877,640	575,528	379,849	249,146	4,082,163	16730.18
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00	ACR	40,876	8,175	5,396	3,539	57,985	237.64
TOTAL Mesquite Bosque (1 gal)	244.00	ACR	4,089,846	817,969	539,860	354,099	5,801,774	23777.76
06. 03. 78 Mesquite Xeric								
06. 03. 78.001 Planting	168.00	ACR	215,019	43,004	28,382	18,616	305,022	1815.60
06. 03. 78.002 Irrigation	168.00	ACR	1,981,326	396,265	261,535	171,543	2,810,670	16730.18
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00	ACR	22,515	4,503	2,972	1,949	31,939	190.12
TOTAL Mesquite Xeric	168.00	ACR	2,218,860	443,772	292,890	192,109	3,147,631	18735.90
06. 03. 79 Lake Restoration								
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	14,896,735	2,979,347	1,966,369	1,289,759	21,132,210	7.04
06. 03. 79.002 Emergent Wetlands (2 lakes)	40.00	ACR	386,032	77,206	50,956	33,423	547,618	13690.45
TOTAL Lake Restoration	2.00	EA	15,282,767	3,056,553	2,017,325	1,323,182	21,679,828	10839914
TOTAL Wetland Restoration	1.00	EA	66,355,552	13,271,110	8,758,933	5,745,064	94,130,659	94130659

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 14 Recreation								
06. 14.002 Access Points								
06. 14.002.001 Site Preparation	1.00	EA	927,000	185,400	122,364	80,260	1,315,024	1315024
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	389,400	257,004	168,571	2,761,975	2761975
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	255,100	168,366	110,433	1,809,399	1809399
06. 14.002.004 Signage	1.00	EA	166,000	33,200	21,912	14,372	235,484	235484.28
06. 14.002.005 Shelters	1.00	EA	2,455,000	491,000	324,060	212,554	3,482,614	3482614
06. 14.002.006 Utilities	1.00	EA	840,000	168,000	110,880	72,727	1,191,607	1191607
06. 14.002.007 Park Furniture	1.00	EA	155,500	31,100	20,526	13,463	220,589	220589.19
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	22,500	14,850	9,740	159,590	159590.25
TOTAL Access Points	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Recreation	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Wetland Restoration	1.00	EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement								
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's							
01.001 Flood Plain Project Land		43,900,000	10,975,000	0	0	54,875,000	
01.002 ROW for Water Supply & Distribu-		800,000	200,000	0	0	1,000,000	
TOTAL LERRD's	1.00 EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration							
06. 03 Wetland Restoration							
06. 03. 00 Mob/Demob							
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	67,009	13,402	8,845	5,802	95,058	1901.16
06. 03. 00.002 Setup and Dismantling	50.00 EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	26,804	5,361	3,538	2,321	38,023	3802.31
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	134,018	26,804	17,690	11,603	190,116	47528.91
06. 03. 00.005 Move & transport around job site	50.00 EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.006 Miscellaneous	1.00 EA	268,037	53,607	35,381	23,207	380,231	380231.30
TOTAL Mob/Demob	1.00 EA	763,904	152,781	100,835	66,139	1,083,659	1083659
06. 03. 01 Clearing and Grubbing	36.00 ACR	156,724	31,345	20,688	13,569	222,326	6175.72
06. 03. 02 Invasive Removal							
06. 03. 02.001 Arundo Removal	10.00 ACR	402,055	80,411	53,071	34,810	570,347	57034.69
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	737,101	147,420	97,297	63,818	1,045,636	9505.78
TOTAL Invasive Removal	120.00 ACR	1,139,155	227,831	150,369	98,628	1,615,983	13466.53
06. 03. 03 Debris Removal	1.00 EA	743,801	148,760	98,182	64,398	1,055,142	1055142
06. 03. 09 Channel Restoration Excavation							
06. 03. 09.001 Excavation							
06. 03. 09.001.001 Excavation	660000.00 CY	1,416,737	283,347	187,009	122,661	2,009,754	3.05
06. 03. 09.001.002 Backfill	660000.00 CY	515,384	103,077	68,031	44,622	731,113	1.11
06. 03. 09.001.003 Hauling	660000.00 CY	849,989	169,998	112,199	73,592	1,205,777	1.83
TOTAL Excavation	660000.00 CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
TOTAL Channel Restoration Excavation	660000.00 CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
06. 03. 10 Grade Control Structure (1 ea)							
06. 03. 10.001 RCC	2400.00 CY	112,575	22,515	14,860	9,747	159,697	66.54

		QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00 TON	42,015	8,403	5,546	3,638	59,601	209.13
06. 03. 10.003	Pozzolan (Fly Ash)	109.00 TON	6,574	1,315	868	569	9,325	85.55
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00 EA	92,219	18,444	12,173	7,984	130,820	130819.68
	TOTAL Grade Control Structure (1 ea)	2400.00 CY	253,382	50,676	33,446	21,938	359,443	149.77
06. 03. 11	Maintainence Structures							
06. 03. 11.001	Maintenance Facility		2,666,964	533,393	352,039	230,906	3,783,301	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00 MI	3,019,164	603,833	398,530	261,399	4,282,925	267682.83
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00 MI	1,328,432	265,686	175,353	115,016	1,884,487	117780.45
06. 03. 11.004	Maintenance Road Underpass @19th		1,336,564	267,313	176,426	115,720	1,896,023	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00 EA	134,018	26,804	17,690	11,603	190,116	38023.13
06. 03. 11.006	Project Signage	6.00 EA	96,493	19,299	12,737	8,354	136,883	22813.88
	TOTAL Maintainence Structures		8,581,635	1,716,327	1,132,776	742,998	12,173,736	
06. 03. 12	Water Supply & Distribution							
06. 03. 12.001	20 mgd pump station,		3,203,037	640,607	422,801	277,319	4,543,764	
06. 03. 12.002	Electronic Flow Regulated Valve		53,607	10,721	7,076	4,641	76,046	
06. 03. 12.003	Electronic Flow Regulated Valves		268,037	53,607	35,381	23,207	380,231	
06. 03. 12.004	Pump Station (incl. mechanical,		2,680,366	536,073	353,808	232,066	3,802,313	
06. 03. 12.005	Reservoir (incl. excavation, aub		1,501,005	300,201	198,133	129,957	2,129,295	
06. 03. 12.006	Ground Water Pond/Reservoir on		375,251	75,050	49,533	32,489	532,324	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00 LF	2,122,850	424,570	280,216	183,796	3,011,432	228.14
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00 LF	3,551,484	710,297	468,796	307,488	5,038,065	190.12
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00 LF	3,570,247	714,049	471,273	309,112	5,064,681	136.88
06. 03. 12.010	Bridge crossing of 16" Waterline		643,288	128,658	84,914	55,696	912,555	
06. 03. 12.011	Bridge crossing of 10" Waterline		428,858	85,772	56,609	37,131	608,370	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00 LF	402,055	80,411	53,071	34,810	570,347	114.07
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00 LF	938,128	187,626	123,833	81,223	1,330,810	53.23
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00 LF	750,502	150,100	99,066	64,978	1,064,648	30.42
06. 03. 12.015	Waterfal to Move Water from		402,055	80,411	53,071	34,810	570,347	
06. 03. 12.016	Internal Drainage Conveyance	30.00 EA	480,053	96,011	63,367	41,563	680,994	22699.81
06. 03. 12.017	Waste and Tire Removal (incl.		1,594,818	318,964	210,516	138,079	2,262,376	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00 EA	533,393	106,679	70,408	46,181	756,660	756660.28
06. 03. 12.019	Monitoring Well (incl. pump,	2.00 EA	96,011	19,202	12,673	8,313	136,199	68099.43
	TOTAL Water Supply & Distribution		23,595,043	4,719,009	3,114,546	2,042,859	33,471,457	
06. 03. 73	Stormwater Outfall							
06. 03. 73.001	Grading/Excavation	3312.00 CY	20,219	4,044	2,669	1,751	28,682	8.66
06. 03. 73.002	Concrete	416.00 CY	93,989	18,798	12,407	8,138	133,331	320.51
06. 03. 73.003	Cobble	22400.00 SF	210,141	42,028	27,739	18,194	298,101	13.31
06. 03. 73.004	Weir, concrete	16.00 CY	3,615	723	477	313	5,128	320.51

	QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 73.005 V-Ditch Excavation	148.00 CY	992	198	131	86	1,407	9.51
TOTAL Stormwater Outfall	8.00 EA	328,955	65,791	43,422	28,481	466,649	58331.18
06. 03. 74 Wetland Ponds							
06. 03. 74.001 Grading/Excavation	149990.00 CY	828,163	165,633	109,317	71,702	1,174,815	7.84
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00 CY	194,421	38,884	25,664	16,833	275,801	6.11
06. 03. 74.003 Hydroseeding	28.00 ACR	75,050	15,010	9,907	6,498	106,465	3802.31
TOTAL Wetland Ponds	28.00 ACR	1,097,634	219,527	144,888	95,033	1,557,081	55610.03
06. 03. 75 Emergent Wetlands							
06. 03. 75.001 Grading/Excavation	20952.00 CY	117,451	23,490	15,504	10,169	166,614	7.95
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00 CY	90,266	18,053	11,915	7,815	128,049	6.11
TOTAL Emergent Wetlands	13.00 ACR	207,717	41,543	27,419	17,984	294,663	22666.40
06. 03. 76 Cottonwood/willow (1 gal)							
06. 03. 76.001 Planting	378.00 ACR	605,374	121,075	79,909	52,413	858,771	2271.88
06. 03. 76.002 Irrigation	378.00 ACR	4,457,984	891,597	588,454	385,972	6,324,007	16730.18
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00 ACR	50,659	10,132	6,687	4,386	71,864	190.12
TOTAL Cottonwood/willow (1 gal)	378.00 ACR	5,114,017	1,022,803	675,050	442,772	7,254,642	19192.17
06. 03. 77 Mesquite Bosque (1 gal)							
06. 03. 77.001 Planting	244.00 ACR	1,171,330	234,266	154,616	101,414	1,661,626	6809.94
06. 03. 77.002 Irrigation	244.00 ACR	2,877,640	575,528	379,849	249,146	4,082,163	16730.18
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00 ACR	40,876	8,175	5,396	3,539	57,985	237.64
TOTAL Mesquite Bosque (1 gal)	244.00 ACR	4,089,846	817,969	539,860	354,099	5,801,774	23777.76
06. 03. 78 Mesquite Xeric							
06. 03. 78.001 Planting	168.00 ACR	215,019	43,004	28,382	18,616	305,022	1815.60
06. 03. 78.002 Irrigation	168.00 ACR	1,981,326	396,265	261,535	171,543	2,810,670	16730.18
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00 ACR	22,515	4,503	2,972	1,949	31,939	190.12
TOTAL Mesquite Xeric	168.00 ACR	2,218,860	443,772	292,890	192,109	3,147,631	18735.90
06. 03. 79 Lake Restoration							

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	14,896,735	2,979,347	1,966,369	1,289,759	21,132,210	7.04
TOTAL Lake Restoration (2 lakes)	3000000	CY	14,896,735	2,979,347	1,966,369	1,289,759	21,132,210	7.04
06. 03. 79.002 Emergent Wetlands (2 lakes)								
06. 03. 79.002.001 Emergent Wetlands	64469.00	CY	277,746	55,549	36,662	24,047	394,004	6.11
06. 03. 79.002.002 Hydroseeding	40.00	ACR	107,215	21,443	14,152	9,283	152,093	3802.31
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	1,072	214	142	93	1,521	38.02
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	386,032	77,206	50,956	33,423	547,618	13690.45
TOTAL Lake Restoration	2.00	EA	15,282,767	3,056,553	2,017,325	1,323,182	21,679,828	10839914
TOTAL Wetland Restoration	1.00	EA	66,355,552	13,271,110	8,758,933	5,745,064	94,130,659	94130659
06. 14 Recreation								
06. 14.002 Access Points								
06. 14.002.001 Site Preparation	1.00	EA	927,000	185,400	122,364	80,260	1,315,024	1315024
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	389,400	257,004	168,571	2,761,975	2761975
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	255,100	168,366	110,433	1,809,399	1809399
06. 14.002.004 Signage	1.00	EA	166,000	33,200	21,912	14,372	235,484	235484.28
06. 14.002.005 Shelters	1.00	EA	2,455,000	491,000	324,060	212,554	3,482,614	3482614
06. 14.002.006 Utilities	1.00	EA	840,000	168,000	110,880	72,727	1,191,607	1191607
06. 14.002.007 Park Furniture	1.00	EA	155,500	31,100	20,526	13,463	220,589	220589.19
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	22,500	14,850	9,740	159,590	159590.25
TOTAL Access Points	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Recreation	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Wetland Restoration	1.00	EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement								
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
01 LERRD's							
01.001 Flood Plain Project Land		43,900,000	10,975,000	0	0	54,875,000	
01.002 ROW for Water Supply & Distribu-		800,000	200,000	0	0	1,000,000	
TOTAL LERRD's	1.00 EA	44,700,000	11,175,000	0	0	55,875,000	55875000
06 Wetland Restoration							
06. 03 Wetland Restoration							
06. 03. 00 Mob/Demob							
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	67,009	13,402	8,845	5,802	95,058	1901.16
06. 03. 00.002 Setup and Dismantling	50.00 EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	26,804	5,361	3,538	2,321	38,023	3802.31
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	134,018	26,804	17,690	11,603	190,116	47528.91
06. 03. 00.005 Move & transport around job site	50.00 EA	134,018	26,804	17,690	11,603	190,116	3802.31
06. 03. 00.006 Miscellaneous	1.00 EA	268,037	53,607	35,381	23,207	380,231	380231.30
TOTAL Mob/Demob	1.00 EA	763,904	152,781	100,835	66,139	1,083,659	1083659
06. 03. 01 Clearing and Grubbing	36.00 ACR	156,724	31,345	20,688	13,569	222,326	6175.72
06. 03. 02 Invasive Removal							
06. 03. 02.001 Arundo Removal	10.00 ACR	402,055	80,411	53,071	34,810	570,347	57034.69
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	737,101	147,420	97,297	63,818	1,045,636	9505.78
TOTAL Invasive Removal	120.00 ACR	1,139,155	227,831	150,369	98,628	1,615,983	13466.53
06. 03. 03 Debris Removal	1.00 EA	743,801	148,760	98,182	64,398	1,055,142	1055142
06. 03. 09 Channel Restoration Excavation							
06. 03. 09.001 Excavation							
06. 03. 09.001.001 Excavation	660000.00 CY	1,416,737	283,347	187,009	122,661	2,009,754	3.05
06. 03. 09.001.002 Backfill	660000.00 CY	515,384	103,077	68,031	44,622	731,113	1.11
06. 03. 09.001.003 Hauling	660000.00 CY	849,989	169,998	112,199	73,592	1,205,777	1.83
TOTAL Excavation	660000.00 CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
TOTAL Channel Restoration Excavation	660000.00 CY	2,782,109	556,422	367,238	240,875	3,946,645	5.98
06. 03. 10 Grade Control Structure (1 ea)							
06. 03. 10.001 RCC	2400.00 CY	112,575	22,515	14,860	9,747	159,697	66.54

		QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00	TON	42,015	8,403	5,546	3,638	59,601	209.13
06. 03. 10.003	Pozzolan (Fly Ash)	109.00	TON	6,574	1,315	868	569	9,325	85.55
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00	EA	92,219	18,444	12,173	7,984	130,820	130819.68
	TOTAL Grade Control Structure (1 ea)	2400.00	CY	253,382	50,676	33,446	21,938	359,443	149.77
06. 03. 11	Maintainence Structures								
06. 03. 11.001	Maintenance Facility			2,666,964	533,393	352,039	230,906	3,783,301	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	3,019,164	603,833	398,530	261,399	4,282,925	267682.83
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	1,328,432	265,686	175,353	115,016	1,884,487	117780.45
06. 03. 11.004	Maintenance Road Underpass @19th			1,336,564	267,313	176,426	115,720	1,896,023	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	134,018	26,804	17,690	11,603	190,116	38023.13
06. 03. 11.006	Project Signage	6.00	EA	96,493	19,299	12,737	8,354	136,883	22813.88
	TOTAL Maintainence Structures			8,581,635	1,716,327	1,132,776	742,998	12,173,736	
06. 03. 12	Water Supply & Distribution								
06. 03. 12.001	20 mgd pump station,			3,203,037	640,607	422,801	277,319	4,543,764	
06. 03. 12.002	Electronic Flow Regulated Valve			53,607	10,721	7,076	4,641	76,046	
06. 03. 12.003	Electronic Flow Regulated Valves			268,037	53,607	35,381	23,207	380,231	
06. 03. 12.004	Pump Station (incl. mechanical,			2,680,366	536,073	353,808	232,066	3,802,313	
06. 03. 12.005	Reservoir (incl. excavation, sub			1,501,005	300,201	198,133	129,957	2,129,295	
06. 03. 12.006	Ground Water Pond/Reservoir on			375,251	75,050	49,533	32,489	532,324	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	2,122,850	424,570	280,216	183,796	3,011,432	228.14
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	3,551,484	710,297	468,796	307,488	5,038,065	190.12
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	3,570,247	714,049	471,273	309,112	5,064,681	136.88
06. 03. 12.010	Bridge crossing of 16" Waterline			643,288	128,658	84,914	55,696	912,555	
06. 03. 12.011	Bridge crossing of 10" Waterline			428,858	85,772	56,609	37,131	608,370	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	402,055	80,411	53,071	34,810	570,347	114.07
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	938,128	187,626	123,833	81,223	1,330,810	53.23
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	750,502	150,100	99,066	64,978	1,064,648	30.42
06. 03. 12.015	Waterfal to Move Water from			402,055	80,411	53,071	34,810	570,347	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	480,053	96,011	63,367	41,563	680,994	22699.81
06. 03. 12.017	Waste and Tire Removal (incl.			1,594,818	318,964	210,516	138,079	2,262,376	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	533,393	106,679	70,408	46,181	756,660	756660.28
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	96,011	19,202	12,673	8,313	136,199	68099.43
	TOTAL Water Supply & Distribution			23,595,043	4,719,009	3,114,546	2,042,859	33,471,457	
06. 03. 73	Stormwater Outfall								
06. 03. 73.001	Grading/Excavation	3312.00	CY	20,219	4,044	2,669	1,751	28,682	8.66
06. 03. 73.002	Concrete	416.00	CY	93,989	18,798	12,407	8,138	133,331	320.51
06. 03. 73.003	Cobble	22400.00	SF	210,141	42,028	27,739	18,194	298,101	13.31
06. 03. 73.004	Weir, concrete	16.00	CY	3,615	723	477	313	5,128	320.51

	QUANTITY UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 73.005 V-Ditch Excavation	148.00 CY	992	198	131	86	1,407	9.51
TOTAL Stormwater Outfall	8.00 EA	328,955	65,791	43,422	28,481	466,649	58331.18
06. 03. 74 Wetland Ponds							
06. 03. 74.001 Grading/Excavation	149890.00 CY	828,163	165,633	109,317	71,702	1,174,815	7.84
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00 CY	194,421	38,884	25,664	16,833	275,801	6.11
06. 03. 74.003 Hydroseeding	28.00 ACR	75,050	15,010	9,907	6,498	106,465	3802.31
TOTAL Wetland Ponds	28.00 ACR	1,097,634	219,527	144,888	95,033	1,557,081	55610.03
06. 03. 75 Emergent Wetlands							
06. 03. 75.001 Grading/Excavation	20952.00 CY	117,451	23,490	15,504	10,169	166,614	7.95
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00 CY	90,266	18,053	11,915	7,815	128,049	6.11
TOTAL Emergent Wetlands	13.00 ACR	207,717	41,543	27,419	17,984	294,663	22666.40
06. 03. 76 Cottonwood/willow (1 gal)							
06. 03. 76.001 Planting	378.00 ACR	605,374	121,075	79,909	52,413	858,771	2271.88
06. 03. 76.002 Irrigation	378.00 ACR	4,457,984	891,597	588,454	385,972	6,324,007	16730.18
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00 ACR	50,659	10,132	6,687	4,386	71,864	190.12
TOTAL Cottonwood/willow (1 gal)	378.00 ACR	5,114,017	1,022,803	675,050	442,772	7,254,642	19192.17
06. 03. 77 Mesquite Bosque (1 gal)							
06. 03. 77.001 Planting	244.00 ACR	1,171,330	234,266	154,616	101,414	1,661,626	6809.94
06. 03. 77.002 Irrigation	244.00 ACR	2,877,640	575,528	379,849	249,146	4,082,163	16730.18
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00 ACR	40,876	8,175	5,396	3,539	57,985	237.64
TOTAL Mesquite Bosque (1 gal)	244.00 ACR	4,089,846	817,969	539,860	354,099	5,801,774	23777.76
06. 03. 78 Mesquite Xeric							
06. 03. 78.001 Planting	168.00 ACR	215,019	43,004	28,382	18,616	305,022	1815.60
06. 03. 78.002 Irrigation	168.00 ACR	1,981,326	396,265	261,535	171,543	2,810,670	16730.18
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00 ACR	22,515	4,503	2,972	1,949	31,939	190.12
TOTAL Mesquite Xeric	168.00 ACR	2,218,860	443,772	292,890	192,109	3,147,631	18735.90
06. 03. 79 Lake Restoration							

	QUANTITY	UOM	CONTRACT	CONTINGN	PE&D+edc	S&A	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	14,896,735	2,979,347	1,966,369	1,289,759	21,132,210	7.04
TOTAL Lake Restoration (2 lakes)	3000000	CY	14,896,735	2,979,347	1,966,369	1,289,759	21,132,210	7.04
06. 03. 79.002 Emergent Wetlands (2 lakes)								
06. 03. 79.002.001 Emergent Wetlands								
06. 03. 79.002.001. 1 Liner, 12" fines, 3:1 slope,	64469.00	CY	277,746	55,549	36,662	24,047	394,004	6.11
TOTAL Emergent Wetlands	64469.00	CY	277,746	55,549	36,662	24,047	394,004	6.11
06. 03. 79.002.002 Hydroseeding	40.00	ACR	107,215	21,443	14,152	9,283	152,093	3802.31
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	1,072	214	142	93	1,521	38.02
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	386,032	77,206	50,956	33,423	547,618	13690.45
TOTAL Lake Restoration	2.00	EA	15,282,767	3,056,553	2,017,325	1,323,182	21,679,828	10839914
TOTAL Wetland Restoration	1.00	EA	66,355,552	13,271,110	8,758,933	5,745,064	94,130,659	94130659
06. 14 Recreation								
06. 14.002 Access Points								
06. 14.002.001 Site Preparation	1.00	EA	927,000	185,400	122,364	80,260	1,315,024	1315024
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	389,400	257,004	168,571	2,761,975	2761975
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	255,100	168,366	110,433	1,809,399	1809399
06. 14.002.004 Signage	1.00	EA	166,000	33,200	21,912	14,372	235,484	235484.28
06. 14.002.005 Shelters	1.00	EA	2,455,000	491,000	324,060	212,554	3,482,614	3482614
06. 14.002.006 Utilities	1.00	EA	840,000	168,000	110,880	72,727	1,191,607	1191607
06. 14.002.007 Park Furniture	1.00	EA	155,500	31,100	20,526	13,463	220,589	220589.19
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	22,500	14,850	9,740	159,590	159590.25
TOTAL Access Points	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Recreation	1.00	EA	7,878,500	1,575,700	1,039,962	682,121	11,176,283	11176283
TOTAL Wetland Restoration	1.00	EA	74,234,052	14,846,810	9,798,895	6,427,184	105,306,942	105306942
99 Monitoring & Adaptive Mangement								
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	118,934,052	26,021,810	9,798,895	6,427,184	161,181,942	161181942

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's	1.00	EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's									
01.001 Flood Plain Project Land			43,900,000	0	0	0	0	43,900,000	
01.002 ROW for Water Supply & Distribu-			800,000	0	0	0	0	800,000	
TOTAL LERRD's	1.00	EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration									
06. 03 Wetland Restoration	1.00	EA	49,512,315	4,951,232	4,357,084	7,058,476	476,446	66,355,552	66355552
06. 14 Recreation	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's									
01.001 Flood Plain Project Land			43,900,000	0	0	0	0	43,900,000	
01.002 ROW for Water Supply & Distribu-			800,000	0	0	0	0	800,000	
TOTAL LERRD's	1.00	EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration									
06. 03 Wetland Restoration									
06. 03. 00 Mob/Demob	1.00	EA	570,000	57,000	50,160	81,259	5,485	763,904	763904.18
06. 03. 01 Clearing and Grubbing	36.00	ACR	116,942	11,694	10,291	16,671	1,125	156,724	4353.45
06. 03. 02 Invasive Removal	120.00	ACR	850,000	85,000	74,800	121,176	8,179	1,139,155	9492.96
06. 03. 03 Debris Removal	1.00	EA	555,000	55,500	48,840	79,121	5,341	743,801	743801.44
06. 03. 09 Channel Restoration Excavation	660000.00	CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
06. 03. 10 Grade Control Structure (1 ea)	2400.00	CY	189,066	18,907	16,638	26,953	1,819	253,382	105.58
06. 03. 11 Maintainence Structures			6,403,332	640,333	563,493	912,859	61,618	8,581,635	
06. 03. 12 Water Supply & Distribution			17,605,840	1,760,584	1,549,314	2,509,889	169,417	23,595,043	
06. 03. 73 Stormwater Outfall	8.00	EA	245,456	24,546	21,600	34,992	2,362	328,955	41119.41
06. 03. 74 Wetland Ponds	28.00	ACR	819,018	81,902	72,074	116,759	7,881	1,097,634	39201.20
06. 03. 75 Emergent Wetlands	13.00	ACR	154,992	15,499	13,639	22,096	1,491	207,717	15978.23
06. 03. 76 Cottonwood/willow (1 gal)	378.00	ACR	3,815,910	381,591	335,800	543,996	36,720	5,114,017	13529.15
06. 03. 77 Mesquite Bosque (1 gal)	244.00	ACR	3,051,708	305,171	268,550	435,051	29,366	4,089,846	16761.67
06. 03. 78 Mesquite Xeric	168.00	ACR	1,655,640	165,564	145,696	236,028	15,932	2,218,860	13207.50
06. 03. 79 Lake Restoration	2.00	EA	11,403,495	1,140,349	1,003,508	1,625,682	109,733	15,282,767	7641384
TOTAL Wetland Restoration	1.00	EA	49,512,315	4,951,232	4,357,084	7,058,476	476,446	66,355,552	66355552
06. 14 Recreation									
06. 14.002 Access Points	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Recreation	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land		43,900,000	0	0	0	0	43,900,000	
01.002 ROW for Water Supply & Distribu-		800,000	0	0	0	0	800,000	
TOTAL LERRD's	1.00 EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	50,000	5,000	4,400	7,128	481	67,009	1340.18
06. 03. 00.002 Setup and Dismantling	50.00 EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	20,000	2,000	1,760	2,851	192	26,804	2680.37
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	100,000	10,000	8,800	14,256	962	134,018	33504.57
06. 03. 00.005 Move & transport around job site	50.00 EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.006 Miscellaneous	1.00 EA	200,000	20,000	17,600	28,512	1,925	268,037	268036.55
TOTAL Mob/Demob	1.00 EA	570,000	57,000	50,160	81,259	5,485	763,904	763904.18
06. 03. 01 Clearing and Grubbing	36.00 ACR	116,942	11,694	10,291	16,671	1,125	156,724	4353.45
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00 ACR	300,000	30,000	26,400	42,768	2,887	402,055	40205.48
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	550,000	55,000	48,400	78,408	5,293	737,101	6700.91
TOTAL Invasive Removal	120.00 ACR	850,000	85,000	74,800	121,176	8,179	1,139,155	9492.96
06. 03. 03 Debris Removal	1.00 EA	555,000	55,500	48,840	79,121	5,341	743,801	743801.44
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation	660000.00 CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
TOTAL Channel Restoration Excavation	660000.00 CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00 CY	84,000	8,400	7,392	11,975	808	112,575	46.91
06. 03. 10.002 Portland Cement	285.00 TON	31,350	3,135	2,759	4,469	302	42,015	147.42
06. 03. 10.003 Pozzolan (Fly Ash)	109.00 TON	4,905	491	432	699	47	6,574	60.31
06. 03. 10.004 Gabion Weirs and Water "V" Ditch	1.00 EA	68,811	6,881	6,055	9,810	662	92,219	92218.75
TOTAL Grade Control Structure (1 ea)	2400.00 CY	189,066	18,907	16,638	26,953	1,819	253,382	105.58

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 11	Maintainence Structures									
06. 03. 11.001	Maintenance Facility			1,990,000	199,000	175,120	283,694	19,149	2,666,964	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	2,252,800	225,280	198,246	321,159	21,678	3,019,164	188697.73
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	991,232	99,123	87,228	141,310	9,530	1,328,432	83027.00
06. 03. 11.004	Maintenance Road Underpass @19th			997,300	99,730	87,762	142,175	9,597	1,336,564	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	100,000	10,000	8,800	14,256	962	134,018	26803.66
06. 03. 11.006	Project Signage	6.00	EA	72,000	7,200	6,336	10,264	693	96,493	16082.19
	TOTAL Maintainence Structures			6,403,332	640,333	563,493	912,859	61,618	8,581,635	
06. 03. 12	Water Supply & Distribution									
06. 03. 12.001	20 mgd pump station,			2,390,000	239,000	210,320	340,718	22,998	3,203,037	
06. 03. 12.002	Electronic Flow Regulated Valve			40,000	4,000	3,520	5,702	385	53,607	
06. 03. 12.003	Electronic Flow Regulated Valves			200,000	20,000	17,600	28,512	1,925	268,037	
06. 03. 12.004	Pump Station (incl. mechanical,			2,000,000	200,000	176,000	285,120	19,246	2,680,366	
06. 03. 12.005	Reservoir (incl. excavation, sub			1,120,000	112,000	98,560	159,667	10,778	1,501,005	
06. 03. 12.006	Ground Water Pond/Reservoir on			280,000	28,000	24,640	39,917	2,694	375,251	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	1,584,000	158,400	139,392	225,815	15,242	2,122,850	160.82
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	2,650,000	265,000	233,200	377,784	25,500	3,551,484	134.02
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	2,664,000	266,400	234,432	379,780	25,635	3,570,247	96.49
06. 03. 12.010	Bridge crossing of 16" Waterline			480,000	48,000	42,240	68,429	4,619	643,288	
06. 03. 12.011	Bridge crossing of 10" Waterline			320,000	32,000	28,160	45,619	3,079	428,858	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	300,000	30,000	26,400	42,768	2,887	402,055	80.41
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	700,000	70,000	61,600	99,792	6,736	938,128	37.53
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	560,000	56,000	49,280	79,834	5,389	750,502	21.44
06. 03. 12.015	Waterfal to Move Water from			300,000	30,000	26,400	42,768	2,887	402,055	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	358,200	35,820	31,522	51,065	3,447	480,053	16001.78
06. 03. 12.017	Waste and Tire Removal (incl.			1,190,000	119,000	104,720	169,646	11,451	1,594,818	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	398,000	39,800	35,024	56,739	3,830	533,393	533392.74
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	71,640	7,164	6,304	10,213	689	96,011	48005.35
	TOTAL Water Supply & Distribution			17,605,840	1,760,584	1,549,314	2,509,889	169,417	23,595,043	
06. 03. 73	Stormwater Outfall									
06. 03. 73.001	Grading/Excavation	3312.00	CY	15,087	1,509	1,328	2,151	145	20,219	6.10
06. 03. 73.002	Concrete	416.00	CY	70,131	7,013	6,172	9,998	675	93,989	225.93
06. 03. 73.003	Cobble	22400.00	SF	156,800	15,680	13,798	22,353	1,509	210,141	9.38
06. 03. 73.004	Weir, concrete	16.00	CY	2,697	270	237	385	26	3,615	225.93
06. 03. 73.005	V-Ditch Excavation	148.00	CY	740	74	65	105	7	992	6.70
	TOTAL Stormwater Outfall	8.00	EA	245,456	24,546	21,600	34,992	2,362	328,955	41119.41
06. 03. 74	Wetland Ponds									
06. 03. 74.001	Grading/Excavation	149890.00	CY	617,948	61,795	54,379	88,095	5,946	828,163	5.53

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00 CY	145,070	14,507	12,766	20,681	1,396	194,421	4.31
06. 03. 74.003 Hydroseeding	28.00 ACR	56,000	5,600	4,928	7,983	539	75,050	2680.37
TOTAL Wetland Ponds	28.00 ACR	819,018	81,902	72,074	116,759	7,881	1,097,634	39201.20
06. 03. 75 Emergent Wetlands								
06. 03. 75.001 Grading/Excavation	20952.00 CY	87,638	8,764	7,712	12,494	843	117,451	5.61
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00 CY	67,353	6,735	5,927	9,602	648	90,266	4.31
TOTAL Emergent Wetlands	13.00 ACR	154,992	15,499	13,639	22,096	1,491	207,717	15978.23
06. 03. 76 Cottonwood/willow (1 gal)								
06. 03. 76.001 Planting	378.00 ACR	451,710	45,171	39,750	64,396	4,347	605,374	1601.52
06. 03. 76.002 Irrigation	378.00 ACR	3,326,400	332,640	292,723	474,212	32,009	4,457,984	11793.61
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00 ACR	37,800	3,780	3,326	5,389	364	50,659	134.02
TOTAL Cottonwood/willow (1 gal)	378.00 ACR	3,815,910	381,591	335,800	543,996	36,720	5,114,017	13529.15
06. 03. 77 Mesquite Bosque (1 gal)								
06. 03. 77.001 Planting	244.00 ACR	874,008	87,401	76,913	124,599	8,410	1,171,330	4800.53
06. 03. 77.002 Irrigation	244.00 ACR	2,147,200	214,720	188,954	306,105	20,662	2,877,640	11793.61
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00 ACR	30,500	3,050	2,684	4,348	293	40,876	167.52
TOTAL Mesquite Bosque (1 gal)	244.00 ACR	3,051,708	305,171	268,550	435,051	29,366	4,089,846	16761.67
06. 03. 78 Mesquite Xeric								
06. 03. 78.001 Planting	168.00 ACR	160,440	16,044	14,119	22,872	1,544	215,019	1279.87
06. 03. 78.002 Irrigation	168.00 ACR	1,478,400	147,840	130,099	210,761	14,226	1,981,326	11793.61
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00 ACR	16,800	1,680	1,478	2,395	162	22,515	134.02
TOTAL Mesquite Xeric	168.00 ACR	1,655,640	165,564	145,696	236,028	15,932	2,218,860	13207.50
06. 03. 79 Lake Restoration								
06. 03. 79.001 Lake Restoration (2 lakes)	3000000 CY	11,115,450	1,111,545	978,160	1,584,619	106,961	14,896,735	4.97
06. 03. 79.002 Emergent Wetlands (2 lakes)	40.00 ACR	288,045	28,804	25,348	41,064	2,772	386,032	9650.81
TOTAL Lake Restoration	2.00 EA	11,403,495	1,140,349	1,003,508	1,625,682	109,733	15,282,767	7641384
TOTAL Wetland Restoration	1.00 EA	49,512,315	4,951,232	4,357,084	7,058,476	476,446	66,355,552	66355552

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	927,000	0	0	0	0	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	0	0	0	0	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	0	0	0	0	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	166,000	0	0	0	0	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	2,455,000	0	0	0	0	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	840,000	0	0	0	0	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	155,500	0	0	0	0	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	0	0	0	0	112,500	112500.00
TOTAL Access Points	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Recreation	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land		43,900,000	0	0	0	0	43,900,000	
01.002 ROW for Water Supply & Distribu-		800,000	0	0	0	0	800,000	
TOTAL LERRD's	1.00 EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	50,000	5,000	4,400	7,128	481	67,009	1340.18
06. 03. 00.002 Setup and Dismantling	50.00 EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	20,000	2,000	1,760	2,851	192	26,804	2680.37
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	100,000	10,000	8,800	14,256	962	134,018	33504.57
06. 03. 00.005 Move & transport around job site	50.00 EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.006 Miscellaneous	1.00 EA	200,000	20,000	17,600	28,512	1,925	268,037	268036.55
TOTAL Mob/Demob	1.00 EA	570,000	57,000	50,160	81,259	5,485	763,904	763904.18
06. 03. 01 Clearing and Grubbing	36.00 ACR	116,942	11,694	10,291	16,671	1,125	156,724	4353.45
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00 ACR	300,000	30,000	26,400	42,768	2,887	402,055	40205.48
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	550,000	55,000	48,400	78,408	5,293	737,101	6700.91
TOTAL Invasive Removal	120.00 ACR	850,000	85,000	74,800	121,176	8,179	1,139,155	9492.96
06. 03. 03 Debris Removal	1.00 EA	555,000	55,500	48,840	79,121	5,341	743,801	743801.44
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation								
06. 03. 09.001.001 Excavation	660000.00 CY	1,057,122	105,712	93,027	150,703	10,172	1,416,737	2.15
06. 03. 09.001.002 Backfill	660000.00 CY	384,562	38,456	33,841	54,823	3,701	515,384	0.78
06. 03. 09.001.003 Hauling	660000.00 CY	634,234	63,423	55,813	90,416	6,103	849,989	1.29
TOTAL Excavation	660000.00 CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
TOTAL Channel Restoration Excavation	660000.00 CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00 CY	84,000	8,400	7,392	11,975	808	112,575	46.91

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00	TON	31,350	3,135	2,759	4,469	302	42,015	147.42
06. 03. 10.003	Pozzolan (Fly Ash)	109.00	TON	4,905	491	432	699	47	6,574	60.31
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00	EA	68,811	6,881	6,055	9,810	662	92,219	92218.75
	TOTAL Grade Control Structure (1 ea)	2400.00	CY	189,066	18,907	16,638	26,953	1,819	253,382	105.58
06. 03. 11	Maintainence Structures									
06. 03. 11.001	Maintenance Facility			1,990,000	199,000	175,120	283,694	19,149	2,666,964	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	2,252,800	225,280	198,246	321,159	21,678	3,019,164	188697.73
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	991,232	99,123	87,228	141,310	9,538	1,328,432	83027.00
06. 03. 11.004	Maintenance Road Underpass @19th			997,300	99,730	87,762	142,175	9,597	1,336,564	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	100,000	10,000	8,800	14,256	962	134,018	26803.66
06. 03. 11.006	Project Signage	6.00	EA	72,000	7,200	6,336	10,264	693	96,493	16082.19
	TOTAL Maintainence Structures			6,403,332	640,333	563,493	912,859	61,618	8,581,635	
06. 03. 12	Water Supply & Distribution									
06. 03. 12.001	20 mgd pump station,			2,390,000	239,000	210,320	340,718	22,998	3,203,037	
06. 03. 12.002	Electronic Flow Regulated Valve			40,000	4,000	3,520	5,702	385	53,607	
06. 03. 12.003	Electronic Flow Regulated Valves			200,000	20,000	17,600	28,512	1,925	268,037	
06. 03. 12.004	Pump Station (incl. mechanical,			2,000,000	200,000	176,000	285,120	19,246	2,680,366	
06. 03. 12.005	Reservoir (incl. excavation, sub			1,120,000	112,000	98,560	159,667	10,778	1,501,005	
06. 03. 12.006	Ground Water Pond/Reservoir on			280,000	28,000	24,640	39,917	2,694	375,251	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	1,584,000	158,400	139,392	225,815	15,242	2,122,850	160.82
06. 03. 12.008	16" Waterlins Pipe (incl. trench	26500.00	LF	2,650,000	265,000	233,200	377,784	25,500	3,551,484	134.02
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	2,664,000	266,400	234,432	379,780	25,635	3,570,247	96.49
06. 03. 12.010	Bridge crossing of 16" Waterline			480,000	48,000	42,240	68,429	4,619	643,288	
06. 03. 12.011	Bridge crossing of 10" Waterline			320,000	32,000	28,160	45,619	3,079	428,858	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	300,000	30,000	26,400	42,768	2,887	402,055	80.41
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	700,000	70,000	61,600	99,792	6,736	938,128	37.53
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	560,000	56,000	49,280	79,834	5,389	750,502	21.44
06. 03. 12.015	Waterfal to Move Water from			300,000	30,000	26,400	42,768	2,887	402,055	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	358,200	35,820	31,522	51,065	3,447	480,053	16001.78
06. 03. 12.017	Waste and Tire Removal (incl.			1,190,000	119,000	104,720	169,646	11,451	1,594,818	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	398,000	39,800	35,024	56,739	3,830	533,393	533392.74
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	71,640	7,164	6,304	10,213	689	96,011	48005.35
	TOTAL Water Supply & Distribution			17,605,840	1,760,584	1,549,314	2,509,889	169,417	23,595,043	
06. 03. 73	Stormwater Outfall									
06. 03. 73.001	Grading/Excavation	3312.00	CY	15,087	1,509	1,328	2,151	145	20,219	6.10
06. 03. 73.002	Concrete	416.00	CY	70,131	7,013	6,172	9,998	675	93,989	225.93
06. 03. 73.003	Cobble	22400.00	SF	156,800	15,680	13,798	22,353	1,509	210,141	9.38
06. 03. 73.004	Weir, concrete	16.00	CY	2,697	270	237	385	26	3,615	225.93

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 73.005 V-Ditch Excavation	148.00 CY	740	74	65	105	7	992	6.70
TOTAL Stormwater Outfall	8.00 EA	245,456	24,546	21,600	34,992	2,362	328,955	41119.41
06. 03. 74 Wetland Ponds								
06. 03. 74.001 Grading/Excavation	149890.00 CY	617,948	61,795	54,379	88,095	5,946	828,163	5.53
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00 CY	145,070	14,507	12,766	20,681	1,396	194,421	4.31
06. 03. 74.003 Hydroseeding	28.00 ACR	56,000	5,600	4,928	7,983	539	75,050	2680.37
TOTAL Wetland Ponds	28.00 ACR	819,018	81,902	72,074	116,759	7,881	1,097,634	39201.20
06. 03. 75 Emergent Wetlands								
06. 03. 75.001 Grading/Excavation	20952.00 CY	87,638	8,764	7,712	12,494	843	117,451	5.61
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00 CY	67,353	6,735	5,927	9,602	648	90,266	4.31
TOTAL Emergent Wetlands	13.00 ACR	154,992	15,499	13,639	22,096	1,491	207,717	15978.23
06. 03. 76 Cottonwood/willow (1 gal)								
06. 03. 76.001 Planting	378.00 ACR	451,710	45,171	39,750	64,396	4,347	605,374	1601.52
06. 03. 76.002 Irrigation	378.00 ACR	3,326,400	332,640	292,723	474,212	32,009	4,457,984	11793.61
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00 ACR	37,800	3,780	3,326	5,389	364	50,659	134.02
TOTAL Cottonwood/willow (1 gal)	378.00 ACR	3,815,910	381,591	335,800	543,996	36,720	5,114,017	13529.15
06. 03. 77 Mesquite Bosque (1 gal)								
06. 03. 77.001 Planting	244.00 ACR	874,008	87,401	76,913	124,599	8,410	1,171,330	4800.53
06. 03. 77.002 Irrigation	244.00 ACR	2,147,200	214,720	188,954	306,105	20,662	2,877,640	11793.61
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00 ACR	30,500	3,050	2,684	4,348	293	40,876	167.52
TOTAL Mesquite Bosque (1 gal)	244.00 ACR	3,051,708	305,171	268,550	435,051	29,366	4,089,846	16761.67
06. 03. 78 Mesquite Xeric								
06. 03. 78.001 Planting	168.00 ACR	160,440	16,044	14,119	22,872	1,544	215,019	1279.87
06. 03. 78.002 Irrigation	168.00 ACR	1,478,400	147,840	130,099	210,761	14,226	1,981,326	11793.61
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00 ACR	16,800	1,680	1,478	2,395	162	22,515	134.02
TOTAL Mesquite Xeric	168.00 ACR	1,655,640	165,564	145,696	236,028	15,932	2,218,860	13207.50
06. 03. 79 Lake Restoration								

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	11,115,450	1,111,545	978,160	1,584,619	106,961	14,896,735	4.97
TOTAL Lake Restoration (2 lakes)	3000000	CY	11,115,450	1,111,545	978,160	1,584,619	106,961	14,896,735	4.97
06. 03. 79.002 Emergent Wetlands (2 lakes)									
06. 03. 79.002.001 Emergent Wetlands	64469.00	CY	207,245	20,724	18,238	29,545	1,994	277,746	4.31
06. 03. 79.002.002 Hydroseeding	40.00	ACR	80,000	8,000	7,040	11,405	770	107,215	2680.37
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	800	80	70	114	8	1,072	26.80
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	288,045	28,804	25,348	41,064	2,772	386,032	9650.81
TOTAL Lake Restoration	2.00	EA	11,403,495	1,140,349	1,003,508	1,625,682	109,733	15,282,767	7641384
TOTAL Wetland Restoration	1.00	EA	49,512,315	4,951,232	4,357,084	7,058,476	476,446	66,355,552	66355552
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	927,000	0	0	0	0	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	0	0	0	0	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	0	0	0	0	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	166,000	0	0	0	0	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	2,455,000	0	0	0	0	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	840,000	0	0	0	0	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	155,500	0	0	0	0	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	0	0	0	0	112,500	112500.00
TOTAL Access Points	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Recreation	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
01 LERRD's									
01.001 Flood Plain Project Land			43,900,000	0	0	0	0	43,900,000	
01.002 ROW for Water Supply & Distribu-			800,000	0	0	0	0	800,000	
TOTAL LERRD's	1.00	EA	44,700,000	0	0	0	0	44,700,000	44700000
06 Wetland Restoration									
06. 03 Wetland Restoration									
06. 03. 00 Mob/Demob									
06. 03. 00.001 Equipment (major and heavy)	50.00	EA	50,000	5,000	4,400	7,128	481	67,009	1340.18
06. 03. 00.002 Setup and Dismantling	50.00	EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.003 Replacement of worn-out quipment	10.00	EA	20,000	2,000	1,760	2,851	192	26,804	2680.37
06. 03. 00.004 Setup & Dismantling of cranes	4.00	EA	100,000	10,000	8,800	14,256	962	134,018	33504.57
06. 03. 00.005 Move & transport around job site	50.00	EA	100,000	10,000	8,800	14,256	962	134,018	2680.37
06. 03. 00.006 Miscellaneous	1.00	EA	200,000	20,000	17,600	28,512	1,925	268,037	268036.55
TOTAL Mob/Demob	1.00	EA	570,000	57,000	50,160	81,259	5,485	763,904	763904.18
06. 03. 01 Clearing and Grubbing	36.00	ACR	116,942	11,694	10,291	16,671	1,125	156,724	4353.45
06. 03. 02 Invasive Removal									
06. 03. 02.001 Arundo Removal	10.00	ACR	300,000	30,000	26,400	42,768	2,887	402,055	40205.48
06. 03. 02.002 Salt Cedar Removal	110.00	ACR	550,000	55,000	48,400	78,408	5,293	737,101	6700.91
TOTAL Invasive Removal	120.00	ACR	850,000	85,000	74,800	121,176	8,179	1,139,155	9492.96
06. 03. 03 Debris Removal	1.00	EA	555,000	55,500	48,840	79,121	5,341	743,801	743801.44
06. 03. 09 Channel Restoration Excavation									
06. 03. 09.001 Excavation									
06. 03. 09.001.001 Excavation	660000.00	CY	1,057,122	105,712	93,027	150,703	10,172	1,416,737	2.15
06. 03. 09.001.002 Backfill	660000.00	CY	384,562	38,456	33,841	54,823	3,701	515,384	0.78
06. 03. 09.001.003 Hauling	660000.00	CY	634,234	63,423	55,813	90,416	6,103	849,989	1.29
TOTAL Excavation	660000.00	CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
TOTAL Channel Restoration Excavation	660000.00	CY	2,075,918	207,592	182,681	295,943	19,976	2,782,109	4.22
06. 03. 10 Grade Control Structure (1 ea)									
06. 03. 10.001 RCC	2400.00	CY	84,000	8,400	7,392	11,975	808	112,575	46.91

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00	TON	31,350	3,135	2,759	4,469	302	42,015	147.42
06. 03. 10.003	Pozzolan (Fly Ash)	109.00	TON	4,905	491	432	699	47	6,574	60.31
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00	EA	68,811	6,881	6,055	9,810	662	92,219	92218.75
	TOTAL Grade Control Structure (1 ea)	2400.00	CY	189,066	18,907	16,638	26,953	1,819	253,382	105.58
06. 03. 11	Maintainence Structures									
06. 03. 11.001	Maintenance Facility			1,990,000	199,000	175,120	283,694	19,149	2,666,964	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	2,252,800	225,280	198,246	321,159	21,678	3,019,164	188697.73
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	991,232	99,123	87,228	141,310	9,538	1,328,432	83027.00
06. 03. 11.004	Maintenance Road Underpass @19th			997,300	99,730	87,762	142,175	9,597	1,336,564	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	100,000	10,000	8,800	14,256	962	134,018	26803.66
06. 03. 11.006	Project Signage	6.00	EA	72,000	7,200	6,336	10,264	693	96,493	16082.19
	TOTAL Maintainence Structures			6,403,332	640,333	563,493	912,859	61,618	8,581,635	
06. 03. 12	Water Supply & Distribution									
06. 03. 12.001	20 mgd pump station,			2,390,000	239,000	210,320	340,718	22,998	3,203,037	
06. 03. 12.002	Electronic Flow Regulated Valve			40,000	4,000	3,520	5,702	385	53,607	
06. 03. 12.003	Electronic Flow Regulated Valves			200,000	20,000	17,600	28,512	1,925	268,037	
06. 03. 12.004	Pump Station (incl. mechanical,			2,000,000	200,000	176,000	285,120	19,246	2,680,366	
06. 03. 12.005	Reservoir (incl. excavation, sub			1,120,000	112,000	98,560	159,667	10,778	1,501,005	
06. 03. 12.006	Ground Water Pond/Reservoir on			280,000	28,000	24,640	39,917	2,694	375,251	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	1,584,000	158,400	139,392	225,815	15,242	2,122,850	160.82
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	2,650,000	265,000	233,200	377,784	25,500	3,551,484	134.02
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	2,664,000	266,400	234,432	379,780	25,635	3,570,247	96.49
06. 03. 12.010	Bridge crossing of 16" Waterline			480,000	48,000	42,240	68,429	4,619	643,288	
06. 03. 12.011	Bridge crossing of 10" Waterline			320,000	32,000	28,160	45,619	3,079	428,858	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	300,000	30,000	26,400	42,768	2,887	402,055	80.41
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	700,000	70,000	61,600	99,792	6,736	938,128	37.53
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	560,000	56,000	49,280	79,834	5,389	750,502	21.44
06. 03. 12.015	Waterfal to Move Water from			300,000	30,000	26,400	42,768	2,887	402,055	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	358,200	35,820	31,522	51,065	3,447	480,053	16001.78
06. 03. 12.017	Waste and Tire Removal (incl.			1,190,000	119,000	104,720	169,646	11,451	1,594,818	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	398,000	39,800	35,024	56,739	3,830	533,393	533392.74
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	71,640	7,164	6,304	10,213	689	96,011	48005.35
	TOTAL Water Supply & Distribution			17,605,840	1,760,584	1,549,314	2,509,889	169,417	23,595,043	
06. 03. 73	Stormwater Outfall									
06. 03. 73.001	Grading/Excavation	3312.00	CY	15,087	1,509	1,328	2,151	145	20,219	6.10
06. 03. 73.002	Concrete	416.00	CY	70,131	7,013	6,172	9,998	675	93,989	225.93
06. 03. 73.003	Cobble	22400.00	SF	156,800	15,680	13,798	22,353	1,509	210,141	9.38
06. 03. 73.004	Weir, concrete	16.00	CY	2,697	270	237	385	26	3,615	225.93

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 73.005 V-Ditch Excavation	148.00 CY	740	74	65	105	7	992	6.70
TOTAL Stormwater Outfall	8.00 EA	245,456	24,546	21,600	34,992	2,362	328,955	41119.41
06. 03. 74 Wetland Ponds								
06. 03. 74.001 Grading/Excavation	149890.00 CY	617,948	61,795	54,379	88,095	5,946	828,163	5.53
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00 CY	145,070	14,507	12,766	20,681	1,396	194,421	4.31
06. 03. 74.003 Hydroseeding	28.00 ACR	56,000	5,600	4,928	7,983	539	75,050	2680.37
TOTAL Wetland Ponds	28.00 ACR	819,018	81,902	72,074	116,759	7,881	1,097,634	39201.20
06. 03. 75 Emergent Wetlands								
06. 03. 75.001 Grading/Excavation	20952.00 CY	87,638	8,764	7,712	12,494	843	117,451	5.61
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00 CY	67,353	6,735	5,927	9,602	648	90,266	4.31
TOTAL Emergent Wetlands	13.00 ACR	154,992	15,499	13,639	22,096	1,491	207,717	15978.23
06. 03. 76 Cottonwood/willow (1 gal)								
06. 03. 76.001 Planting	378.00 ACR	451,710	45,171	39,750	64,396	4,347	605,374	1601.52
06. 03. 76.002 Irrigation	378.00 ACR	3,326,400	332,640	292,723	474,212	32,009	4,457,984	11793.61
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00 ACR	37,800	3,780	3,326	5,389	364	50,659	134.02
TOTAL Cottonwood/willow (1 gal)	378.00 ACR	3,815,910	381,591	335,800	543,996	36,720	5,114,017	13529.15
06. 03. 77 Mesquite Bosque (1 gal)								
06. 03. 77.001 Planting	244.00 ACR	874,008	87,401	76,913	124,599	8,410	1,171,330	4800.53
06. 03. 77.002 Irrigation	244.00 ACR	2,147,200	214,720	188,954	306,105	20,662	2,877,640	11793.61
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00 ACR	30,500	3,050	2,684	4,348	293	40,876	167.52
TOTAL Mesquite Bosque (1 gal)	244.00 ACR	3,051,708	305,171	268,550	435,051	29,366	4,089,846	16761.67
06. 03. 78 Mesquite Xeric								
06. 03. 78.001 Planting	168.00 ACR	160,440	16,044	14,119	22,872	1,544	215,019	1279.87
06. 03. 78.002 Irrigation	168.00 ACR	1,478,400	147,840	130,099	210,761	14,226	1,981,326	11793.61
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00 ACR	16,800	1,680	1,478	2,395	162	22,515	134.02
TOTAL Mesquite Xeric	168.00 ACR	1,655,640	165,564	145,696	236,028	15,932	2,218,860	13207.50
06. 03. 79 Lake Restoration								

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	11,115,450	1,111,545	978,160	1,584,619	106,961	14,896,735	4.97
TOTAL Lake Restoration (2 lakes)	3000000	CY	11,115,450	1,111,545	978,160	1,584,619	106,961	14,896,735	4.97
06. 03. 79.002 Emergent Wetlands (2 lakes)									
06. 03. 79.002.001 Emergent Wetlands									
06. 03. 79.002.001. 1 Liner, 12" fines, 3:1 slope,	64469.00	CY	207,245	20,724	18,238	29,545	1,994	277,746	4.31
TOTAL Emergent Wetlands	64469.00	CY	207,245	20,724	18,238	29,545	1,994	277,746	4.31
06. 03. 79.002.002 Hydroseeding	40.00	ACR	80,000	8,000	7,040	11,405	770	107,215	2680.37
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	800	80	70	114	8	1,072	26.80
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	288,045	28,804	25,348	41,064	2,772	386,032	9650.81
TOTAL Lake Restoration	2.00	EA	11,403,495	1,140,349	1,003,508	1,625,682	109,733	15,282,767	7641384
TOTAL Wetland Restoration	1.00	EA	49,512,315	4,951,232	4,357,084	7,058,476	476,446	66,355,552	66355552
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	927,000	0	0	0	0	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	1,947,000	0	0	0	0	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	1,275,500	0	0	0	0	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	166,000	0	0	0	0	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	2,455,000	0	0	0	0	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	840,000	0	0	0	0	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	155,500	0	0	0	0	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	112,500	0	0	0	0	112,500	112500.00
TOTAL Access Points	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Recreation	1.00	EA	7,878,500	0	0	0	0	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	57,390,815	4,951,232	4,357,084	7,058,476	476,446	74,234,052	74234052
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	102,090,815	4,951,232	4,357,084	7,058,476	476,446	118,934,052	118934052
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
SUBTOTAL							154,754,757	
CONTN MANAGEMENT (Acct. 31)							6,427,184	
TOTAL INCL OWNER COSTS							161,181,942	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's	1.00	EA	0	0	0	044700000		44,700,000	44700000
06 Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22242804785		57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22287504785		102,090,815	102090815
OVERHEAD (10.0%)								4,951,232	
SUBTOTAL								107,042,047	
HOME OFC (8.0%)								4,357,084	
SUBTOTAL								111,399,131	
PROFIT (12.0%)								7,058,476	
SUBTOTAL								118,457,606	
BOND (0.72%)								476,446	
TOTAL INCL INDIRECTS								118,934,052	
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's									
01.001 Flood Plain Project Land			0	0	0	0	43900000	43,900,000	
01.002 ROW for Water Supply & Distribu-			0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00	EA	0	0	0	0	44700000	44,700,000	44700000
06 Wetland Restoration									
06. 03 Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22	234926285	49,512,315	49512315
06. 14 Recreation	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22	242804705	57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22	287504785	102,090,815	102090815
OVERHEAD (10.0%)								4,951,232	
SUBTOTAL								107,042,047	
HOME OFC (8.0%)								4,357,084	
SUBTOTAL								111,399,131	
PROFIT (12.0%)								7,058,476	
SUBTOTAL								118,457,606	
BOND (0.72%)								476,446	
TOTAL INCL INDIRECTS								118,934,052	
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's									
01.001 Flood Plain Project Land			0	0	0	0	43900000	43,900,000	
01.002 ROW for Water Supply & Distribu-			0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00	EA	0	0	0	0	44700000	44,700,000	44700000
06 Wetland Restoration									
06. 03 Wetland Restoration									
06. 03. 00 Mob/Demob	1.00	EA	0	0	0	0	570,000	570,000	570000.00
06. 03. 01 Clearing and Grubbing	36.00	ACR	2,667	62,032	49,910	0	5,000	116,942	3248.40
06. 03. 02 Invasive Removal	120.00	ACR	0	0	0	0	850,000	850,000	7083.33
06. 03. 03 Debris Removal	1.00	EA	0	0	0	0	555,000	555,000	555000.00
06. 03. 09 Channel Restoration Excavation	660000.00	CY	36,788	1015997	1059920	0	0	2,075,918	3.15
06. 03. 10 Grade Control Structure (1 ea)	2400.00	CY	944	24,144	6,135	38,532	120,255	189,066	78.78
06. 03. 11 Maintainence Structures			0	0	0	0	6403332	6,403,332	
06. 03. 12 Water Supply & Distribution			0	0	0		017605840	17,605,840	
06. 03. 73 Stormwater Outfall	8.00	EA	597	15,630	11,382	61,643	156,800	245,456	30681.95
06. 03. 74 Wetland Ponds	28.00	ACR	13,402	368,063	384,223	10,732	56,000	819,018	29250.63
06. 03. 75 Emergent Wetlands	13.00	ACR	2,476	67,646	82,363	4,983	0	154,992	11922.43
06. 03. 76 Cottonwood/willow (1 gal)	378.00	ACR	0	0	0	0	3815910	3,815,910	10095.00
06. 03. 77 Mesquite Bosque (1 gal)	244.00	ACR	0	0	0	0	3051708	3,051,708	12507.00
06. 03. 78 Mesquite Xeric	168.00	ACR	0	0	0	0	1655640	1,655,640	9855.00
06. 03. 79 Lake Restoration	2.00	EA	143,195	4076977	7230386	15,332	80,800	11,403,495	5701747
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22	234926285	49,512,315	49512315
06. 14 Recreation									
06. 14.002 Access Points	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Recreation	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22	242804785	57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22	287504785	102,090,815	102090815
OVERHEAD (10.0%)								4,951,232	
SUBTOTAL								107,042,047	
HOME OFC (8.0%)								4,357,084	
SUBTOTAL								111,399,131	
PROFIT (12.0%)								7,058,476	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
SUBTOTAL								118,457,606	
BOND (0.72%)								476,446	
TOTAL INCL INDIRECTS								118,934,052	
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land		0	0	0	0	43900000	43,900,000	
01.002 ROW for Water Supply & Distribu-		0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00 EA	0	0	0	0	44700000	44,700,000	44700000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	0	0	0	0	50,000	50,000	1000.00
06. 03. 00.002 Setup and Dismantling	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	0	0	0	0	20,000	20,000	2000.00
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	0	0	0	0	100,000	100,000	25000.00
06. 03. 00.005 Move & transport around job site	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.006 Miscellaneous	1.00 EA	0	0	0	0	200,000	200,000	200000.00
TOTAL Mob/Demob	1.00 EA	0	0	0	0	570,000	570,000	570000.00
06. 03. 01 Clearing and Grubbing	36.00 ACR	2,667	62,032	49,910	0	5,000	116,942	3248.40
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00 ACR	0	0	0	0	300,000	300,000	30000.00
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	0	0	0	0	550,000	550,000	5000.00
TOTAL Invasive Removal	120.00 ACR	0	0	0	0	850,000	850,000	7083.33
06. 03. 03 Debris Removal	1.00 EA	0	0	0	0	555,000	555,000	555000.00
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
TOTAL Channel Restoration Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00 CY	0	0	0	0	84,000	84,000	35.00
06. 03. 10.002 Portland Cement	285.00 TON	0	0	0	0	31,350	31,350	110.00
06. 03. 10.003 Pozzolan (Fly Ash)	109.00 TON	0	0	0	0	4,905	4,905	45.00
06. 03. 10.004 Gabion Weirs and Water "V" Ditch	1.00 EA	944	24,144	6,135	38,532	0	68,811	68810.58
TOTAL Grade Control Structure (1 ea)	2400.00 CY	944	24,144	6,135	38,532	120,255	189,066	78.78

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 11 Maintainence Structures									
06. 03. 11.001 Maintenance Facility			0	0	0	0	1990000	1,990,000	
06. 03. 11.002 Maintenance Roads (hard surface)	16.00	MI	0	0	0	0	2252800	2,252,800	140800.00
06. 03. 11.003 Maintenance Roads & Trails (soft	16.00	MI	0	0	0	0	991,232	991,232	61952.00
06. 03. 11.004 Maintenance Road Underpass @19th			0	0	0	0	997,300	997,300	
06. 03. 11.005 Bridges & Culverts (med) @Storm	5.00	EA	0	0	0	0	100,000	100,000	20000.00
06. 03. 11.006 Project Signage	6.00	EA	0	0	0	0	72,000	72,000	12000.00
TOTAL Maintainence Structures			0	0	0	0	6403332	6,403,332	
06. 03. 12 Water Supply & Distribution									
06. 03. 12.001 20 mgd pump station,			0	0	0	0	2390000	2,390,000	
06. 03. 12.002 Electronic Flow Regulated Valve			0	0	0	0	40,000	40,000	
06. 03. 12.003 Electronic Flow Regulated Valves			0	0	0	0	200,000	200,000	
06. 03. 12.004 Pump Station (incl. mechanical,			0	0	0	0	2000000	2,000,000	
06. 03. 12.005 Reservoir (incl. excavation, sub			0	0	0	0	1120000	1,120,000	
06. 03. 12.006 Ground Water Pond/Reservoir on			0	0	0	0	280,000	280,000	
06. 03. 12.007 20" Waterline Pipe (incl. trench	13200.00	LF	0	0	0	0	1584000	1,584,000	120.00
06. 03. 12.008 16" Waterline Pipe (incl. trench	26500.00	LF	0	0	0	0	2650000	2,650,000	100.00
06. 03. 12.009 10" Waterline Pipe Loop (incl.	37000.00	LF	0	0	0	0	2664000	2,664,000	72.00
06. 03. 12.010 Bridge crossing of 16" Waterline			0	0	0	0	480,000	480,000	
06. 03. 12.011 Bridge crossing of 10" Waterline			0	0	0	0	320,000	320,000	
06. 03. 12.012 8" Waterline Pipe to existing	5000.00	LF	0	0	0	0	300,000	300,000	60.00
06. 03. 12.013 Overbank Canal Delivery Convey-	25000.00	LF	0	0	0	0	700,000	700,000	28.00
06. 03. 12.014 Terrace and LFC Canal Delivery	35000.00	LF	0	0	0	0	560,000	560,000	16.00
06. 03. 12.015 Waterfal to Move Water from			0	0	0	0	300,000	300,000	
06. 03. 12.016 Internal Drainage Conveyance	30.00	EA	0	0	0	0	358,200	358,200	11940.00
06. 03. 12.017 Waste and Tire Removal (incl.			0	0	0	0	1190000	1,190,000	
06. 03. 12.018 Supply Well (incl. pump, mechan-	1.00	EA	0	0	0	0	398,000	398,000	398000.00
06. 03. 12.019 Monitoring Well (incl. pump,	2.00	EA	0	0	0	0	71,640	71,640	35820.00
TOTAL Water Supply & Distribution			0	0	0	0	17605840	17,605,840	
06. 03. 73 Stormwater Outfall									
06. 03. 73.001 Grading/Excavation	3312.00	CY	290	7,938	7,149	0	0	15,087	4.56
06. 03. 73.002 Concrete	416.00	CY	296	6,980	3,792	59,360	0	70,131	168.59
06. 03. 73.003 Cobble	22400.00	SF	0	0	0	0	156,800	156,800	7.00
06. 03. 73.004 Weir, concrete	16.00	CY	11	268	146	2,283	0	2,697	168.59
06. 03. 73.005 V-Ditch Excavation	148.00	CY	0	444	296	0	0	740	5.00
TOTAL Stormwater Outfall	8.00	EA	597	15,630	11,382	61,643	156,800	245,456	30681.95
06. 03. 74 Wetland Ponds									
06. 03. 74.001 Grading/Excavation	149890.00	CY	11,635	320,472	297,476	0	0	617,948	4.12

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00	CY	1,767	47,591	86,747	10,732	0	145,070	3.21
06. 03. 74.003 Hydroseeding	28.00	ACR	0	0	0	0	56,000	56,000	2000.00
TOTAL Wetland Ponds	28.00	ACR	13,402	368,063	384,223	10,732	56,000	819,018	29250.63
06. 03. 75 Emergent Wetlands									
06. 03. 75.001 Grading/Excavation	20952.00	CY	1,655	45,550	42,088	0	0	87,638	4.18
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00	CY	820	22,095	40,275	4,983	0	67,353	3.21
TOTAL Emergent Wetlands	13.00	ACR	2,476	67,646	82,363	4,983	0	154,992	11922.43
06. 03. 76 Cottonwood/willow (1 gal)									
06. 03. 76.001 Planting	378.00	ACR	0	0	0	0	451,710	451,710	1195.00
06. 03. 76.002 Irrigation	378.00	ACR	0	0	0	0	3326400	3,326,400	8800.00
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00	ACR	0	0	0	0	37,800	37,800	100.00
TOTAL Cottonwood/willow (1 gal)	378.00	ACR	0	0	0	0	3815910	3,815,910	10095.00
06. 03. 77 Mesquite Bosque (1 gal)									
06. 03. 77.001 Planting	244.00	ACR	0	0	0	0	874,008	874,008	3582.00
06. 03. 77.002 Irrigation	244.00	ACR	0	0	0	0	2147200	2,147,200	8800.00
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00	ACR	0	0	0	0	30,500	30,500	125.00
TOTAL Mesquite Bosque (1 gal)	244.00	ACR	0	0	0	0	3051708	3,051,708	12507.00
06. 03. 78 Mesquite Xeric									
06. 03. 78.001 Planting	168.00	ACR	0	0	0	0	160,440	160,440	955.00
06. 03. 78.002 Irrigation	168.00	ACR	0	0	0	0	1478400	1,478,400	8800.00
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00	ACR	0	0	0	0	16,800	16,800	100.00
TOTAL Mesquite Xeric	168.00	ACR	0	0	0	0	1655640	1,655,640	9855.00
06. 03. 79 Lake Restoration									
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	140,670	4008990	7106460	0	0	11,115,450	3.71
06. 03. 79.002 Emergent Wetlands (2 lakes)	40.00	ACR	2,525	67,987	123,926	15,332	80,800	288,045	7201.12
TOTAL Lake Restoration	2.00	EA	143,195	4076977	7230386	15,332	80,800	11,403,495	5701747
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,222	34926285	49,512,315	49512315

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	0	0	0	0	927,000	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	0	0	0	0	1947000	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	0	0	0	0	1275500	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	0	0	0	0	166,000	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	0	0	0	0	2455000	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	0	0	0	0	840,000	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	0	0	0	0	155,500	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	0	0	0	0	112,500	112,500	112500.00
TOTAL Access Points	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Recreation	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22	2242804785	57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22	287504785	102,090,815	102090815

OVERHEAD (10.0%)	4,951,232
SUBTOTAL	107,042,047
HOME OFC (8.0%)	4,357,084
SUBTOTAL	111,399,131
PROFIT (12.0%)	7,058,476
SUBTOTAL	118,457,606
BOND (0.72%)	476,446
TOTAL INCL INDIRECTS	118,934,052
CONTINGENCY	26,021,810
SUBTOTAL	144,955,862
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)	9,798,895
SUBTOTAL	154,754,757
CONTN MANAGEMENT (Acct. 31)	6,427,184
TOTAL INCL OWNER COSTS	161,181,942

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land		0	0	0	0	43900000	43,900,000	
01.002 ROW for Water Supply & Distribu-		0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00 EA	0	0	0	0	44700000	44,700,000	44700000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	0	0	0	0	50,000	50,000	1000.00
06. 03. 00.002 Setup and Dismantling	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	0	0	0	0	20,000	20,000	2000.00
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	0	0	0	0	100,000	100,000	25000.00
06. 03. 00.005 Move & transport around job site	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.006 Miscellaneous	1.00 EA	0	0	0	0	200,000	200,000	200000.00
TOTAL Mob/Demob	1.00 EA	0	0	0	0	570,000	570,000	570000.00
06. 03. 01 Clearing and Grubbing	36.00 ACR	2,667	62,032	49,910	0	5,000	116,942	3248.40
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00 ACR	0	0	0	0	300,000	300,000	30000.00
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	0	0	0	0	550,000	550,000	5000.00
TOTAL Invasive Removal	120.00 ACR	0	0	0	0	850,000	850,000	7083.33
06. 03. 03 Debris Removal	1.00 EA	0	0	0	0	555,000	555,000	555000.00
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation								
06. 03. 09.001.001 Excavation	660000.00 CY	21,978	619,674	437,448	0	0	1,057,122	1.60
06. 03. 09.001.002 Backfill	660000.00 CY	7,260	204,514	180,048	0	0	384,562	0.58
06. 03. 09.001.003 Hauling	660000.00 CY	7,550	191,809	442,424	0	0	634,234	0.96
TOTAL Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
TOTAL Channel Restoration Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00 CY	0	0	0	0	84,000	84,000	35.00

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00	TON	0	0	0	0	31,350	31,350	110.00
06. 03. 10.003	Pozzolan (Fly Ash)	109.00	TON	0	0	0	0	4,905	4,905	45.00
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00	EA	944	24,144	6,135	38,532	0	68,811	68810.58
	TOTAL Grade Control Structure (1 ea)	2400.00	CY	944	24,144	6,135	38,532	120,255	189,066	78.78
06. 03. 11	Maintainence Structures									
06. 03. 11.001	Maintenance Facility			0	0	0	0	1990000	1,990,000	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	0	0	0	0	2252800	2,252,800	140800.00
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	0	0	0	0	991,232	991,232	61952.00
06. 03. 11.004	Maintenance Road Underpass @19th			0	0	0	0	997,300	997,300	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	0	0	0	0	100,000	100,000	20000.00
06. 03. 11.006	Project Signage	6.00	EA	0	0	0	0	72,000	72,000	12000.00
	TOTAL Maintainence Structures			0	0	0	0	6403332	6,403,332	
06. 03. 12	Water Supply & Distribution									
06. 03. 12.001	20 mgd pump station,			0	0	0	0	2390000	2,390,000	
06. 03. 12.002	Electronic Flow Regulated Valve			0	0	0	0	40,000	40,000	
06. 03. 12.003	Electronic Flow Regulated Valves			0	0	0	0	200,000	200,000	
06. 03. 12.004	Pump Station (incl. mechanical,			0	0	0	0	2000000	2,000,000	
06. 03. 12.005	Reservoir (incl. excavation, sub			0	0	0	0	1120000	1,120,000	
06. 03. 12.006	Ground Water Pond/Reservoir on			0	0	0	0	280,000	280,000	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	0	0	0	0	1584000	1,584,000	120.00
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	0	0	0	0	2650000	2,650,000	100.00
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	0	0	0	0	2664000	2,664,000	72.00
06. 03. 12.010	Bridge crossing of 16" Waterline			0	0	0	0	480,000	480,000	
06. 03. 12.011	Bridge crossing of 10" Waterline			0	0	0	0	320,000	320,000	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	0	0	0	0	300,000	300,000	60.00
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	0	0	0	0	700,000	700,000	28.00
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	0	0	0	0	560,000	560,000	16.00
06. 03. 12.015	Waterfal to Move Water from			0	0	0	0	300,000	300,000	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	0	0	0	0	358,200	358,200	11940.00
06. 03. 12.017	Waste and Tire Removal (incl.			0	0	0	0	1190000	1,190,000	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	0	0	0	0	398,000	398,000	398000.00
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	0	0	0	0	71,640	71,640	35820.00
	TOTAL Water Supply & Distribution			0	0	0	0	17605840	17,605,840	
06. 03. 73	Stormwater Outfall									
06. 03. 73.001	Grading/Excavation	3312.00	CY	290	7,938	7,149	0	0	15,087	4.56
06. 03. 73.002	Concrete	416.00	CY	296	6,980	3,792	59,360	0	70,131	168.59
06. 03. 73.003	Cobble	22400.00	SF	0	0	0	0	156,800	156,800	7.00
06. 03. 73.004	Weir, concrete	16.00	CY	11	268	146	2,283	0	2,697	168.59

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 73.005 V-Ditch Excavation	148.00	CY	0	444	296	0	0	740	5.00
TOTAL Stormwater Outfall	8.00	EA	597	15,630	11,382	61,643	156,800	245,456	30681.95
06. 03. 74 Wetland Ponds									
06. 03. 74.001 Grading/Excavation	149890.00	CY	11,635	320,472	297,476	0	0	617,948	4.12
06. 03. 74.002 Liner, 12" fines, 3:1 slope,	45128.00	CY	1,767	47,591	86,747	10,732	0	145,070	3.21
06. 03. 74.003 Hydroseeding	28.00	ACR	0	0	0	0	56,000	56,000	2000.00
TOTAL Wetland Ponds	28.00	ACR	13,402	368,063	384,223	10,732	56,000	819,018	29250.63
06. 03. 75 Emergent Wetlands									
06. 03. 75.001 Grading/Excavation	20952.00	CY	1,655	45,550	42,088	0	0	87,638	4.18
06. 03. 75.002 Liner, 12" fines, 3:1 slope,	20952.00	CY	820	22,095	40,275	4,983	0	67,353	3.21
TOTAL Emergent Wetlands	13.00	ACR	2,476	67,646	82,363	4,983	0	154,992	11922.43
06. 03. 76 Cottonwood/willow (1 gal)									
06. 03. 76.001 Planting	378.00	ACR	0	0	0	0	451,710	451,710	1195.00
06. 03. 76.002 Irrigation	378.00	ACR	0	0	0	0	3326400	3,326,400	8800.00
06. 03. 76.003 Maintenance of Plants & Irrigat-	378.00	ACR	0	0	0	0	37,800	37,800	100.00
TOTAL Cottonwood/willow (1 gal)	378.00	ACR	0	0	0	0	3815910	3,815,910	10095.00
06. 03. 77 Mesquite Bosque (1 gal)									
06. 03. 77.001 Planting	244.00	ACR	0	0	0	0	874,008	874,008	3582.00
06. 03. 77.002 Irrigation	244.00	ACR	0	0	0	0	2147200	2,147,200	8800.00
06. 03. 77.003 Maintenance of Plants and Irrig-	244.00	ACR	0	0	0	0	30,500	30,500	125.00
TOTAL Mesquite Bosque (1 gal)	244.00	ACR	0	0	0	0	3051708	3,051,708	12507.00
06. 03. 78 Mesquite Xeric									
06. 03. 78.001 Planting	168.00	ACR	0	0	0	0	160,440	160,440	955.00
06. 03. 78.002 Irrigation	168.00	ACR	0	0	0	0	1478400	1,478,400	8800.00
06. 03. 78.003 Maintenance of Plants and Irrig-	168.00	ACR	0	0	0	0	16,800	16,800	100.00
TOTAL Mesquite Xeric	168.00	ACR	0	0	0	0	1655640	1,655,640	9855.00
06. 03. 79 Lake Restoration									

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	140,670	4008990	7106460	0	0	11,115,450	3.71
TOTAL Lake Restoration (2 lakes)	3000000	CY	140,670	4008990	7106460	0	0	11,115,450	3.71
06. 03. 79.002 Emergent Wetlands (2 lakes)									
06. 03. 79.002.001 Emergent Wetlands	64469.00	CY	2,525	67,987	123,926	15,332	0	207,245	3.21
06. 03. 79.002.002 Hydroseeding	40.00	ACR	0	0	0	0	80,000	80,000	2000.00
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	0	0	0	0	800	800	20.00
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	2,525	67,987	123,926	15,332	80,800	288,045	7201.12
TOTAL Lake Restoration	2.00	EA	143,195	4076977	7230386	15,332	80,800	11,403,495	5701747
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22234926285		49,512,315	49512315
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	0	0	0	0	927,000	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	0	0	0	0	1947000	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	0	0	0	0	1275500	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	0	0	0	0	166,000	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	0	0	0	0	2455000	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	0	0	0	0	840,000	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	0	0	0	0	155,500	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	0	0	0	0	112,500	112,500	112500.00
TOTAL Access Points	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Recreation	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22242804785		57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22287504785		102,090,815	102090815
OVERHEAD (10.0%)								4,951,232	
SUBTOTAL								107,042,047	
HOME OFC (8.0%)								4,357,084	
SUBTOTAL								111,399,131	
PROFIT (12.0%)								7,058,476	
SUBTOTAL								118,457,606	
BOND (0.72%)								476,446	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL INCL INDIRECTS								118,934,052	
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

	QUANTITY UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
01 LERRD's								
01.001 Flood Plain Project Land		0	0	0	0	43900000	43,900,000	
01.002 ROW for Water Supply & Distribu-		0	0	0	0	800,000	800,000	
TOTAL LERRD's	1.00 EA	0	0	0	0	44700000	44,700,000	44700000
06 Wetland Restoration								
06. 03 Wetland Restoration								
06. 03. 00 Mob/Demob								
06. 03. 00.001 Equipment (major and heavy)	50.00 EA	0	0	0	0	50,000	50,000	1000.00
06. 03. 00.002 Setup and Dismantling	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.003 Replacement of worn-out quipment	10.00 EA	0	0	0	0	20,000	20,000	2000.00
06. 03. 00.004 Setup & Dismantling of cranes	4.00 EA	0	0	0	0	100,000	100,000	25000.00
06. 03. 00.005 Move & transport around job site	50.00 EA	0	0	0	0	100,000	100,000	2000.00
06. 03. 00.006 Miscellaneous	1.00 EA	0	0	0	0	200,000	200,000	200000.00
TOTAL Mob/Demob	1.00 EA	0	0	0	0	570,000	570,000	570000.00
06. 03. 01 Clearing and Grubbing	36.00 ACR	2,667	62,032	49,910	0	5,000	116,942	3248.40
06. 03. 02 Invasive Removal								
06. 03. 02.001 Arundo Removal	10.00 ACR	0	0	0	0	300,000	300,000	30000.00
06. 03. 02.002 Salt Cedar Removal	110.00 ACR	0	0	0	0	550,000	550,000	5000.00
TOTAL Invasive Removal	120.00 ACR	0	0	0	0	850,000	850,000	7083.33
06. 03. 03 Debris Removal	1.00 EA	0	0	0	0	555,000	555,000	555000.00
06. 03. 09 Channel Restoration Excavation								
06. 03. 09.001 Excavation								
06. 03. 09.001.001 Excavation	660000.00 CY	21,978	619,674	437,448	0	0	1,057,122	1.60
06. 03. 09.001.002 Backfill	660000.00 CY	7,260	204,514	180,048	0	0	384,562	0.58
06. 03. 09.001.003 Hauling	660000.00 CY	7,550	191,809	442,424	0	0	634,234	0.96
TOTAL Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
TOTAL Channel Restoration Excavation	660000.00 CY	36,788	1015997	1059920	0	0	2,075,918	3.15
06. 03. 10 Grade Control Structure (1 ea)								
06. 03. 10.001 RCC	2400.00 CY	0	0	0	0	84,000	84,000	35.00

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 10.002	Portland Cement	285.00	TON	0	0	0	0	31,350	31,350	110.00
06. 03. 10.003	Pozzolan (Fly Ash)	109.00	TON	0	0	0	0	4,905	4,905	45.00
06. 03. 10.004	Gabion Weirs and Water "V" Ditch	1.00	EA	944	24,144	6,135	38,532	0	68,811	68810.58
	TOTAL Grade Control Structure (1 ea)	2400.00	CY	944	24,144	6,135	38,532	120,255	189,066	78.78
06. 03. 11	Maintainence Structures									
06. 03. 11.001	Maintenance Facility			0	0	0	0	1990000	1,990,000	
06. 03. 11.002	Maintenance Roads (hard surface)	16.00	MI	0	0	0	0	2252800	2,252,800	140800.00
06. 03. 11.003	Maintenance Roads & Trails (soft	16.00	MI	0	0	0	0	991,232	991,232	61952.00
06. 03. 11.004	Maintenance Road Underpass @19th			0	0	0	0	997,300	997,300	
06. 03. 11.005	Bridges & Culverts (med) @Storm	5.00	EA	0	0	0	0	100,000	100,000	20000.00
06. 03. 11.006	Project Signage	6.00	EA	0	0	0	0	72,000	72,000	12000.00
	TOTAL Maintainence Structures			0	0	0	0	6403332	6,403,332	
06. 03. 12	Water Supply & Distribution									
06. 03. 12.001	20 mgd pump station,			0	0	0	0	2390000	2,390,000	
06. 03. 12.002	Electronic Flow Regulated Valve			0	0	0	0	40,000	40,000	
06. 03. 12.003	Electronic Flow Regulated Valves			0	0	0	0	200,000	200,000	
06. 03. 12.004	Pump Station (incl. mechanical,			0	0	0	0	2000000	2,000,000	
06. 03. 12.005	Reservoir (incl. excavation, sub			0	0	0	0	1120000	1,120,000	
06. 03. 12.006	Ground Water Pond/Reservoir on			0	0	0	0	280,000	280,000	
06. 03. 12.007	20" Waterline Pipe (incl. trench	13200.00	LF	0	0	0	0	1584000	1,584,000	120.00
06. 03. 12.008	16" Waterline Pipe (incl. trench	26500.00	LF	0	0	0	0	2650000	2,650,000	100.00
06. 03. 12.009	10" Waterline Pipe Loop (incl.	37000.00	LF	0	0	0	0	2664000	2,664,000	72.00
06. 03. 12.010	Bridge crossing of 16" Waterline			0	0	0	0	480,000	480,000	
06. 03. 12.011	Bridge crossing of 10" Waterline			0	0	0	0	320,000	320,000	
06. 03. 12.012	8" Waterline Pipe to existing	5000.00	LF	0	0	0	0	300,000	300,000	60.00
06. 03. 12.013	Overbank Canal Delivery Convey-	25000.00	LF	0	0	0	0	700,000	700,000	28.00
06. 03. 12.014	Terrace and LFC Canal Delivery	35000.00	LF	0	0	0	0	560,000	560,000	16.00
06. 03. 12.015	Waterfal to Move Water from			0	0	0	0	300,000	300,000	
06. 03. 12.016	Internal Drainage Conveyance	30.00	EA	0	0	0	0	358,200	358,200	11940.00
06. 03. 12.017	Waste and Tire Removal (incl.			0	0	0	0	1190000	1,190,000	
06. 03. 12.018	Supply Well (incl. pump, mechan-	1.00	EA	0	0	0	0	398,000	398,000	398000.00
06. 03. 12.019	Monitoring Well (incl. pump,	2.00	EA	0	0	0	0	71,640	71,640	35820.00
	TOTAL Water Supply & Distribution			0	0	0	0	17605840	17,605,840	
06. 03. 73	Stormwater Outfall									
06. 03. 73.001	Grading/Excavation	3312.00	CY	290	7,938	7,149	0	0	15,087	4.56
06. 03. 73.002	Concrete	416.00	CY	296	6,980	3,792	59,360	0	70,131	168.59
06. 03. 73.003	Cobble	22400.00	SF	0	0	0	0	156,800	156,800	7.00
06. 03. 73.004	Weir, concrete	16.00	CY	11	268	146	2,283	0	2,697	168.59

		QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 73.005	V-Ditch Excavation	148.00	CY	0	444	296	0	0	740	5.00
	TOTAL Stormwater Outfall	8.00	EA	597	15,630	11,382	61,643	156,800	245,456	30681.95
06. 03. 74	Wetland Ponds									
06. 03. 74.001	Grading/Excavation	149890.00	CY	11,635	320,472	297,476	0	0	617,948	4.12
06. 03. 74.002	Liner, 12" fines, 3:1 slope,	45128.00	CY	1,767	47,591	86,747	10,732	0	145,070	3.21
06. 03. 74.003	Hydroseeding	28.00	ACR	0	0	0	0	56,000	56,000	2000.00
	TOTAL Wetland Ponds	28.00	ACR	13,402	368,063	384,223	10,732	56,000	819,018	29250.63
06. 03. 75	Emergent Wetlands									
06. 03. 75.001	Grading/Excavation	20952.00	CY	1,655	45,550	42,088	0	0	87,638	4.18
06. 03. 75.002	Liner, 12" fines, 3:1 slope,	20952.00	CY	820	22,095	40,275	4,983	0	67,353	3.21
	TOTAL Emergent Wetlands	13.00	ACR	2,476	67,646	82,363	4,983	0	154,992	11922.43
06. 03. 76	Cottonwood/willow (1 gal)									
06. 03. 76.001	Planting	378.00	ACR	0	0	0	0	451,710	451,710	1195.00
06. 03. 76.002	Irrigation	378.00	ACR	0	0	0	0	3326400	3,326,400	8800.00
06. 03. 76.003	Maintenance of Plants & Irrigat-	378.00	ACR	0	0	0	0	37,800	37,800	100.00
	TOTAL Cottonwood/willow (1 gal)	378.00	ACR	0	0	0	0	3815910	3,815,910	10095.00
06. 03. 77	Mesquite Bosque (1 gal)									
06. 03. 77.001	Planting	244.00	ACR	0	0	0	0	874,008	874,008	3582.00
06. 03. 77.002	Irrigation	244.00	ACR	0	0	0	0	2147200	2,147,200	8800.00
06. 03. 77.003	Maintenance of Plants and Irrig-	244.00	ACR	0	0	0	0	30,500	30,500	125.00
	TOTAL Mesquite Bosque (1 gal)	244.00	ACR	0	0	0	0	3051708	3,051,708	12507.00
06. 03. 78	Mesquite Xeric									
06. 03. 78.001	Planting	168.00	ACR	0	0	0	0	160,440	160,440	955.00
06. 03. 78.002	Irrigation	168.00	ACR	0	0	0	0	1478400	1,478,400	8800.00
06. 03. 78.003	Maintenance of Plants and Irrig-	168.00	ACR	0	0	0	0	16,800	16,800	100.00
	TOTAL Mesquite Xeric	168.00	ACR	0	0	0	0	1655640	1,655,640	9855.00
06. 03. 79	Lake Restoration									

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. 03. 79.001 Lake Restoration (2 lakes)	3000000	CY	140,670	4008990	7106460	0	0	11,115,450	3.71
TOTAL Lake Restoration (2 lakes)	3000000	CY	140,670	4008990	7106460	0	0	11,115,450	3.71
06. 03. 79.002 Emergent Wetlands (2 lakes)									
06. 03. 79.002.001 Emergent Wetlands									
06. 03. 79.002.001. 1 Liner, 12" fines, 3:1 slope,	64469.00	CY	2,525	67,987	123,926	15,332	0	207,245	3.21
TOTAL Emergent Wetlands	64469.00	CY	2,525	67,987	123,926	15,332	0	207,245	3.21
06. 03. 79.002.002 Hydroseeding	40.00	ACR	0	0	0	0	80,000	80,000	2000.00
06. 03. 79.002.003 Plant Maintenance (1 year)	40.00	ACR	0	0	0	0	800	800	20.00
TOTAL Emergent Wetlands (2 lakes)	40.00	ACR	2,525	67,987	123,926	15,332	80,800	288,045	7201.12
TOTAL Lake Restoration	2.00	EA	143,195	4076977	7230386	15,332	80,800	11,403,495	5701747
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22234926285		49,512,315	49512315
06. 14 Recreation									
06. 14.002 Access Points									
06. 14.002.001 Site Preparation	1.00	EA	0	0	0	0	927,000	927,000	927000.00
06. 14.002.002 Access and Circulation	1.00	EA	0	0	0	0	1947000	1,947,000	1947000
06. 14.002.003 Protection Access Control	1.00	EA	0	0	0	0	1275500	1,275,500	1275500
06. 14.002.004 Signage	1.00	EA	0	0	0	0	166,000	166,000	166000.00
06. 14.002.005 Shelters	1.00	EA	0	0	0	0	2455000	2,455,000	2455000
06. 14.002.006 Utilities	1.00	EA	0	0	0	0	840,000	840,000	840000.00
06. 14.002.007 Park Furniture	1.00	EA	0	0	0	0	155,500	155,500	155500.00
06. 14.002.008 Interpretive Guidance Media	1.00	EA	0	0	0	0	112,500	112,500	112500.00
TOTAL Access Points	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Recreation	1.00	EA	0	0	0	0	7878500	7,878,500	7878500
TOTAL Wetland Restoration	1.00	EA	200,068	5630490	8824319	131,22242804785		57,390,815	57390815
99 Monitoring & Adaptive Mangement									
TOTAL Oeste Feas. Study Cost Estimate	1.00	EA	200,068	5630490	8824319	131,22287504785		102,090,815	102090815
OVERHEAD (10.0%)								4,951,232	
SUBTOTAL								107,042,047	
HOME OFC (8.0%)								4,357,084	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
SUBTOTAL								111,399,131	
PROFIT (12.0%)								7,058,476	
SUBTOTAL								118,457,606	
BOND (0.72%)								476,446	
TOTAL INCL INDIRECTS								118,934,052	
CONTINGENCY								26,021,810	
SUBTOTAL								144,955,862	
PL'NG, EGR'NG, DESIGN + EDC (Ac. 30)								9,798,895	
SUBTOTAL								154,754,757	
CONTN MANAGEMENT (Acct. 31)								6,427,184	
TOTAL INCL OWNER COSTS								161,181,942	

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

Appendix L

Recreation and Environmental Education

September 2006

City of Phoenix
Parks and Recreation Department

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1

INTRODUCTION

The United States Army Corps of Engineers and the city of Phoenix have entered into a contract for a Feasibility Study of an environmental restoration project known as Rio Salado Oeste, located on the Salt River between 19th and 83rd Avenues. The river is virtually dry and has suffered an almost total loss of native habitat as a result of early 20th century reclamation projects. This desert riparian habitat is a critical and diminishing resource throughout Arizona.

The Rio Salado Oeste study area is approximately three miles west of downtown Phoenix. The upstream boundary is located at 19th Avenue. The study area extends west approximately seven miles.

2

RECREATION FEATURES

"A planning objective of the Rio Salado Oeste Feasibility Study is to ***"increase environmental education and passive recreation opportunities incidental to the restoration effort."*** To that end, the goal of the Recreation and Environmental Education Component is to ***provide opportunities for visitors of all ages 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 the Salt River had on the environment and cultures throughout history."***

Existing Recreation Opportunities

On the western border of the study area is the Estrella Mountain Regional Park. The park is owned and managed by Maricopa County Parks and Recreation Department. The rugged and scenic Sierra Estrella mountains are the most dominant feature of Estrella Mountain Regional Park. The terrain of these mountains is characterized by very steep slopes, numerous rock outcropping, shallow soils and sparse desert vegetation.

Maricopa County has developed a master plan for the 19,200 acre park, located approximately 20 miles southwest of downtown Phoenix. The master plan envisions the preservation of scenic desert wilderness areas while incorporating sensitive development of recreational facilities and activities. The Plan accommodates the expected annual demand of 1 million visitors while insuring that the existing Sonoran Desert environment remains in its existing condition. In fact, 90 percent of the park will remain essentially untouched. The remaining 10 percent will be sensitively utilized for educational, camping, picnicking, and sporting activities.

While water is a highly attractive feature for recreational participants, park trails and facilities have presently been planned away from the Gila River. Once the County completes the Sun Circle Trail System through this reach of the Gila and Salt Rivers, recreation use patterns are expected to expand throughout the study area. The Sun Circle Trail, a component of the National

Recreation Trail system, comprises a 110 mile loop encompassing the Phoenix metro area. The trail offers a unique opportunity for hiking, horseback riding and bicycling throughout the urban area. Approximately 70 percent of the Sun Circle trail system is in place. The County has an agreement with the Maricopa County Flood District to establish the Sun Circle Trail within the flood control district corridor from Skunk Creek to the Gila River - Salt River confluence. The Rio Salado Oeste Project is an excellent opportunity to designate a segment of the Sun Circle Trail. This will benefit Rio Salado Oeste, Rio Salado and Tres Rios with a major non-motorized travel-way connecting the three river restoration projects to the other valley areas.

Future Opportunities

The Rio Salado Oeste 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 Laveen and Estrella Planning Areas. Rio Salado Oeste will provide a educational and recreational connection to the desert riparian habitat corridor created by the Rio Salado and Tres Rios Projects. By connecting the seven-mile gap between the two projects, Rio Salado Oeste will enhance the unique recreation and education opportunities for residents and out-of-town visitors. Drawing on a population base of 3.2 million in Maricopa County, it is estimated that visitation to the Rio Salado Oeste project will exceed 350,000 annually. 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 a restored 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 this day-use area can 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 our diverse society, the Rio Salado Oeste project will have design components ranging from areas adapted for special needs to multi-lingual signage.

For planning purposes the features have been divided into three primary areas: ***The Bank, The Terrace***, and ***The Channel***. Each of these areas provides a different setting for passive recreational opportunities which coincide with educational opportunities allowing participants to *learn, see* and *experience* the renewed resource first-hand. The goals of recreation within the three levels of the project were formulated as stated in USACE, Policy Guidance Letter No. 59, Recreation Development at Ecosystem Recreation Projeets (11 June 1998).

> ***The Bank*** provides recreational experiences ineluding walking, biking, and horsebaek riding to scenic overlooks. Constructed features, which will interpret cultural, biological, will accommodate abundant educational opportunities and ecological themes related to the restored desert riparian habitat.
>
> ***The Terrace*** is the area where the habitat has a more permanent water source to create a self-sustaining ecosystem. *The Terrace* will provide for sensitive habitats within the Rio Salado Oeste Project and will need to be managed to ensure its establishment and sustainability.
>
> ***The Channel*** represents an area seeming to be relatively unaltered by humans, and will undergo physical changes in response to seasonal river flows and flooding. People will enter this zone on its terms, and it will contain few manmade features, allowing one to observe the natural forces of land and water that define and shape desert rivers and associated habitat.

The Bank Experience

Rio Salado Oeste will provide a variety of recreation opportunities for users. Those visiting the project will be able to arrive by private vehicle or alternate mode of transportation, including horse, public transit or bicycle. Users would enter at one of four drive-in access points at 35th Ave., 51st Ave. North and South, and 75th Ave. Visitors may also enter at one of the five walk-in access points at 19th Ave., 23rd Ave., 43rd Ave., 75th Ave., or 83rd Ave. Minor access points are also occurring in nine locations which remain to be determined. These points coincide with existing river crossings or roads. Amenities at each access point will vary, but may include: parking; restroom facilities; water fountains; shade structures; site furniture; and appropriate lighting. Each access point will serve as a trailhead and will provide appropriate signage, orientation kiosk, or visitor center to give visitors an overview of the activities and experiences available and orient users to the sensitivity of the area and appropriate uses and expectations. All improved facilities within *the Bank* experience will be designed to provide accessibility to all members of the community.

Opportunities available at ***The Bank*** will include:

Trails:

Multi-use non-motorized trails will allow visitors to explore ***The Bank*** on foot, horseback, or bicycle. The hard surface trail will accommodate a variety of cycling activities allowing travel along the entire project. Natural surface trails will traverse the bank leading foot traffic, equestrians and mountain bicyclists to scenic overlooks or loops throughout the area. Additionally, a barrier free trail will be provided for users with limited mobility. Interpretive trails will allow for self-guided tours of the area.

The Sun Cirele Trail will be established through the bank area. Extending through other areas of the Valley, the Sun Circle Trail will serve as a non-motorized transportation corridor providing access to Rio Salado Oeste from central and south Phoenix and the East Valley along the ***Rio Vista Trail*** and from the West Valley along the West Valley Recreation Corridor.

Scenic Overlooks:

Accessible locations along the roadways and trails will allow for family picnicking, informal play and scenic vistas of the surrounding landscape. More secluded areas will accommodate informal seating and meditation areas.

Education Opportunities:

An opportunity exists for a major Interpretive Center to furnish visitors programmatic information regarding the restoration of the habitat, the water cycle, a historical perspective of the rivers, and the flora and fauna within the project area. Additionally, there will be exhibits, signage, and multimedia displays.

Outdoor Gathering Area:

Gathering areas will be provided for groups to attend lectures by special interest speakers.

Staging Areas:

Areas will be designed for groups and classes to gather and prepare for a learning experience at the Rio Salado Oeste Project.

The Terrace Experience

The Terrace is the true sensitive habitat of the Rio Salado Oeste Project, and will provide visitors unique opportunities to view, enjoy and experience a restored desert riparian habitat. This area will allow one to explore wetland habitats and surrounding cottonwood/willow forests. Natural surface trails will lead visitors to *The Terrace* from *The Bank*, and perhaps allow for occasional crossings of *The Channel*, expanding opportunities to explore more river habitat. Visitors to the area will leave with a heightened awareness of the fragile relationship between water availability and habitat in the desert.

Opportunities available at ***The Terrace*** will include:

Trails:
Trails will provide a transition from *The Bank* to the more sensitive *Terrace Habitat* and will be available, for research activities and wildlife watching. A barrier-free interpretive trail will be provided featuring multi-lingual signage regarding the project.

Scenic Overlooks:
Locations along *The Terrace* will allow scenic vistas of the restored river bed and surrounding landscape.

Habitat Views:
Special areas will provide wildlife blinds allowing visitors an opportunity to observe wildlife in its restored natural habitat without disturbing the seclusion needed by most. Interpretive signage will be provided.

Demonstration Walks:
Pathways along *The Terrace* will provide visitors insight into the inner workings of a habitat restoration project and its role in water conservation. Special "wetlands" walks or trails to areas featuring aquatic habitat will be provided as appropriate to the season and species.

Research Areas:
These unique study areas will allow opportunities for educational institutions to conduct long- and/or short-term research into the unique workings of the Rio Salado Oeste project including water conservation, riparian areas, and habitat restoration.

Bird Watching:
These unique areas will allow opportunities for novice and experienced bird watchers to view and learn about the variety of waterfowl, birds of prey, migratory and song birds that will find sanctuary within the Rio Salado Oeste habitat.

Urban Fishing:
When water quality and habitat features allow, ponds providing habitat for fish may allow anglers opportunities to fish.

Outdoor Classrooms:
Areas will be designed for groups and classes of up to 50 to assemble for programmatic learning experiences.

The Channel Experience

The Channel will be accessible by the trail system from *The Bank* at select locations along *The Terrace*. At each transition point to *The Terrace*, appropriate signage will inform visitors of the new habitat they are entering, and any user restrictions and expectations. *The Channel* will provide opportunities for environmental education and developing an understanding of how the habitat has been restored. Some areas of *The Channel* may be designated as "sensitive" habitat, and will be protected from public impacts.

3

VISITATION ESTIMATES

Annual Visitation

The Rio Salado Oeste Recreation and Environmental Education Component is planned to provide high quality experiences in an outdoor setting unique to the Phoenix metropolitan area. The unparalleled desert river restoration project provides an outstanding prospect for physical and programmatic activities, yet also places a great responsibility upon the sponsoring agencies to design and manage these activities for sustainability of the restoration. From the outset of the project it will be realized that the overriding concern will be to create conditions favorable to the return of the natural systems formerly associated with the river, and that human use will be secondary. However, it is also of great value to the project that the public have the opportunity within this constraint to experience, enjoy, and learn from the river.

How to best achieve this balance is worthy of much additional study and is beyond the scope of this initial effort; however, some basic assumptions must be made in order to determine preliminary cost estimates and to serve as the basis for design.

Due to the location of the project and the intimacy of the expected recreation and education experience, it is projected that most visitors will arrive by private vehicle. However, in order to mitigate potential environmental impacts from increased traffic, facilities will be developed that promote alternative transportation and energy efficiency. Initial capacity of the parking facilities will be designed for not more than 500 vehicles in order to limit the potential impact of human activities upon the restoration project.

Based on historical data maintained by the City of Phoenix for resource-based recreational sites, it is estimated that 2.75 visitors arrive in each private vehicle. Additionally, an estimated one visitor per four vehicles arrives at a site by an alternate mode of transportation including bicycle, foot traffic and public transportation. It would be a legitimate goal of the Recreation/Education component to increase the ratio of visitors arriving by alternate means such as busses.

In the Valley of the Sun, visitation to outdoor recreational sites coincides with temperature. Visitation occurs in two seasons: WINTER (October through May); and SUMMER (June through September.) The WINTER months in the Valley have maximum average temperatures of 87 degrees. Visitors from around the world come to Phoenix during this time, and numerous "winter residents" arrive. SUMMER months bring hot sunny days and occasional afternoon thunderstorms. Temperatures average 102 degrees, making the early mornings and evenings the best time for outdoor activities.

Anticipated visitation at Rio Salado Oeste is based on use projections during PRIME TIME and NON-PRIME TIME throughout the year. PRIME TIME includes weekends and holidays. NON-PRIME TIME is weekdays. A typical visit to Rio Salado Oeste is expected to span three hours, although many visits will be longer, and some much shorter. Turnover refers to the number of times a parking space will be filled daily.

Below is a breakdown of anticipated visitation during WINTER and SUMMER.

WINTER 79% of annual use

PRIME TIME	70 days	1.5 turnovers	144,375 visitors
NON-PRIME TIME	170 days	0.5 turnover	116,875 visitors
		Winter	**274,313**

SUMMER 21 % of annual use

PRIME TIME	28 days	1 turnovers	38,500 visitors
NON-PRIME TIME	92 days	0 .25 turnover	31,625 visitors
		Summer	**79,063**

TOTAL ANNUAL VISITATION 353,376

Future Visitation Growth

The Rio Salado Oeste project is located in an area of Phoenix that is under tremendous population growth pressure. The area from 27th Avenue to the west, city limits south of Interstate 10, and north of the Salt River (the Estrella Village Planning Area) is expected to have a population of approximately 100,000 when fully developed in approximately 15 years. The Laveen Village Planning Area (between the river and South Mountain from 27th Avenue to the Gila River Indian Community) adjoins the project area to the south and east of 83rd Avenue and will be home to approximately 95,000 new residents. Obviously, the existing rural, open character of the landscape in this part of the City will change greatly with the addition of almost 200,000 people. This new population will be living within approximately 7 miles of the project. Efforts are underway to plan a network of trails and pathways to connect future parks within the area and to provide linkages to the Salt River throughout its Phoenix reach.

As the population grows, and the Rio Salado Oeste project matures, visitation to the resource is anticipated to increase. It is anticipated that WINTER PRIME TIME visitation will be at facility capacity with additional growth from those visiting the resource through alternative means such as improved trail linkages. Growth in the next 50 years could increase during the winter to a total of 274,313 visitors.

The greatest increase over time will be during the four summer months. The City of Phoenix has documented changes in user patterns during the summer months with other resource-based facilities. As trees mature providing more shade and facilities are at capacity during SUMMER

PRIME TIME, visitors will seek alternative times to enjoy Rio Salado Oeste. It is anticipated that visitation during the summer in the next 50 years will increase to a total of 79,063 visitors.

Overall visitation increase for the resource over 50 years is projected to be approximately 353,375.

Rio Salado Oeste			
Recreation Plan			
Baseline Visitation Estimate			
	Days	Turnover/Day	Visits*
Winter (Oct-May)	243		
Prime Time	78	1.50	160,875
Non-Prime Time	165	0.50	113,438
Winter Total			**274,313**
Summer (Jun-Sep)	122		
Prime Time	36	1.00	49,500
Non-Prime Time	86	0.25	29,563
Summer Total			**79,063**
Grand Total (By Vehicle)			**353,376**
Add – Arrive by Alternative Mode (10%)			35,338
Total Visitation			**388,714**
Less Transfers (10%)			38,871
Baseline Visitation for Benefit analysis (Rounded)			**349,843**
* Note – Based Upon Parking Capacity for 500 spaces			
Average of 2.75 Persons/Vehicle			

Potential Visitor Impact

While these numbers are relatively large and may be seen as potentially threatening to the success of the restoration project, it should be kept in mind that the project will be constructed in proximity to over 2,500,000 people. Within the life of the project the population of metropolitan Phoenix is projected to increase to approximately 4,700,000.

The City of Phoenix has vast experience with large numbers of visitors to its resource-based recreation sites. The Summit Trail at Squaw Peak currently has about 500,000 hikers a year; the Echo Canyon Trail on Camelback Mountain carries approximately 300,000 hikers each year, and South Mountain Park, the largest municipal park in the nation, has approximately 3,000,000 visitors each year, most of whom use some portion of the natural areas.

Rio Salado Oeste must be artfully designed and carefully managed. The discussion in earlier chapters regarding the functions of the recreation and environmental education improvements stressed the intent to segregate the visitor experiences from the core restoration of the river channel where critical habitat is likely to occur. By providing visitor-related improvements at locations appropriate to the specific habitat, environmental education and recreation functions can serve as an integral part of the project. Indeed, the education and recreation components of the project are much more likely to enhance the restoration by building an informed and supportive base of popular opinion than they are likely to degrade the project by overcrowding facilities and disrupting natural functions.

Nonetheless, visitors must be carefully managed to prevent adverse effects to the project and other adjacent property owners. The presumption is that the visitor management program will include Phoenix Park Ranger coverage for the project area in addition to the design features already discussed.

4

Point Value Assessment

One of the Specific Planning Objectives stated in the Rio Salado Oeste Feasibility Study is to "increase environmental education and passive recreation opportunities". The vision for these opportunities is described in detail in Chapter One, *Description of Recreation Features.*

There is an inherent difficulty in determining the values of environmental education and recreation when they are considered separate experiences. The dichotomy of the two is not as easily determined as it might seem. As an example, a recent survey by Arizona State Parks lists *visiting historic/archeological sites, retracing historic/prehistoric routes, and wildlife viewing/ bird watching* as three of the six most important activities for users of non-motorized trails. *Day hiking, walking*, and *backpacking* are the other three. It would be a logical deduction that the environmental education experience and the resource-based recreation experience are virtually inseparable. Indeed, the currently popular "ecotourism" trend is built upon the premise that first-hand learning experiences are rewarding not only as an educational experience but also as healthy, stimulating recreation. The education experience **is** recreation, in other words.

Nonetheless, an attempt to logically separate the facilities supportive of the individual experiences is presented in this chapter.

Point Value Estimates for Recreation

(A) RECREATION EXPERIENCE
Total possible points: 30 scored points: 24

Numerous high quality value activities to include: habitat restoration; riparian resource areas; water conservation areas; flora and fauna sanctuary and conservation areas; study areas; urban fishing opportunities; outdoor classroom; birding; interpretive opportunities and scenic overlooks.

Some general activities to include: hiking; horseback riding; cycling; fishing and picnicking.

(B) AVAILABILITY OF OPPORTUNITY
Total possible points: 18 scored points: 8

The Rio Salado and Tres Rios Projects will be connected by Rio Salado Oeste and will present similar types of activities. Rio Salado Oeste will provide a vital wildlife corridor connecting the two other projects and offering continuous riparian habitat, and spreading out impacts of visitor use. No other similar activities exist within one hour travel time. The nearest *water-based* recreation sites with a natural riparian habitat are located well over an

hour and a half away, which are the Salt River Recreation Area and Verde River Recreation Area in the Tonto National Forest, northeast of the valley.

(C) CARRYING CAPACITY
Total possible points: 14 scored points: 14

Ultimate facilities to achieve intent of selected alternative. Areas within Rio Salado Oeste will be designed and managed to provide for recreational experiences while preserving the resource.

(D) ACCESSIBILITY
Total possible points: 18 scored points: 18

Good access, high standard road to site; good access within site. Rio Salado Oeste is located within a major metropolitan area with access to the interstate highway system, ultimately integrated with public transportation routes, traffic thoroughfares, and a planned system of neighborhood and regional trail linkages.

(E) ENVIRONMENTAL
Total possible points: 20 scored points: 12

High esthetic quality to include: geology; hydrology of project; topography; water resources; vegetation; and wildlife. Efforts are currently being made by local and federal governments to mitigate any existing negative factors of illegal dumping.

TOTAL POSSIBLE POINTS: 100 TOTAL SCORED POINTS: 76

5

ENVIRONMENTAL EDUCATION PROGRAM

Objectives

The purpose of the Environmental Education Program will be to provide visitors with educational information to understand and enhance the Rio Salado Oeste experience. The program will include educational information presented in a creative and exciting way. The objectives are defined in terms of what the visitor will learn while at Rio Salado Oeste.

The program is structured so visitors will learn the following:

The site is a constructed habitat restoration project that has multiple uses.
Rio Salado Oeste can benefit people
Complex ecological interactions occur among the organisms in a habitat restoration project including microorganisms, aquatic insects, plants, birds and other wildlife.
Wildlife can best be seen when visitors blend in quietly with nature.
To more fully experience the restored environment, the visitor should rely not only on sight but also on hearing, touch and smell.
People play the major role in Phoenix's urban water cycle.
A desert riparian area is a unique and limited resource to be appreciated and respected.

These learning objectives will be realized through the construction of physical features such as an environmental education center with major interpretive displays and exhibits, interpretive trails, and various view points located around the Rio Salado Oeste project and the development of interpretive signs, displays, and supplemental materials.

Partnerships

School districts, organizations, and individuals within the community as well as other governmental agencies will wish to become more involved with the Rio Salado Oeste Interpretive Education Program. They may fund or manage certain public use features and / or provide volunteer services. Individual volunteers and student programs may be organized to help with planting and replanting within the Rio Salado Oeste Project. School districts and local organizations that become partners could set up or rotate interpretive displays within the facility. A cascade effect will also be put into place. The vision is to incorporate students and programs from the universities, community colleges, high schools, elementary schools, and pre-schools, each educational level providing mentoring to the next.

School Curriculum

Support materials for school curriculum would be developed for pre- and post- visit activities as well as for onsite visits. These could include a packet of teaching materials to provide some hands on experience prior to a class visit. The packet could contain wildlife specimens, maps, diagrams, field guides for plant and animal identification, water-quality testing kits, and perhaps dip nets for viewing and identifying species during the visit. The curriculum would also be presented in an outdoor classroom setting at the site.

Guided Nature Walks

A monthly schedule of guided nature walks could become a part of the interpretive education program. These walks could be developed and led by volunteers. Environmental and wildlife organizations such as the Audubon Society, Sonoran Arthropod Studies Institute, and the Arizona Native Plant Society as well as agencies such as the Arizona Game and Fish Department could periodically sponsor events which would be open to the general public.

Cost Estimates

Rio Salado Oeste will serve as a day-use recreational amenity for the public to enjoy on a 7-day a week basis, 365 days a year. Daily operation and maintenance will be consistent with the approved standards set by the City of Phoenix Parks and Recreation Department. The following are cost estimates for the recreational components of Rio Salado Oeste. These costs were developed based the current recreational operation and maintenance costs for Rio Salado. The projected operation and maintenance costs for Rio Salado Oeste are estimated at $1.035 million. This breaks down to a cost of approximately $312 per acre for the 3,315 acre site. The cost to operate and maintain the habitat is a separate cost and is not included within this estimate.

Rio Salado Oeste Recreation

Operation and Maintenance Costs:

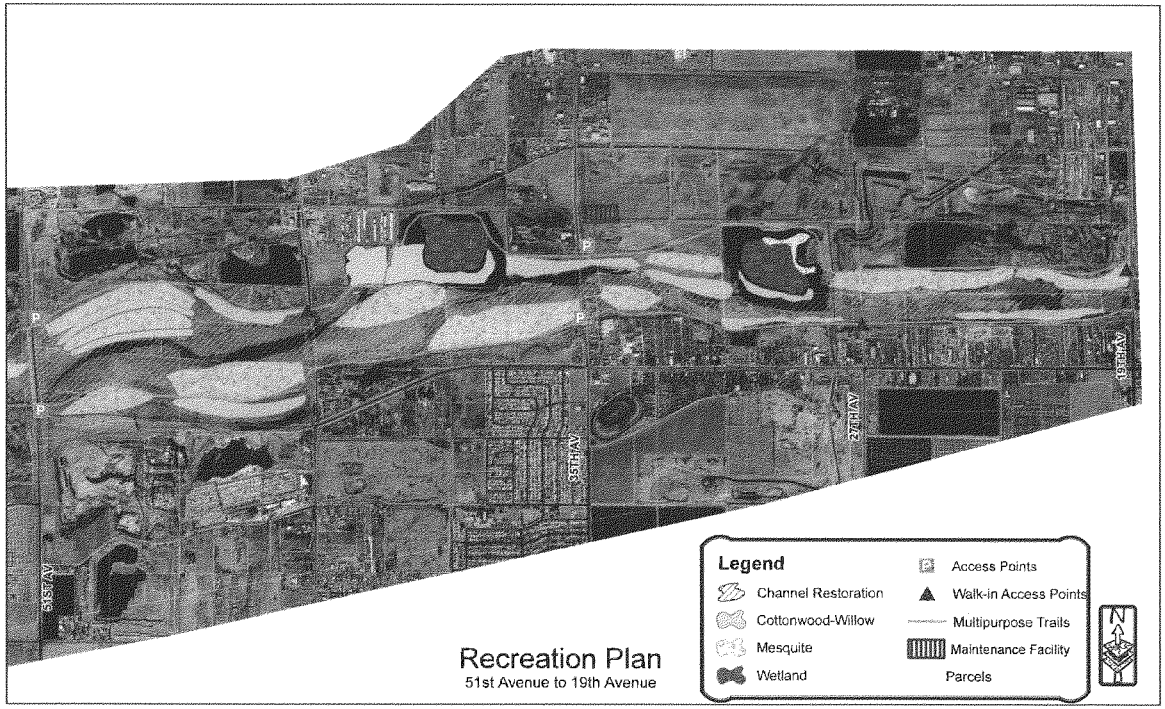
Personnel	**$ 560,783**
Commodities	**125,000**
Contractual	**100,000**
Annual Maint. Cost	**785,783**
Equipment Initial cost	**250,000**
FIRST YEAR & ANNUAL O & M COST	**$1,035,783**

Recreation Plan Features with Costs

Component	Quantity	Unit Cost	Recreation Cost
Site Preparation			
Site Prep to include: clearing, grubbing, and grading	9	Lump Sum	$250,000.00
Vegetative Restoration (Drive in Access)	4	Lump Sum	$600,000.00
Vegetative Restoration (Walk in Access)	5	Lump Sum	$75,000.00
Access and Circulation			
Entry Road w/Turnaround to include: curb, gutter, driveway, & road	4	Lump Sum	$600,000.00
Parking lot	500	$1500/space	$750,000.00
Sidewalks and Ramps	40,000 sf.	$6.00 each	$240,000.00
Multi-Use Trails (24mi * 5280 * 5ft)	47000	$6.00 / sy	$282,000.00
Bridges and Culverts (small) @ Canals, and Localized Drainage Areas	10	$7,500 each	$75,000.00
Protection Access Control			
Access Control Gates (vehicular)	10	$7,500 each	$75,000.00
Access Control Gates (pedestrian)	18	$3,500 each	$63,000.00
Handrails	5,000 l.f.	$50.00 each	$250,000.00
Guardrails	3,000 l.f.	$50.00 each	$150,000.00
Fencing	5,000 l.f.	$30.00 each	$150,000.00
Walls	1,500 l.f.	$125.00 each	$187,500.00
Security lights	100	$4,000 each	$400,000.00
Signage			
Entrance identification signage	8	$15,000 each	$120,000.00
Traffic Control (vehicular)	20	$500 each	$10,000.00
Traffic Control (pedestrian)	27	$500 each	$13,500.00
Instructional/Directional	45	$500 each	$22,500.00
Shelters			
Picnic (large)	5	$60,000 each	$300,000.00
Picnic (small)	5	$25,000 each	$125,000.00
Restroom Facility/Comfort Station	5	$250,000 each	$1,250,000.00
Shelter w/Bulletin Boards	4	$25,000 each	$100,000.00
Trail Shelter w/Railing (large)	9	$40,000 each	$360,000.00
Trail Shelter w/Railing (medium)	4	$30,000 each	$120,000.00
Trail Shelter w/Railing (small)	10	$20,000 each	$200,000.00
Utilities			
Municipal Water Supply and Wastewater Disposal	5	Lump Sum	$500,000.00
Storm Drainage	4	Lump Sum	$80,000.00
Drinking Fountain w/Chiller	12	$5,000 each	$60,000.00

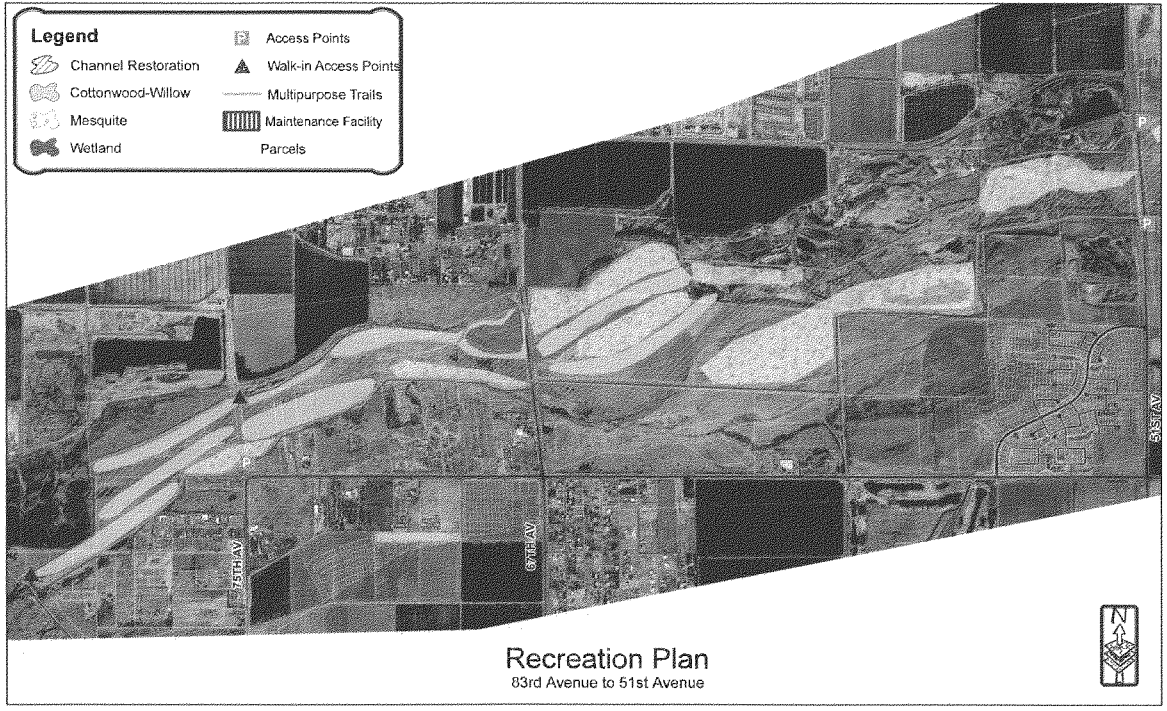
Electical	4	Lump Sum	$200,000.00
Park Furniture			
Benches:	14	$1,500 each	$21,000.00
Off-the-Shelf	40	$800 each	$32,000.00
Recycled/Custom	50	$500 each	$25,000.00
Picnic Tables	40	$1000 each	$40,000.00
Trash Receptacles	75	$500 each	$37,500.00
Interpretive Guidance Media			
Display Boards	50	$600 each	$30,000.00
Interpretive Markers	100	$600 each	$60,000.00
Bulletin Boards	9	$2,500 each	$22,500.00
		Subtotal	**$7,876,500.00**
	Contingency	20%	$1,575,300
	PED+EDC	11%	$1,039,698
	S&A	7%	$681,947
		Total	**$11,173,445**

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Recreation Plan
51st Avenue to 19th Avenue

Rio Salado Oeste
Salt River - Phoenix, Arizona
Final Feasibility Report



Recreation Plan
83rd Avenue to 51st Avenue

Electical	4	Lump Sum	$200,000.00
Park Furniture			
Benches:	14	$1,500 each	$21,000.00
Off-the-Shelf	40	$800 each	$32,000.00
Recycled/Custom	50	$500 each	$25,000.00
Picnic Tables	40	$1000 each	$40,000.00
Trash Receptacles	75	$500 each	$37,500.00
Interpretive Guidance Media			
Display Boards	50	$600 each	$30,000.00
Interpretive Markers	100	$600 each	$60,000.00
Bulletin Boards	9	$2,500 each	$22,500.00
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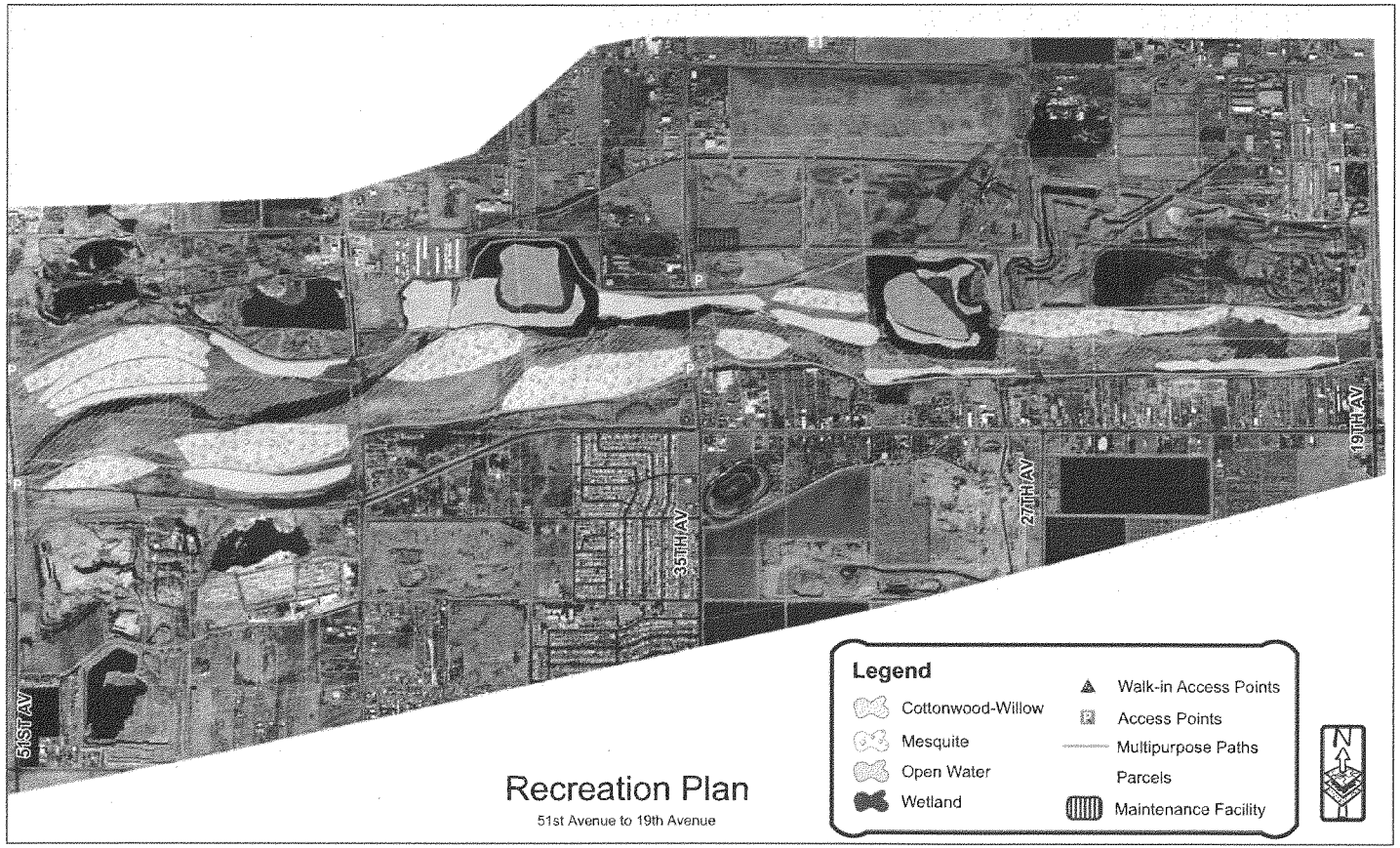


Recreation Plan

51st Avenue to 19th Avenue

Legend

- Cottonwood-Willow
- Mesquite
- Open Water
- Wetland
- Walk-in Access Points
- Access Points
- Multipurpose Paths
- Parcels
- Maintenance Facility

Recreation Plan

83rd Avenue to 51st Avenue

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

APPENDIX M

WETLAND RESTORATION

September 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

RIO SALADO OESTE
Wetland Restoration Report

WASS Gerke and Associates

August 2003

INTRODUCTION

The Rio Salado Oeste project site is located along the Salt River in western Phoenix, Arizona. The study area extends from 19th Avenue to 83rd Avenue within the 100-year floodplain. Land use in the river and along the banks is characterized by residential housing, sand and gravel extraction, automotive recycling, debris disposal at permitted and non-permitted landfill areas, and agricultural fields. Water sources to the project area mainly consist of effluent from the nearby 23rd Avenue WWTP, stormwater drainage, pumped groundwater from dewatering wells, and agricultural tailwater. This report describes 14 outfalls that deliver these flows on a periodic or semi-continuous basis to the Rio Salado Oeste reach of the Salt River. The goal is to assess the opportunities each outfall provides with respect to restoring, preserving, and/or creating sustainable habitat features and to provide concept level ideas for implementation. Further, the potential to realize planned or incidental water quality benefits at each outfall is also assessed at the conceptual level.

BACKGROUND

Historically, the Salt River was a perennial stream. Flow originated in the White Mountains in eastern Arizona with the highest flows typically coinciding with the runoff generated by spring snow melt in the contributing watershed. During the early 1900's

dams were constructed to store and divert river flows into canals for agricultural use, urban development, and flood control as Phoenix grew into one of the largest metropolitan areas in the Southwestern United States. The upstream series of dams have effectively reduced base flows on the river, such that the riparian vegetation historically associated with the Salt River has been destroyed.

Phoenix was developed into an urban city, built from sand and gravel mined from the dry river. In the early days, exhausted gravel pits were used as landfills for municipal and construction debris. The twentieth century left the Salt River in the Phoenix area void of high value riparian vegetation, scarred with pits, and scattered with toxic and non-toxic trash and debris.

With the exception of dam releases, river flows from the mountains were replaced with concrete pipes discharging urban stormwater, agricultural tailwater, and treated municipal and industrial wastewater into the Salt River in and around Phoenix. By the 1980's the quality of water in the river could be characterized by high levels of heavy-metals and pesticides. Improved treatment for municipal and industrial wastewater, the increased use of environmentally friendly pesticides, and stormwater management practices enacted within the watershed have dramatically improved the quality of such discharges. Currently, these discharges support vegetative communities that range from xeric to riparian in nature and provide moderate habitat values at areas proximal to the outfalls. The aerial extent and vegetative character at these sites are dependent upon the temporal occurrence and amount of flow, and the character and quality of the surrounding soils.

The availability of land and water in the Oeste project area allows many opportunities to enhance, restore, or create riparian habitats associated with these outfalls in the Salt River. These efforts will also likely result in water quality improvements to several of the discharges because of the physical, biological, and chemical reactions that take place within the wetland environment. At a minimum, one can likely expect a decrease in oxygen-demanding substances, attenuation and bioconversion of organic compounds including some pesticides, and attenuation/removal of select heavy metals via metal-sulfide complexation which can render them biologically unavailable.

INVESTIGATIONS

Field investigations conducted during May and June 2003 of the study area consisted of visual inspection of surface waters and vegetative communities associated with 14 outfalls that discharge to the Rio Salado Oeste reach of the Salt River. These outfalls provide stormwater, agricultural, and wastewater runoff to the river and were located (GPS coordinates) and characterized based on the following elements:

- presence and character of vegetation: hydro-riparian, meso-riparian, xero-riparian;
- visual assessment of soils in the immediate area of the outfall: clay/silt, sand, gravel/cobbles;
- presence and aerial extent surface water at each outfall.

RESTORATION OPPORTUNITIES

Based on the results of the findings, recommendations can be made whether existing vegetative communities might be restored, created, or preserved. Restoration is recommended at outfalls where vegetative communities are characterized by a mixture of native and non-native species. Restoration and creation is recommended at locations where water appears to be available, soils are capable of retaining sufficient moisture, e.g. the presence of silts and/or clays, and little to no native vegetation is present. Preservation is recommended at outfalls with predominately native vegetation (or at least non-invasive exotics) with limited soil and/or water conditions to support native vegetation.

In general, active restoration activities will likely include the following:

- Addition of soils or amendment of existing site soils;
- Selective removal of exotics, primarily salt cedar (*T. ramosissima*) and giant reed (*Arundo donax*);
- Clearing, grubbing, grading, and excavation to removal of material, increase open water areas, increase emergent marsh areas, and to route water for irrigation;
- Construction of energy dissipation, flow metering, and flow routing structures.

The following sections will now provide photographs and narratives regarding the findings and specific restoration recommendations for each outfall site.

FINDINGS AND RECOMMENDATIONS

The 14 outfalls investigated within the Rio Salado Oeste study area are provided in **Figure 1** which depicts the name and location given to each outfall. Field investigations were performed to document the type of outfall structure, vegetation, and soil, and to comment on its restoration potential. Field data sheets for each location are included in **Appendix A**.

Vegetation at each location was divided into three categories: hydro-riparian, meso-riparian, and xero-riparian. Hydro-riparian communities were delineated based on the presence of perennial water, distance from water source, and several indicator species. Meso-riparian communities were based on the presence of shallow (or perched) groundwater, intermittent flow, or indicator species. Xero-riparian areas contained many of the same species as the uplands, but the plants occurred at a higher density and were typically larger.

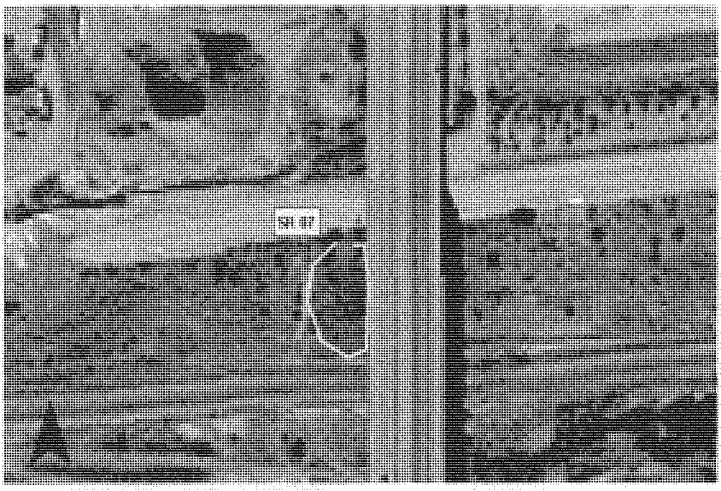
SR 07

Outfall SR 07 is a 54-inch concrete culvert with a trash screen situated on the north side of the Salt River channel immediately upstream from the 19th Avenue Bridge at N33° 24' 68.0", W112° 05' 98.5". Annually, the amount of flow expected at this site due to precipitation is approximately 79 acre-ft per year (AF/Yr). At the time of the site visit, a small amount of flowing water from the outfall supported a stand of cattails (*Typha sp.*) immediately below the concrete apron of the outfall. Meso-riparian species included Shoestring acacia (*Acacia stenophylla.*), Desert broom (*Baccharis sarothroides*), and

Chilean mesquite (*Prosopis sp*). The xero-riparian species surrounding the area were unidentified annual grasses, Russian thistle (*Salsola iberica*), and eucalyptus. Soils at this site were primarily sand with some silt.

SR 07: North bank west of 19th Avenue

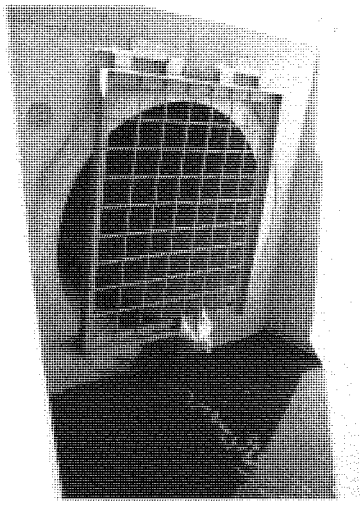
Outfall SR 07 has a relatively robust meso-riparian community. The site appears to have ideal water supply and soil conditions for the creation of a mesquite bosque. Additional opportunities include removal of trash and debris, and planting of native mesquite (*P. juliflora* var. *velutina*), Paloverde (*Cercidium sp.*), and appropriate ground cover species.



Aerial extent of vegetation at SR 07

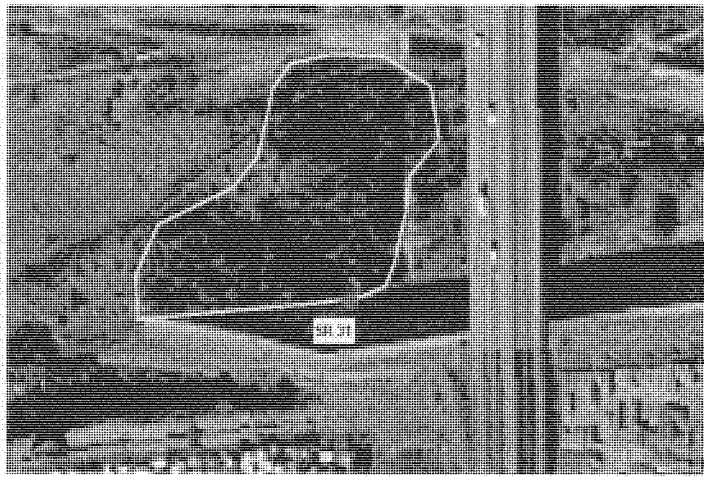
SR 31

Outfall SR 31 is a 60-inch concrete culvert with a trash screen, located on the south side of the Salt River channel near 19th Avenue at N33° 24'59.6" W112° 06'00.5". The annual stormwater runoff flow estimate for this outfall is approximately 231 AF/Yr. Below the outfall was a small pool (5 to 10 feet) of open water approximately 2-3 feet deep. Meso-riparian species surrounding the pool included velvet mesquite (*Prosopis juliflora* var. *velutina*), salt cedar (*Tamarix ramosissima*), palm (*Washingtonia sp.*), exotic emergent likely wild taro (*Colocasia esculenta*) and Paloverde (*Cercidium sp.*). Salt bush (*Atriplex sp.*), salt cedar (*T. ramosissima*), and Paloverde (*Cercidium sp.*) were also categorized as meso-riparian species at this site. Soil types included clay/silt and some sand.



SR 31: South bank west of 19th Avenue

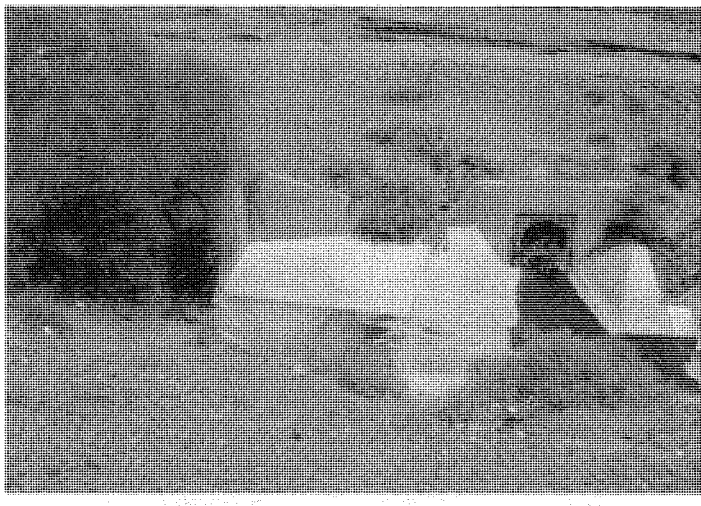
Outfall SR 31 has standing water and lush vegetation. The site has potential, due to the water supply and low permeability soils, for the development of a wetland and riparian corridor. Restoration could be achieved with exotics removal, mainly palm and an unidentified emergent plant (likely wild taro), and replacement with native bulrush and sedges. Minor excavation at this outfall could also be used to create a wetland pond and riparian corridor which would allow additional planting areas for willow and cottonwood trees, as well as mid- and under-story riparian vegetation.



Aerial extent of vegetation at SR 31

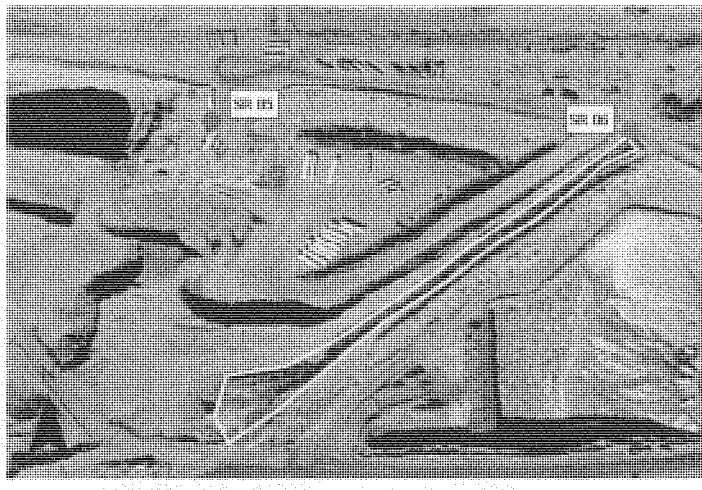
SR 06

Outfall SR 06 is a 78-inch concrete culvert with an open channel both upstream and downstream near 22nd Avenue on the north side of the Salt River channel at N33° 25'01.3" W112° 06'59.1". Estimated runoff to this outfall is approximately 561 AF/Yr, but none of the flow reaches the Salt River channel, instead it is routed into a large sand and gravel pit and allowed to infiltrate or otherwise evaporate. An area of approximately 50 ft^2 of standing water between 0-2 feet deep was located below the outfall. Hydro-riparian species included flat-sedge (*Cyperus sp.*), Fremont cottonwood (*Populus fremontii*) Gooding's willow (*Salix gooddingii*), and eucalyptus. Desert broom (*Baccharis sp.*) dominated the meso-riparian community at this site. The xero-riparian species included unidentified annual grasses, Paloverde (*Cercidium sp.*), and salt bush (*Atriplex sp.*). Soils at the site included clay/silt, sand, gravel, and cobble.



SR 06: North bank at 25th Avenue

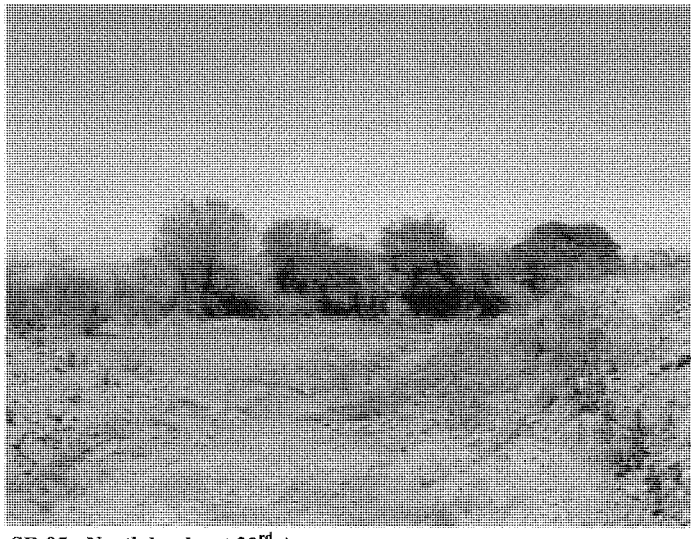
SR 06 is located within the property of Rinker Materials sand and gravel mine between the 19th Avenue and 27th Avenue on the northern side of the Salt River. This outfall currently receives dry-weather flows and stormwater runoff via vegetated open-channels. SR 06 discharges to sand and gravel pits where the water either infiltrates or evaporates. At this time, the restoration recommendation is to maintain and protect the open channel conveyances leading to the outfall. If land use and ownership changes in the future, the area may provide habitat features that could be used for trail alignments for access to the project.



Aerial extent of vegetation at SR 06

SR 05

Outfall SR 05 included a pair of concrete pipes emptying into a single, large concrete spill pad on the north side of the Salt River channel near 25th Avenue at N33° 25'01.7" W112° 06'78.5". Almost 125 AF/Yr of stormwater runoff was estimated to discharge from this outfall. At the time of the visit, standing water encompassed an area of approximately 20 ft^2 below the spill pad. From the spill pad water discharges to an isolated gravel pit where it infiltrates and or evaporates. Only xero-riparian species such as salt bush (*Atriplex sp.*), unidentified annual grasses, and Paloverde (*Cercidium sp.*) were documented at this site. The dominant soil type was gravel/cobble.



SR 05: North banks at 23rd Avenue

SR 05 is also located within the property of Rinker Materials sand and gravel mine on the north side of the Salt River. The outfall receives dry-weather flows and stormwater runoff. SR 05 also discharges to sand and gravel pits where the water infiltrates or evaporates. Currently, the restoration recommendation is to maintain and protect the open channel conveyances leading to the outfall. Little to no vegetative community exists at this outfall; therefore, an aerial photo is not available for this site.

SR 04

Outfall SR 04 included four 84-inch concrete pipes on the north side of the Salt River channel near 27th Avenue at N33° 24'86.5" W112° 06'98.8". Although this outfall is estimated to discharge 341 AF/Yr, no standing water was visible at the outfall, but open

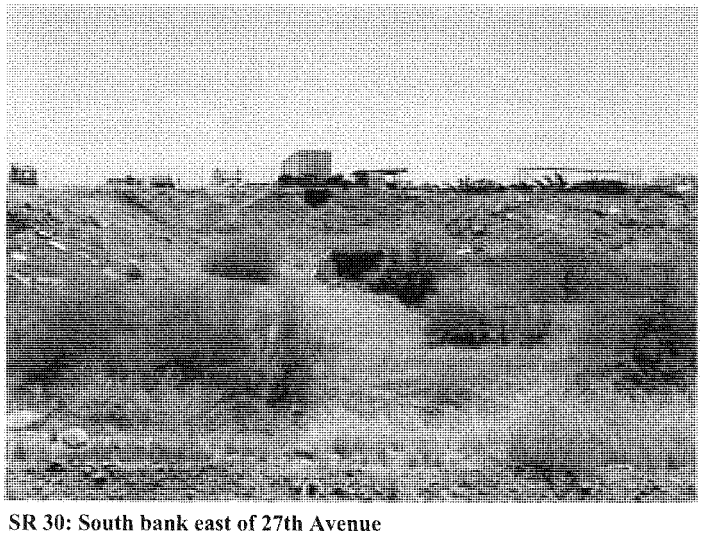
water was present upstream in an open channel. Meso and xero-riparian vegetation was observed at this site and consisted of species such as Paloverde (*Cercidium sp.*), desert broom (*Baccharis sp.*), Gooding's willow (*Salix gooddingii*), and unidentified annual grasses were found upstream in the invert and side slopes of the open approach channel. The dominant soil types at this site were clay/silt and gravel.

SR 04: North bank near 27th Avenue

SR 04 is also located within the property of Rinker Materials sand and gravel mine on the north side of the Salt River near 27th Avenue. The outfall receives dry-weather flows and stormwater runoff. SR 04 also discharges to sand and gravel pits where the water infiltrates or evaporates. The restoration recommendation is also to maintain and protect the open channel conveyances. Little to no vegetative community exists at this outfall location; therefore, an aerial photo is not available for this site.

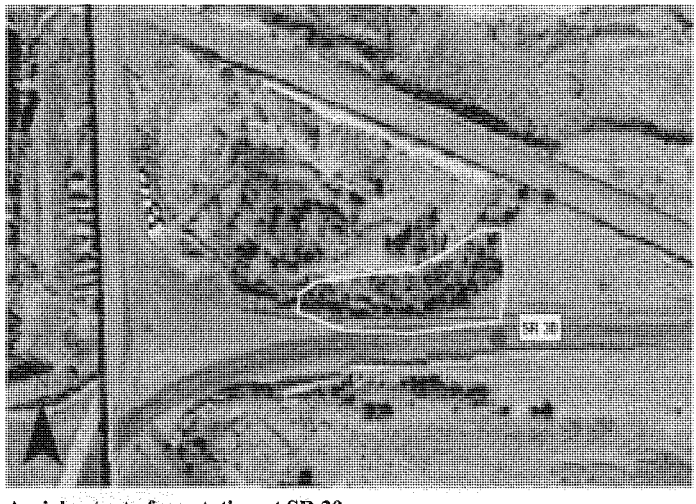
SR 30

Outfall SR 30 is a USGS gauge site (flow and quality) and consists of a large, 108-inch concrete culvert with a trash screen located on the south side of the Salt River channel near 27th Avenue at N33° 24'59.5" W112° 06'98.0". Up to 196 AF/Yr of stormwater flow is estimated to be discharged at this outfall. Minimal standing water (a pool of less than 5 feet across, and less than 6-inches deep) was visible at the site. Saltcedar (*T. ramosissima*) dominated the hydro-riparian vegetation at 27th Avenue. Desert broom (*Baccharis sp.*) and Paloverde (*Cercidium sp.*) were also present and comprise the meso to xero-riparian community at this site. The main soil types were sand and gravel/cobble. A review of the water quality data collected by the USGS for this site indicates a high potential to experience elevated heavy-metal and suspended solids concentrations in flows from this outfall (USGS 1995).



SR 30: South bank east of 27th Avenue

Historically, this outfall has produced significant heavy-metal concentrations and sediment loads. As such, this site could be outfitted with a treatment wetland system designed to manage sediments and the associated heavy-metals. Energy dissipation will likely need to be provided at the upstream end of the treatment wetland, as well as, access to an area that would be designed for periodic sediment removal. Given the potential for high energy flows at this site, the energy dissipation would also serve to route excessive flows to the main channel. Because this outfall flows only in response to storm events, it is recommended that project infrastructure be designed to supply an additional water source to maintain the treatment wetland and riparian area



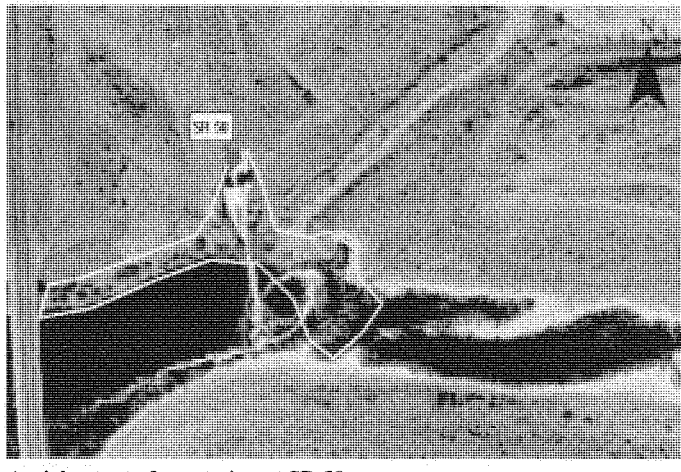
Aerial extent of vegetation at SR 30

SR 58

Outfall SR 58 is a 60-inch concrete culvert with rock gabions located on the north side of the Salt River channel northeast of 35th Avenue at N33° 24'74.6" W112° 07'99.1". This outfall appears to flow in response to discharges of filtered effluent from the City of Phoenix 23rd Avenue Waste Water Treatment Plant (WWTP). Both standing and flowing water were apparent at this location at the time of the site visit. The size of the pool immediately below the outfall fluctuates over the course of the year as evidence by dried alga along the perimeter of the water body. At the time of the site visit, the pool was approximately 100 ft^2, four feet deep, and fed into a large water body in the Salt River channel. Lush vegetation surrounded the outfall including cattail (*Typha sp.*), velvet mesquite (*P. juliflora* var. *velutina*), salt cedar (*T. ramosissima*) and Paperflower (*Psilostrophe sp.*). Brittle-bush (*Encelia sp.*) dominated the meso-riparian community at this site. Soil types included clay/silt and gravel/cobble.

SR 58: North banks east of 35th Avenue

Outfall SR 58 discharges a large, and currently un-quantified, amount of effluent year-round. The effluent has created a large lake that extends a quarter to one-half mile downstream. The banks of the lake offer enhancement potential by replacing the non-native invasive grasses with bulrush, cattail, and native sedges. Because the area of inundation varies on a temporal basis, perimeter vegetation selection should include facultative as well as obligate wetland species. Consideration should also be given to augmenting the outfall area with cottonwood and willow tree species as long as appropriate soil conditions are present or created.

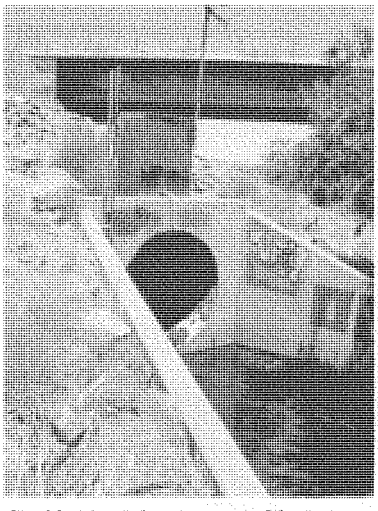


Aerial extent of vegetation at SR 58

SR 03

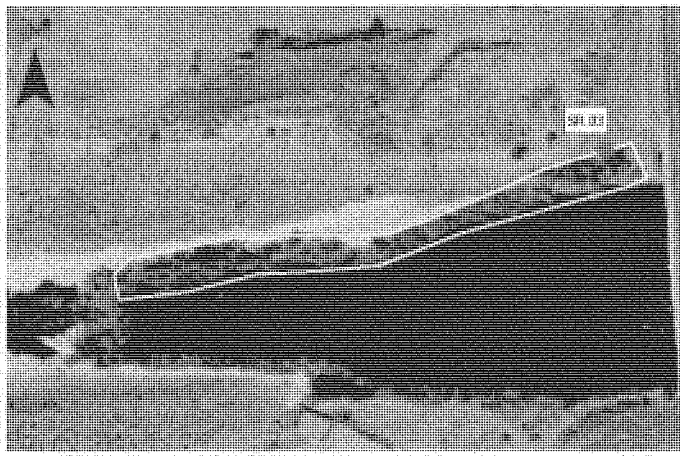
Outfall SR 03 is a 75-inch concrete culvert located on the north side of the Salt River channel, northwest of the 35th Avenue Bridge at N33° 24'71.9" W112° 08'07.3". Approximately 224 AF/Yr of stormwater runoff is estimated to be discharged from this

outfall. At the time of the site visit a small pool existed below this outfall structure, and routed into the same in-channel large water body as SR 58. Hydro-riparian species were present at this site including Freemont cottonwood (*P. fremontii*) and Gooding's willow (*S. gooddingii*). Palm (*Washingtonia sp.*) and Paloverde (*Cercidium sp.*) were also present. The dominant soil type was gravel/cobble.



SR 03: North banks west of 35th Avenue

Outfall SR 03, north bank west of 35th Avenue, appears to have sufficient water to support hydro-riparian trees including native willows which could be established along the wetted perimeter. The site could also be restored by the removal of trash, non-native palm trees, and the establishment of a small pocket-forest of cottonwood trees. In both cases native mid- and under-story vegetation should be augmented as well.

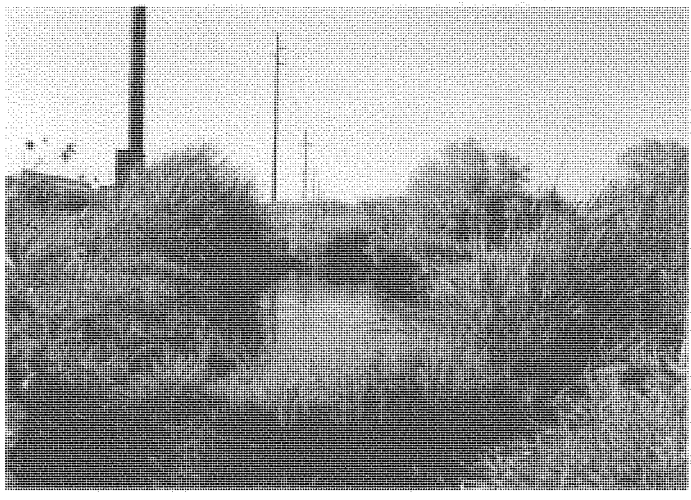


Aerial extent of vegetation at SR 03

SR 02

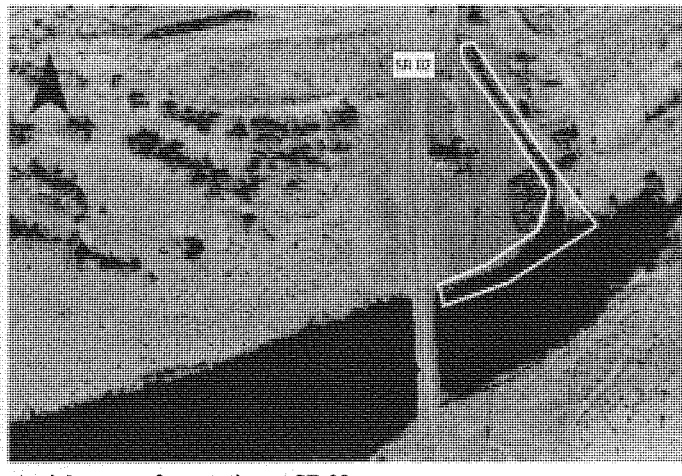
Outfall SR 02 is a 90-inch concrete culvert flowing into an unlined canal on the north side of the Salt River channel, near the 43rd Avenue alignment at N33° 24'57.7" W112° 09'08.0". This outfall receives an undocumented amount of irrigation tailwater from Peterson's farm (effluent reuse from the 23rd Avenue WWTP). It is also estimated that up to 274 AF/Yr of stormwater runoff can be discharged from this outfall. At the time of the site visit, both standing and flowing water were visible and flow is routed into a common, large pool of water in the river channel. This pool becomes channelized at the downstream end and continues downstream with intermittent open-water and marsh areas extending all the way to the 51st Avenue Bridge at times of the year. Several hydro-riparian species surround this important water-body, including cattail (*Typha sp.*), salt cedar (*T. ramosissima*), castor bean (*Ricinus sp.*), and sunflower (*Heloanthus sp.*). The meso-riparian species at the site include Paloverde (*Cercidium sp.*), Salt bush (*Atriplex*

sp.), Brittle-bush (*Encelia sp.*), and Russian thistle (*Salsola sp.*). The soil types at this site include sand and gravel/cobble.



SR 02: North bank at 43rd Avenue

Outfall SR 02 is an unlined canal entering from Peterson farms. The water supply at this location supports a corridor of riparian plants, and lake that extends from one-quarter to nearly one mile. Restoration opportunities include planting willows and cottonwoods along the banks of the riparian corridor. In addition, non-native grasses could be selectively replaced with bulrush, cattail, and native sedges. The potential exists at this outfall to divert a portion of the flow downstream several meters from the toe of the north bank to an area that appears to have at one time supported a willow forest. Restoration in that area includes supplying water and plantings. The majority of existing dead snags in that area should be left in place.



Aerial extent of vegetation at SR 02

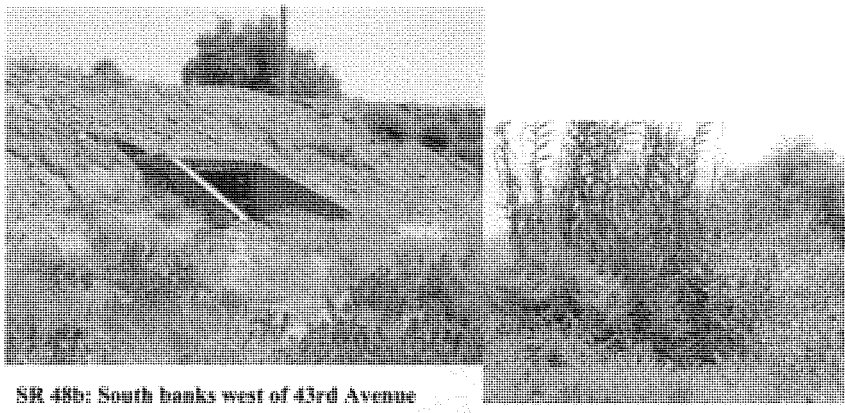
SR 48a

Outfall SR 48a is a 48-inch concrete storm drain with a flood gate on the south side of the Salt River channel near 43rd Avenue, approximately 50 feet west of 48b. No water was visible at this outfall and an estimate of annual discharge is not currently available. Several large hydro-riparian trees currently exist including cottonwood (*P. fremontii*), willow (*S. gooddingii*), Paloverde (*Cercidium sp.*), and mesquite (*Prosopis sp.*). Annual grasses surrounded the site. The dominant soil type was clay/silt with some small gravel.

SR 48a: South bank at 43rd Avenue

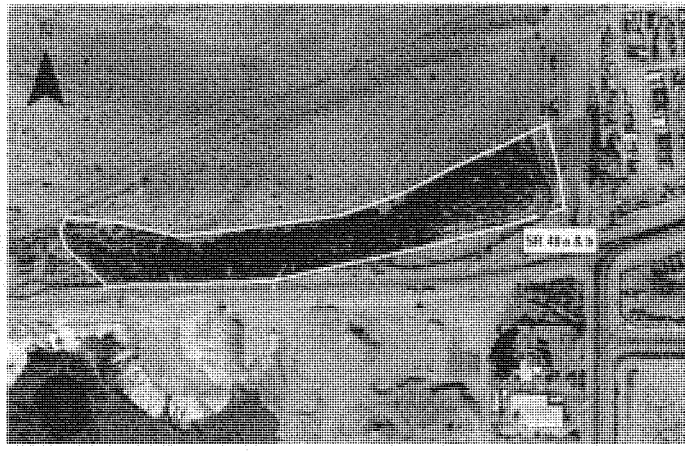
SR 48b

Outfall SR 48b is a large concrete culvert with a flood gate on the south side of the Salt River channel near 43rd Avenue at N33° 24'23.1" W112° 09'08.6". At this time, no information is available with respect to anticipated annual flow volumes from this outfall. At the time of the site visit, no standing water was visible immediately adjacent to the outfall, but standing water was found about 25 feet away in a small channel. Salt cedar (*T. ramosissima*), salt bush (*Atriplex sp.*), Giant Reed (*Arundo donax*), mesquite (*Prosopis sp.*) and Sunflower (*Helianthus sp.*) were the dominant hydro-riparian species at this site. The meso-riparian community consisted mainly of desert broom (*Baccharis sp.*) and unidentified grasses. Clay/silt and sand were the main soils at this outfall.



SR 48b: South banks west of 43rd Avenue

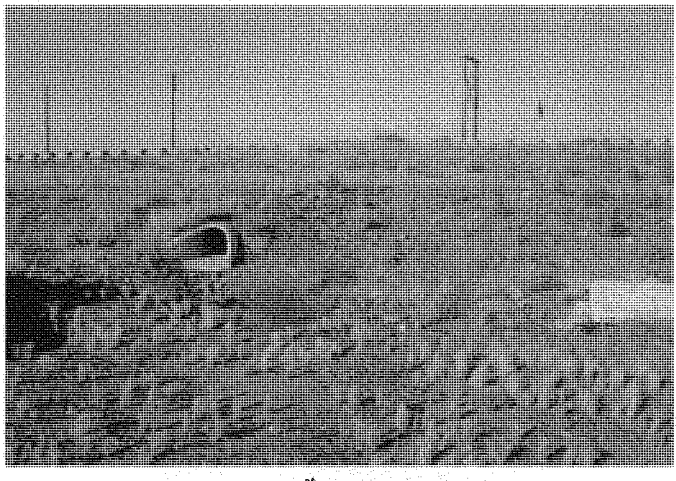
Outfalls SR 48a and 48b appear to deliver sporadic flows to an area of the river bottom that possesses low permeability soils. These soils appear to retain moisture between flow events. The existing community at these outfalls should be restored to reduce the Arundo population and increase native hydro- and meso-riparian species. Reeds (bulrush, spike-rush, horsetail rush, and sedges) could be planted in the shallow standing water and mesquite bosque established to surround the immediate area.



Aerial extent of vegetation at SR 48a & b

SR 47

Outfall SR 47 is a 48-inch culvert on the north side of the Salt River channel just west of 51st Avenue, 50 feet north of SR 01, at N33° 24'52.6" W112° 10'17.4". At this time, no flow estimate is available for this outfall and no standing water was visible at this site during the visit. No hydro-riparian species were evident, but annual grasses and brittle-bush (*Encelia sp.*) were found nearby. The dominant soils were sand and gravel.

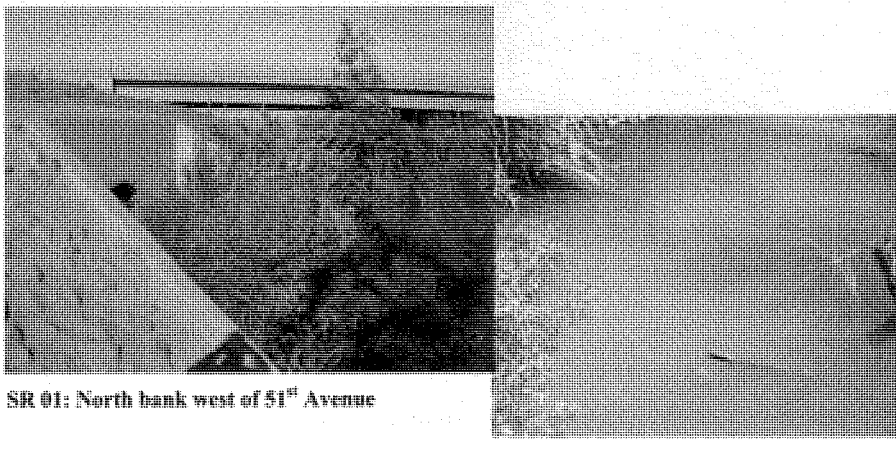


SR 47: North banks west of 51st Street

Outfall SR 47 appears to be dry the majority of the year, passing short duration high energy flow events periodically. Trash removal is recommended, at this site. Due to the lack of available water supply and high scour potential during flow events, no restoration is recommended for this site. Creation could be considered pending a thorough investigation of the need for energy dissipation and the provision of a supplemental water source and appropriate soils.

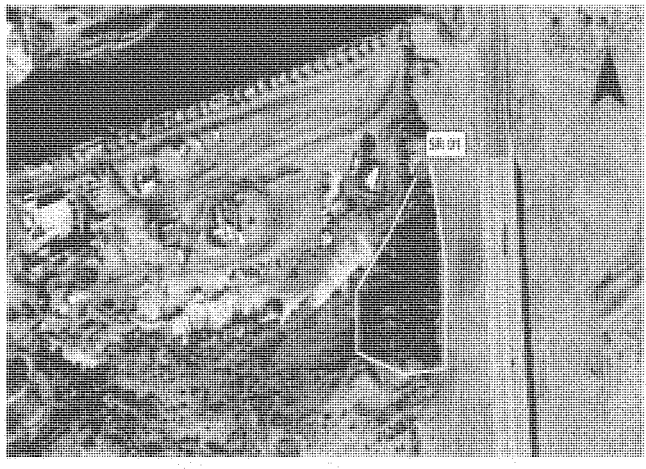
SR 01

Outfall SR 01 is a 96-inch culvert without a trash screen on the north side of the Salt River channel near 51st Avenue at N33° 24'525" W112° 10'174". The stormwater runoff discharged from this outfall on an annual basis is approximately 274 AF/Yr. A small pond of standing water approximately 3-4 feet deep was present directly below the outfall. Hydro-riparian vegetation existed within 5-10 feet of the standing water that included: cattail (*Typha sp.*), willow (*S. gooddingii*), Paloverde (*Cercidium sp.*), mesquite (*Prosopis sp.*) and Sunflower (*Helianthus sp.*). Meso-riparian species at this site included unidentified annual grasses, desert broom (*Baccharis sp.*), and Paperflower (*Psilostrophe sp.*). Silt and gravel/cobble were the dominant soil types at this site. As was the case with the majority of the outfalls visited, trash and debris occupy significant portions of the sites and any restoration activities should include removal of such materials.



SR 01: North bank west of 51st Avenue

Outfall SR 01 has a variety of native willow and cattails surrounding the open water. Protection/preservation is suggested for the immediate region. Nearby salt cedar could be replaced with bulrush and spike rush (e.g. *Schoenoplectus martine, Eleocharis sp.*) in moist soils and mesquite in drier regions. An under-story/groundcover dominated by *Anemopsis californicus* (Yerba Manza) could likely be established under the canopy species. If desired and pending a site specific water budget, flow may be available or could be supplied via project infrastructure that could be routed from this location to support downstream features such as a cottonwood forest or mesquite bosque.



Aerial extent of vegetation at SR 01

<u>SR 49 & SRP 67th Avenue Drain</u>

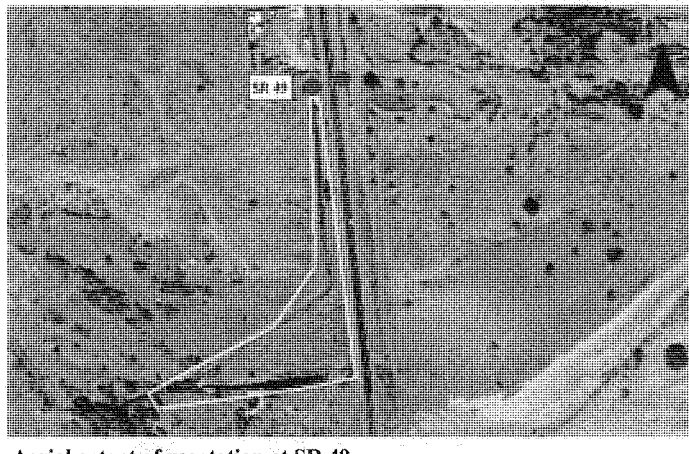
Outfall SR 49 & the SRP 67th Avenue drain consists of two open, concrete-lined channels leading from 96-inch concrete culverts on the north side of the Salt River channel near 67th Avenue at N33° 24'01.0" W112° 12'24.9". Both channels transport a combination of

agricultural and urban runoff to the Salt River channel over the course of any given year. It is estimated that the stormwater runoff discharged from these outfalls is approximately 558 AF/Yr. In addition, 1,044 AF/Yr of irrigation water is discharged from the SRP 67th Avenue Drain. No water was visible in the channel on the west side of 67th Avenue (SR 49), but flowing water was apparent in the eastern channel (SRP drain). Both channels empty into a standing pool of water on the west side of 67th Avenue. Hydro and meso-riparian species currently present included: Paloverde (*Cercidium sp.*), desert broom (*Baccharis sp.*), Canyon Ragweed (*Ambrosia ambrosioides*), salt cedar (*T. ramosissima*), and mesquite (*Prosopis sp.*). The dominant soil type is clay/silt.

SR 49: North bank west of 67th Avenue

SRP 67th Avenue Drain: North bank east of 67th Avenue

Outfalls SR 49 and the SRP 67th Avenue drain discharge into open channels that enter the Salt River from the north bank. The SRP 67th Avenue drain flows regularly with agricultural return flows, while SR 49 typically flows in response to runoff generating storm events. During the site visit the water appeared muddy in color, and as such, sediment removal would likely improve water quality. This is especially so since pesticides and other organic contaminants are often bond to the sediment in agricultural tail water. Restoration through the creation of a treatment wetland area is recommended to reduce sediment loads. Such a system would likely entail the creation of a forebay structure to dissipate energy, route flows, and provide initial settling. Water would then flow to a densely vegetated emergent marsh area designed for sediment removal. Treated water would be discharged into the existing open channel system and ultimately the existing riparian area located approximately ¼-mile downstream of 67th Avenue. Restoration of the existing riparian area would entail exotic plant removal, debris removal, and establishment of additional native vegetation.



Aerial extent of vegetation at SR 49

RECOMMENDATIONS

Table 1 lists the recommendation for each site.

Table 1: Site specific recommendations

Site ID	*Location*	*Create*	*Enhance*	*Protect*	*Comments*
SR 07	19th Avenue NW		X		Trash removal and increase natives; enhance mesquite bosque and Paloverde complex
SR 31	19th Avenue SW	X	X		Wetland and riparian corridor
SR 06	22nd Avenue N			X	Protect Upstream Conveyance Channel Vegetation
SR 05	25th Avenue N			X	Protect Upstream Conveyance Channel Vegetation
SR 30	27th Avenue SE	X	X	X	Trash removal, limited potential for increasing habitat, Create Treatment Wetlands for Water Quality Improvements
SR 04	27th Avenue N			X	Protect Upstream Conveyance Channel Vegetation
SR 58	35th Avenue NE		X		Augment wetland plant species with bulrush and cattails
SR 03	35th Avenue NW		X	X	Replacement of palm with willow and cottonwood
SR 02	43rd Avenue N	X	X	X	Add cottonwood and willow trees in the channel banks and bulrush and cattails in the shallow muds. Create diversion channel to historic forest area adjacent to N. bank.
SR 40	43rd Avenue S		X		Remove exotics (Arundo and salt cedar)

Table 1 cont'd

Site ID	*Location*	*Create*	*Enhance*	*Protect*	*Comments*
SR 01	51st Avenue NW		X	X	Trash removal, bar screening, bulrush, cattails, cottonwood, willow.
SR 47	51st Avenue (50 ft North of SR 01)		X	X	Trash removal only
SR 49	67th Avenue	X	X		Trash removal and the development of a settling pond to remove fine sediments from agriculture.

WATER SUPPLY VERSUS AERIAL EXTENT OF EXISTING HABITAT

The annual amount of water discharged from each outfall as estimated from regional regression equations for precipitation and gauge data for dry-weather flows was compared to the aerial extent of existing habitat (vegetative cover) in an attempt to develop a predictive relationship for subsequent restoration efforts to be focused at outfalls throughout the Oeste Reach of the Rio Salado. If one includes the combined data set for both precipitation and dry-weather flows, no real trend appears ($R^2 = 0.53$). Given that the annual precipitation is only on the order of 9 inches per year, the result indicates that a substantial amount of dry-weather flows enter this reach of the river and that dry-weather discharges such as those from the 23rd Avenue WWTP or from Peterson Farms (SR 02) likely support more vegetation than from runoff generating storm events. When the data set is reduced to include only those outfalls that receive storm water flows (Table 2), the relationship improves dramatically ($R^2 = 0.95$) as seen in Figure 2.

Table 2. Area versus existing habitat acreage at outfalls with runoff estimates.

Outfall Name	Existing Habitat (Acres)	Annual Runoff Amount (Acre-Ft)
SR 01	1.6	274
SR 03	0.9	224
SR 07	0.1	79
SR 30	0.6	196
SR 31	1.3	231
SR 49	3.5	558

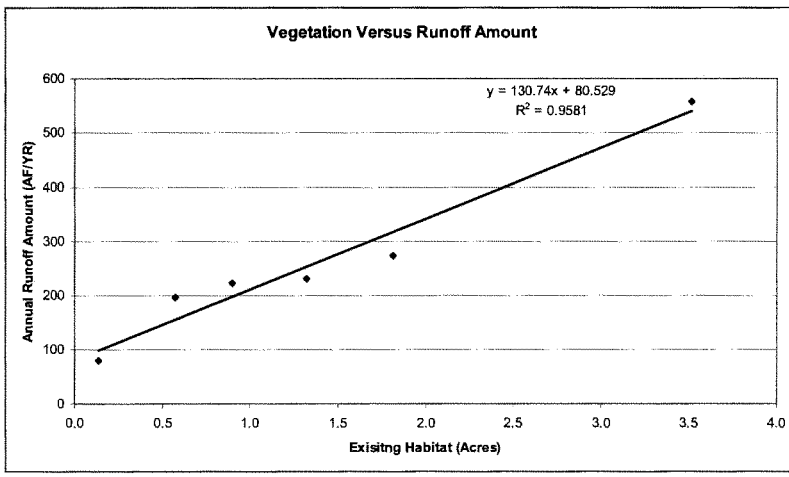


Figure 2. Plot of the existing habitat acres versus the annual runoff estimated for selected outfalls into the Oeste reach of the Rio Salado. Outfalls receiving process water from Sand and Gravel Operations were not included.

Although the relationship developed can likely be used to guide restoration activities associated with the outfalls, the data reveal how important dry weather discharges have been and continue to be to the development and sustenance of riparian habitat associated with outfalls. As such, it is recommended that restoration designs consider a means of supplying supplemental project water to sustain existing habitat should the dry weather

discharges be eliminated through future conservation measures or changes in the land use enacted in the contributing watershed.

OPERATIONS & MAINTENANCE ROADWAY ACCESS TO OUTFALL AREA(S)

High quality riparian habitat is located downstream of several outfalls in the Oeste reach of the Rio Salado. Such existing habitat, if preserved and augmented, could form the basis for full-scale restoration efforts. Because these features are located along the bank of the project, conflicts can occur between the operations and maintenance (O&M) roadway alignment and the discharge from the outfall(s). The conflict arises when high energy discharges from the outfall scour/erode the O&M roadway features placed downstream of the outfall, or roadways are impassable due to flow depth or velocity.

This section focuses upon ways of minimizing such conflicts through alignment, design, and operational methods. Careful thought in the conceptual stages of the Rio Oeste should be used to route the alignment of the O&M roadway through the project. Questions to be answered and or considered include: does the sponsor really need all-weather access to both sides of each outfall; does the alignment necessarily need to be downstream of the outfall discharge point or can the alignment route on the bank side of the outfall; does O&M access have to be contiguous along both sides of the channel?

If it is determined that all-weather access is required immediately adjacent to or downstream of the outfalls then there are several options to be considered in the conceptual phase that if adopted at that time can result in cost-effective solutions that maintain the character and extent of the existing habitat. Such considerations include

bridging the outfall, re-routing a portion of the high energy flows, and provision of energy dissipation structures. Such solutions can be independent or considered together to derive the desired result during design. In all cases, the overall goal is to provide adequate access to the outfall while preserving, and in some instances, restoring riparian habitat.

Finally, some consideration should be given to the use of "wet" crossings at outfalls that have minimal potential to discharge high energy flows to the project. Such a crossing (albeit was likely not an engineered crossing) is currently established at the SR 02 outfall (North bank, at 43rd Avenue). Such crossings are characterized by hard rock bottoms with 0 to 16 inches of flow depth. Although not a pedestrian crossing, such features can be used in areas of the project where visitation is restricted to O&M or project personnel.

In summary, there are several outfalls that discharge to the Rio Salado Oeste project that currently support riparian habitat. As the project develops, there will be times when access to these structures will be required for operation and maintenance activities, and at selected areas, by public visitors. Paramount is the ability of these structures to pass large flows while not destroying access point(s) or the existing riparian habitat. Special attention during the conceptual design phase of this project to these areas must be given by the design team so that economical and functional access will be provided. If consideration is left until the final design phases, costs alone may sway the team and result in loss of existing habitat.

CONCLUSIONS

Appropriate soil characteristics, water supply and quality are essential elements of riverine based ecosystem restoration. Paramount to guiding the development of restoration recommendations is the premise not to degrade desirable habitat areas that are currently associated with a given existing outfall. Prior to implementing any of the recommendations contained within this report, site specific water budgets should be refined to ensure that enhancement is realistic given the amount of water delivered at an outfall. Such information can also be used to assess the need for augmenting dry-weather and stormwater discharges with project infrastructure and water supply. This is especially important for outfalls like SR 02 (N. Bank at 43rd Avenue) where there may be an opportunity to divert a portion of the existing flows to an area that appears to have historically supported a riparian area. Further, the need for importing soil to a site or amending existing soils must also be defined on a site-specific basis and supported by appropriate agronomic testing and water holding analyses prior to implementing restoration enhancement or creation efforts. At least one potential borrow site has been tentatively identified (pending quality and engineering analyses) at the Rinker Materials facility located in the NW quadrant of 19th Avenue and the Salt River. Lastly, the water quality discharged from outfalls that serve agricultural (SRP 67th Ave. Drain) and industrial land use's (SR 30) should be determined so natural treatment system(s) can be designed and constructed if desired.

Literature Cited

Kearny, T.H., R.H. Peebles, and Collaborators, 1997. *Arizona Flora.* University of California Press, Los Angeles, CA.

USGS, 1995. Statistical Summary of Select Physical, Chemical, and Microbial Characteristics, and Estimates of Constituent Loads in Urban Stormwater, Maricopa County. Thomas Lopes *et al.*

Figure 1 Outfall Location Map
Appendix A Field Data Sheets

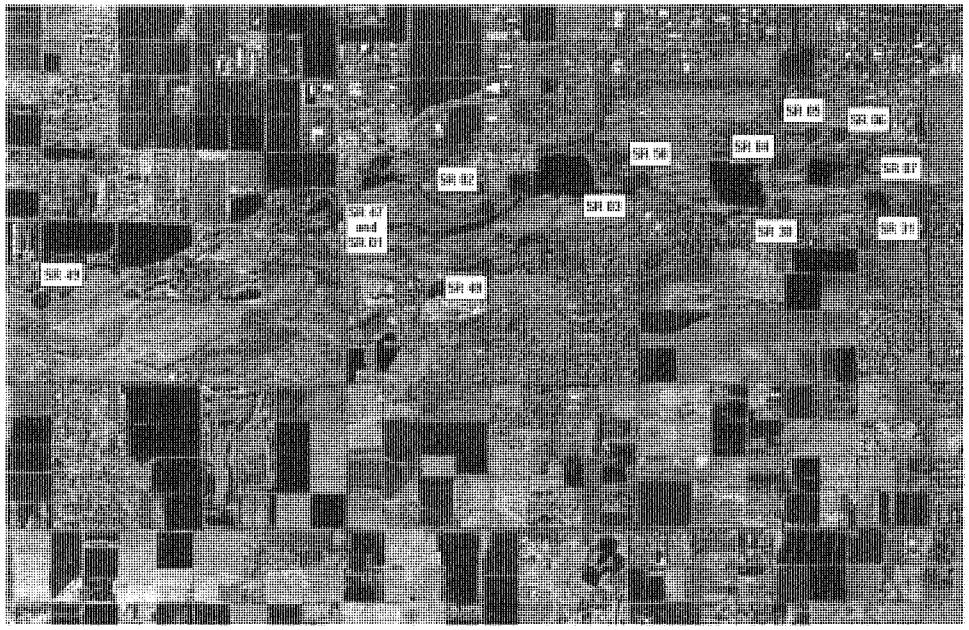
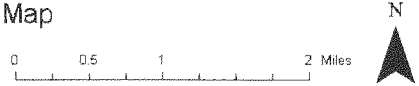


Figure 1. Rio Salado Oeste Outfall Location Map

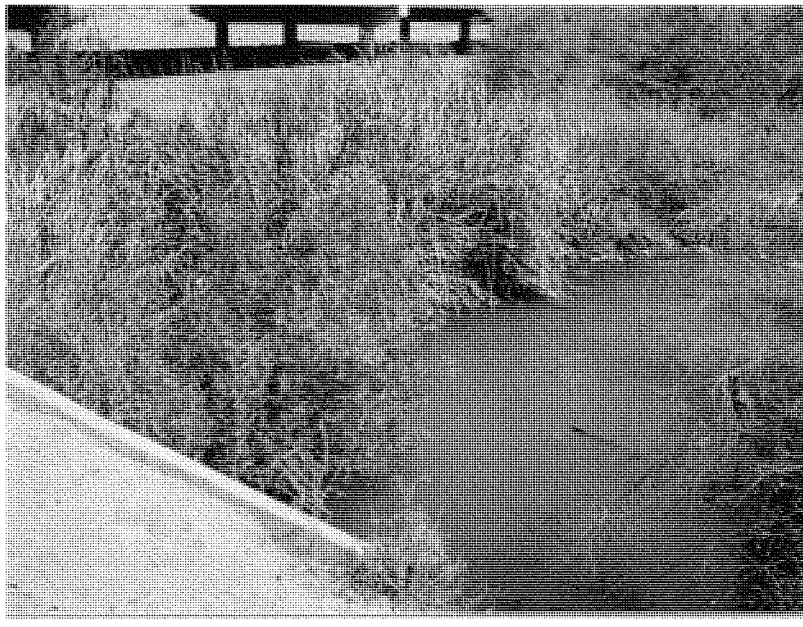


APPENDIX A – Field Data Sheets

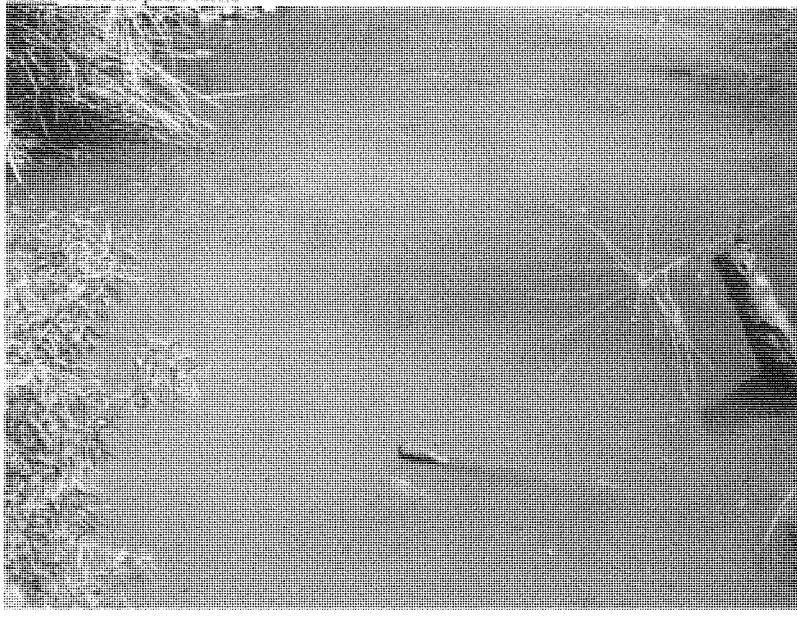
Stormwater Outfall field notes from 6-23-2003
Rio Salado Oeste

SR 47 51st Avenue and Salt River—North side 50 feet north of SR 01

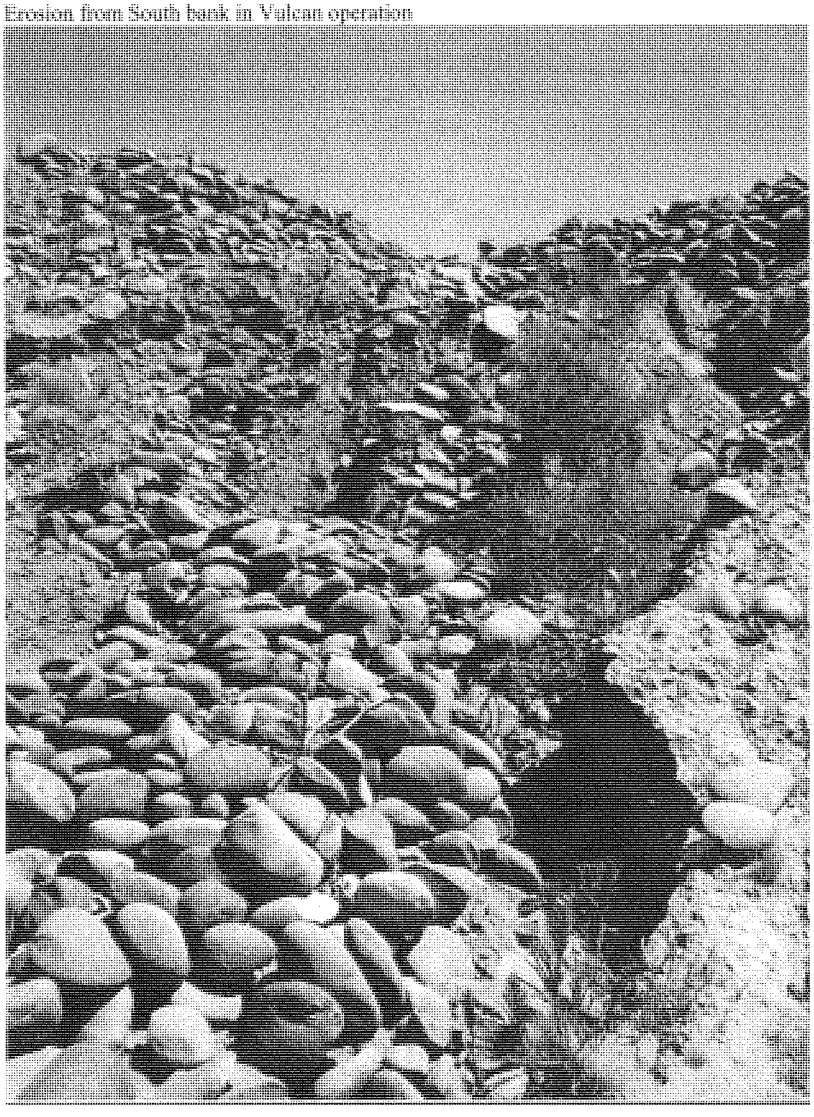
SR 47 Vegetation (good) — cattails, reeds, etc.



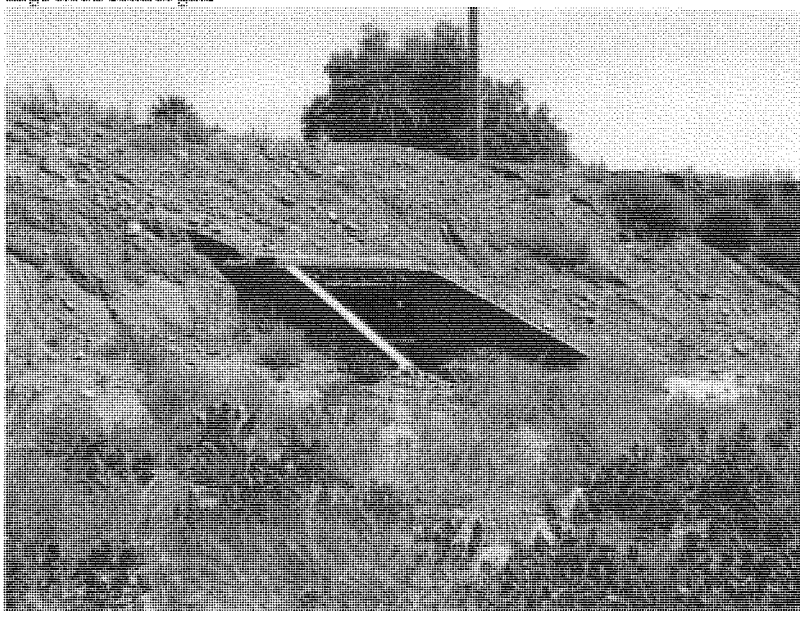
SR47 Western pond turtle



45th Avenue and Salt River
Erosion from South bank in Vulcan operation



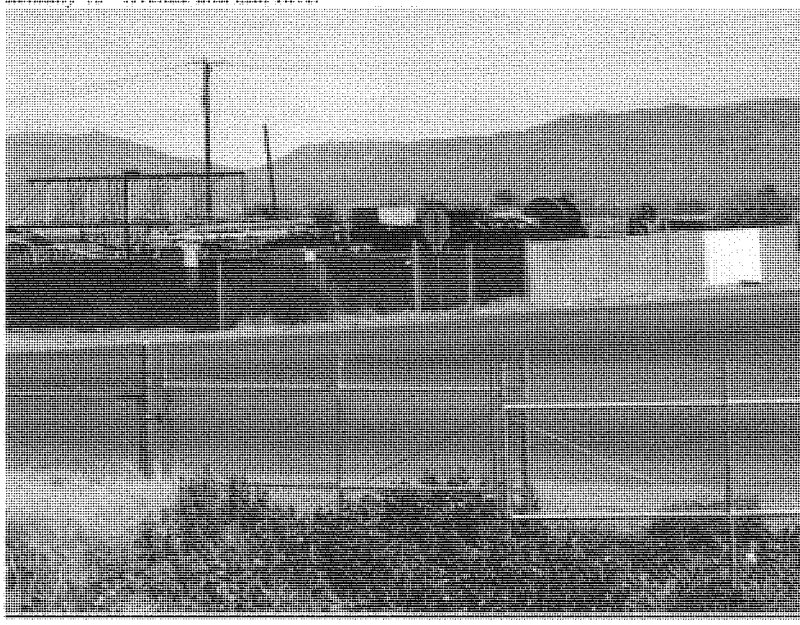
SR 48 45th Avenue and Salt River—South Side
actually 43rd Avenue and Salt River
large flood control gate



SR 48 45th Avenue and Salt River—South Side
actually 43rd Avenue and Salt River
standing water and lots of vegetation—some Arundo, reeds,

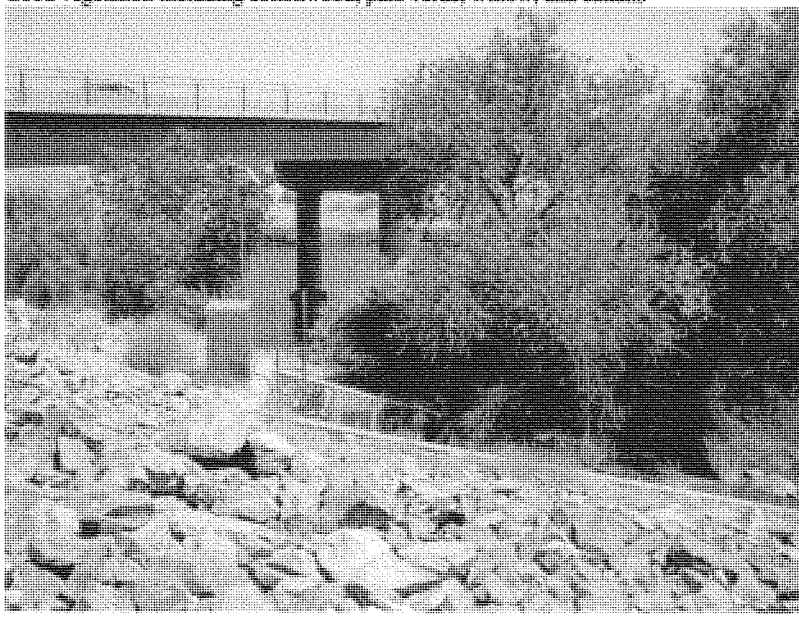
SR 48 45th Avenue and Salt River—South Side

actually 43rd Avenue and Salt River



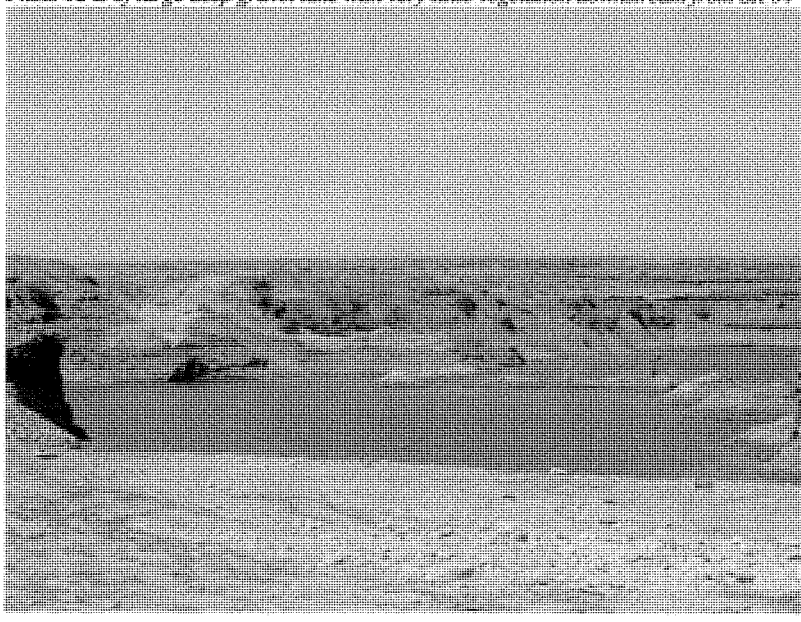
SR 03 35th Avenue and Salt River—North Side
USGS gaging station, large concrete culvert

SR 03 35th Avenue and Salt River—North Side
Flowing water and pond
Good vegetation including cottonwood, palo verde, willow, and cattails

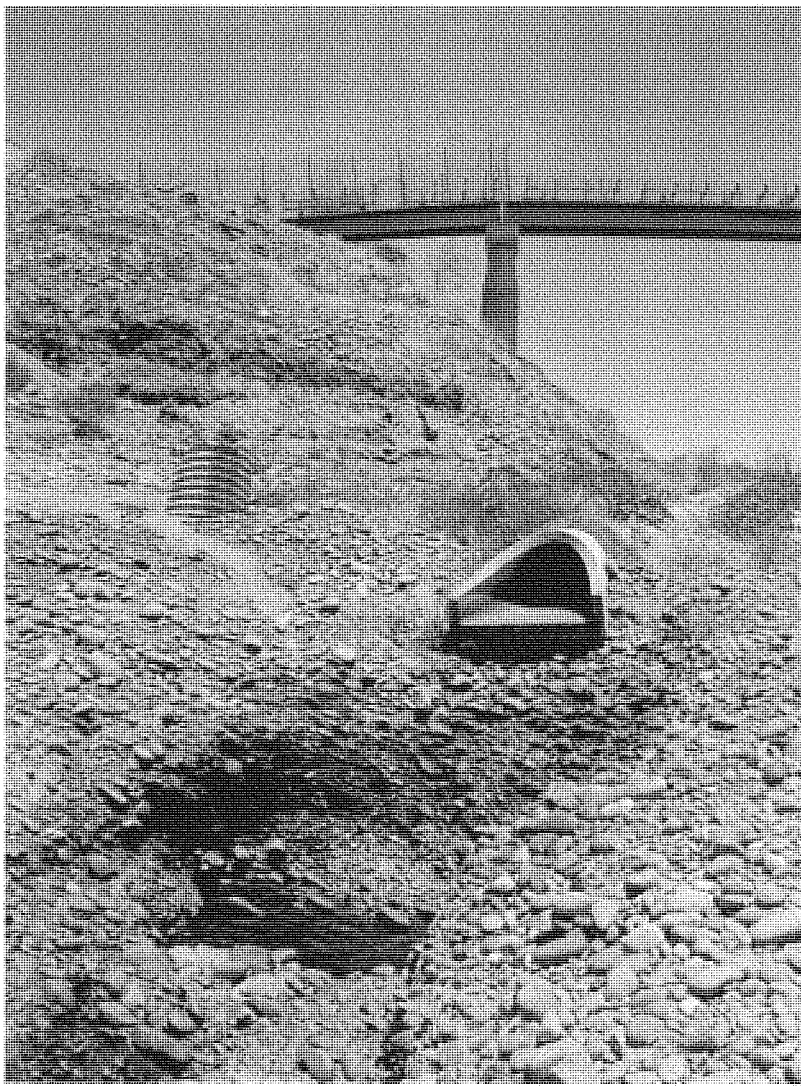


SR 30
27th Avenue and Salt River—South Side
large concrete pipe with trash screen

SR 04 27th Avenue and Salt River—North Side
flowing water north of River channel, directly adjacent to gravel mining operation
Photo 12 is of large deep gravel lake with very little vegetation downstream from SR 04

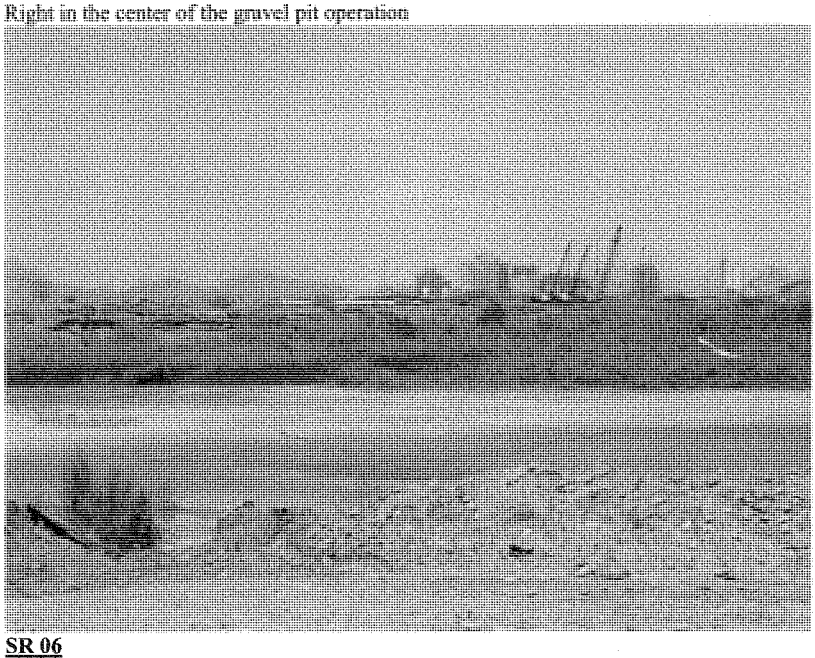


Sand and Gravel drain north side west of conveyer



Sand and gravel culvert, south west of conveyer

SR 05 25th Avenue and Salt River—North Side
couldn't find where the outfall started, but we think we found where both SR 05 and 06 empty into large gravel pit with deep water
Think that Photo #8 is a large open water wetland cause from the outfall.
Right in the center of the gravel pit operation



SR 06
22nd Avenue and Salt River—North Side
same as SR 05, we think we may have found where water empties, but couldn't determine exactly where the water originated.

SR 07 19th Avenue and Salt River—North Side
large round concrete culvert with trash screen
small communities of plants (reeds, cattail, etc)
a little flowing water

US Army Corps of Engineers
Los Angeles District

RIO SALADO OESTE
Maricopa County, Arizona
Feasibility Study

Appendix N

MONITORING
AND
ADAPTIVE MANAGEMENT

February 2006

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
PLANNING DIVISION, WATER RESOURCES BRANCH
P.O. BOX 532771
LOS ANGELES, CALIFORNIA 90053-2325

Appendix N
MONITORING AND ADAPTIVE MANAGEMENT

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INTRODUCTION

The Salt River, although highly modified and controlled, remains a natural river system where changes may occur. While planning for this project has accounted for the possible factors affecting the study area it is inevitable that uncertainty will remain with the outcome of the recommended plan. Implementation of a monitoring and adaptive management plan will not alleviate all uncertainty but will provide flexibility to account for changing environmental conditions and new information as well as measure project success.

The Monitoring and Adaptive Management Plan is an essential element in the overall implementation of the proposed 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 described in ER 1105-2-100 Planning Guidance Notebook Page 3-25, monitoring and adaptive management:

"*Monitoring may be necessary to determine if the predicted outputs are being achieved and to provide feed back for future projects. The cost of monitoring included in the total project cost and cost shared with the non-Federal sponsor shall not exceed one percent of the total first cost of ecosystem restoration features. For complex specifically authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended. The cost of the adaptive management action, if needed, will be limited to 3 percent of the total project cost excluding monitoring costs.*"

It is assumed that Monitoring and Adaptive Management Plan for the tentative recommended plan will be 4% of total construction or $3.9 Million over 5 years. The plan includes cost shared monitoring and adaptive management actions during the first five years after initial project implementation. After the first five years, monitoring and/or adaptive management becomes the responsibility of the local sponsor (City of Phoenix). However, the local sponsor can use this plan to help guide monitoring efforts and refine the project features such that project goals and objectives are achieved.

It is recommended that the plan be reevaluated and updated during PED taking into account lessons learned from the Rio Salado and Tres Rios projects in the immediate vicinity as well as other projects such as Va Shly'ay Akimel further upstream on the Salt River. Since this project, if implemented, will complete the restoration of the Salt River from approximately I-10 to the confluence of the Agua Fria that entire 21 mile reach should be considered and monitored as one system. A monitoring and adaptive management plan may be applied to the entire area as a whole.

GOALS AND OBJECTIVES

The primary study objective was to restore native riparian, wetland, and floodplain habitats and manage undesirable plant, fish and wildlife species. In order to carry out

that objective several different measures are required including, provide water supply and distribution, restore an active channel, and implement revegetation.

To accomplish that objective the goal is to restore the necessary native vegetation within the study area. The following table includes the projected acreages of habitat assumed to be restored with the tentatively recommended plan.

Table 1 Acres Of Habitat Restored With The Tentatively Recommended Plan

Habitat	Acres
Channel	170
In Channel Wetlands	34
Cottonwood/Willow	375
Mesquite	417
Wetlands	156
Scrub Shrub	410

SUCCESS CRITERA EVALUATION

Criteria for successfully achieving the goal of native riparian habitat restoration are recommended as: 1. the restored vegetation listed above have an 80% survival rate, 2. project features are resilient to floodplain changes, and 3. increased wildlife use of the project area, and 4. public recreation use increases and does not conflict with restoration project.

RECOMMENDED METHODS

While there are potential scientific lessons to be learned from restoration projects this plan is not intended to be a rigorous scientific investigation. It is designed as 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 and to identify areas where improvement to the function can be made as necessary.

Variables to be Sampled

Aerial Mapping

Prior to and immediately following construction digital orthophotography of the project area should be obtained and vegetation mapped. This will provide an overall baseline map of the project area and verify modifications performed during construction. At a minimum the cover types identified in the recommended plan should be quantified.

Vegetation Success

Species composition and densities from implementation will be known. Monitoring of vegetation should be completed annually to determine survival and percent cover. Assessing survival will be accomplished through observations at each plot of restored habitat and can be accomplished in conjunction with percent cover measurements. The sampling recommended below follows sampling performed in measuring existing habitat conditions and described in Appendix I, Functional Assessment.

Sampling

A 100m long transect will be established generally parallel to the river channel. Along the transect establish a series of 10m x 10m quadrats, creating a belt transect. Within the quadrat species composition and survival should be noted by randomly locating a 1m X 1m square. The following data should be recorded based on the methods stated below:

Percent herbaceous cover	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.
Percent shrub cover	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.
Percent tree canopy	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.

Avian surveys

The construction of the Audubon center at Central Avenue provides an opportunity to involve the public in project monitoring. Recommend that annual bird counts be coordinate with Audubon to include seasonal point count surveys throughout the restored river reaches. This should include at least one season's counts prior to construction and annually after construction.

Water Supply and Distribution

Successful restoration in this arid environment depends on water above anything else. Monitoring of the irrigation system for its ability to effectively distribute water to the restored vegetation will be necessary and perhaps an area where adaptive measures may be taken. It is also assumed at this time that lessons from other projects may be applied prior to construction.

Irrigation
Success of irrigation practices to provide sufficient water to restored habitat will be evaluated through observation and measurement of distribution and vegetative survival. Modifications to methods or quantities may be necessary to ensure survival or it may be possible to reduce water demand.

Storm water
Monitoring of storm water quantity and quality should be conducted annually. Quantities of average runoff from rainfall were calculated in the feasibility study and are included in the report. Dry weather flows however were not quantified or estimated and if sufficient may contribute to irrigation on a site specific basis. Water quality was not assumed to be a concern in the study and it is assumed that wetland vegetation will sufficiently improve poor water quality. Monitoring will either confirm or identify if corrective action is necessary.

Active Channel function

The proposed restoration includes grading and excavation to reestablish an active river channel. That channel will be an average of 5ft depth and vary in width from 200-400 feet. It is assumed that the channel will migrate slightly within this range and will change as flows occur. No stabilization was found to be necessary in project modeling other than at the proposed grade control structure downstream of the 35th Avenue Bridge. If a flow event occurs the channel should be evaluated for its performance and ability to maintain stability and function. It is assumed that where water is available vegetation will regenerate much like on Rio Salado upsteam. Seasonal flows within the channel should be measured annually and vegetation documented.

Photo points

Photo points should be established through the project area for documentation of project changes. These points should be accessible during flood events and in areas that will not be obscured as vegetation grows. Photographs should be taken prior to construction, seasonally during construction, and seasonally each year following construction. This will provide visual documentation to changes within the project area and confirm other measurements taken above.

Additional Monitoring

Insects: Mosquito monitoring should be done annually during the Operations and Maintenance period to address concerns regarding disease vector control. 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.

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 City of Phoenix, 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 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 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.

After the first five years, any continuing monitoring and adaptive management will be at the discretion of the local sponsors. The City will be responsible for preparing the monitoring reports and for funding and implementing any modifications necessary to ensure the success of the project.

ADAPTIVE MANAGEMENT

The detailed Monitoring and Adaptive Management plan to be completed during PED will take into account lessons learned from both Rio Salado and Tres Rios projects and will identify adaptive management criteria and measures required for implementation of the Oeste project.

It is recommended that a Technical Committee be established to provide advice pertaining to adaptive management measures if features do not achieve the identified goal and objectives. That committee will include representatives from the Corps of Engineers, City of Phoenix and the Flood Control District of Maricopa County. It is also recommended that representatives of resource agencies (US Fish and Wildlife Service, Arizona Game and Fish) local academic institutions (Arizona State or University of Arizona) and non government organizations such as Audubon be represented on the technical committee.

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 flooding.

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 sponsor, 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 may 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, the local contribution may be put into an escrow account to be used for future adaptive management needs.

CONCLUSION

The Monitoring and Adaptive Management Plan is an essential element in the overall implementation of the proposed 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. While planning for this project has accounted for the possible factors affecting the study area it is inevitable that uncertainty will remain with the outcome of the recommended plan. Implementation of a monitoring and adaptive management plan will not alleviate all uncertainty but will provide flexibility to account for changing environmental conditions and new information as well as measure project success.

The plan described above is a recommended plan for Rio Salado Oeste that will be built upon and modified to take into account lessons learned from the Rio Salado and Tres Rios projects as they are constructed and operated.